

Policy mixes for incumbency: the destructive recreation of renewable energy, shale gas 'fracking,' and nuclear power in the United Kingdom

Article (Accepted Version)

Johnstone, Philip, Stirling, Andrew and Sovacool, Benjamin (2017) Policy mixes for incumbency: the destructive recreation of renewable energy, shale gas 'fracking,' and nuclear power in the United Kingdom. *Energy Research & Social Science*, 33. pp. 147-162. ISSN 2214-6296

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/70344/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

Copyright and reuse:

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

Policy Mixes for Incumbency: Exploring the destructive recreation of renewable energy, shale gas ‘fracking,’ and nuclear power in the United Kingdom

Abstract

The notion of a ‘policy mix’ can describe interactions across a wide range of innovation policies, including ‘motors for creation’ as well as for ‘destruction’. This paper focuses on the United Kingdom’s (UK) ‘new policy direction’ that has weakened support for renewables and energy efficiency schemes while strengthening promotion of nuclear power and hydraulic fracturing for natural gas (‘fracking’). The paper argues that a ‘policy apparatus for incumbency’ is emerging which strengthens key regime-based technologies while arguably damaging emerging niche innovations. Basing the discussion around the three technology-based cases of renewable energy and efficiency, fracking, and nuclear power, this paper refers to this process as “*destructive recreation*”. Our study raises questions over the extent to which policymaking in the energy field is not so much driven by stated aims around sustainability transitions, as by other policy drivers. It investigates different ‘strategies of incumbency’ including ‘securitization’, ‘masking’, ‘reinvention’, and ‘capture.’ It suggests that analytical frameworks should extend beyond the particular sectors in focus, with notions of what counts as a relevant ‘policy maker’ correspondingly also expanded, in order to explore a wider range of nodes and critical junctures as entry points for understanding how relations of incumbency are forged and reproduced.

1. Introduction

Transitions to more sustainable and low carbon forms of energy production are not occurring at the rates deemed necessary by the latest evidence on anthropogenic climate change (World Bank 2014; IEA 2016a; IIASA 2012). In order to meet agreed climate goals, transformation of the energy system evidently needs to be ‘accelerated’ (Jefferson 2008). The EU is in danger of missing its 2030 and 2050 climate change goals unless more rapid decarbonisation of the energy sector is undertaken (Khanam et al 2017; Spencer et al. 2016). With renewable technologies as the cornerstone of energy sector transformations, the House of Commons Energy and Climate Change Committee (ECCC) has raised concern that the United Kingdom (UK) will not achieve its 2020 renewable energy targets (ECCC 2016).

Recent EU policy initiatives have also highlighted the aim of accelerating the decarbonisation of the economy in order to meet these targets (European Commission 2015). Furthermore, academic studies of ‘sustainability transitions’ (Markard et al. 2012) have increased attention to the means by which transitions might be speeded up in order address growing policy urgency (Kern & Rogge 2016; Sovacool 2016; Bromley 2016; Fouquet 2016).

Across this combined academic and policy literature, two related issues consistently emerge to form central points of departure for this paper. First, that a major reason for transitions to unfold more slowly than might otherwise be expected, lies in obstruction and resistance by actors at the ‘regime’ level – typically involving established industries blocking the deployment of new technologies like renewables in order to protect existing business models and networks in order to maintain positions of incumbency in sociotechnical systems (Smink et al. 2013). Second, another reason why

interventions to accelerate transitions may not be occurring at desired rates, is that there is often a lack of coordination between differing instruments for the promotion of sustainability transitions, requiring instead a focus on interactions in diverse ‘policy mixes’ (Kivimaa & Kern 2016; Rogge & Reichardt 2013; Nauwelaers et al. 2009; Quitzow 2015; Magro & Wilson 2013). In this latter field, a tandem view is adopted of interactions between policies aimed (on the one hand) at ending particular unsustainable technological trajectories, and (on the other hand) at promoting new ‘niche’ technologies (Kivimaa & Kern 2016).

This study explores a recent critical juncture in UK energy policy involving three new policy mixes around renewables and energy efficiency, fracking, and nuclear power. Described by the Government as the “resetting” of UK energy policy (Rudd quoted in Mason 2015a), this critical juncture was ushered in by a cluster of decisions taken at the end of 2015, reorienting five years of important policy developments related in these areas into a ‘new direction for UK energy policy’ (DECC 2016a). These distinct new policy mixes culminated dynamics that could be characterised equally as ‘creative’ and ‘destructive’ (Kivimaa & Kern 2016).

As will be described, this mix of policies included: high-level foreign policy support (in the decision to enable Chinese investment in UK nuclear power); other dedicated new financing arrangements; and changes to planning law. These strengthened the position of fracking and nuclear power, while weakening the position of ‘challenger’ technologies including onshore wind and solar. It is on these grounds that these three policy mixes can each be considered as examples of “a policy apparatus for incumbency” – a term arguably also describing a wider collection of UK energy policy interventions.

This policy apparatus for incumbency was justified by UK Government on the basis that it would foster “*lower costs, keep the lights on, and ensure the development of clean technology*” (Leadsom 2016). Yet in analysing these claims, it is difficult to justify them against the evidence available at the time to the UK Government concerning the economics of these various options. It is on these grounds that this policy apparatus for incumbency can – by counterpoint with Schumpeter’s highlighted process of ‘creative destruction’ – be considered ‘*destructive re-creation*’. Rather than the incumbent configuration being subject to destruction, it is instead re-created by destructive pressures that bear instead bear on emerging niche innovations (like renewable technologies and energy efficiency improvements).

2. Conceptual background: policy mixes, sustainability transitions and the understudied role of incumbency

This section offers an outline of the conceptual framework used to guide this analysis concerning policy mixes, sustainability transitions and incumbency. Table 1 offers a summary of key concepts.

Table 1: Key conceptual terms in policy mixes, sustainability transitions, and incumbency

Concept	Description	Source(s)
Niche	"Niches form the micro-level [of the MLP], the locus where novelties emerge. These can be small market niches or technological niches, where resources are provided by public subsidies...Niches act as 'incubation rooms', shielding new technologies from main-stream market selection"*	Verbong & Geels (2007: 1026)
Sociotechnical Regime	A "...semi-coherent set of rules carried by different social groups. By providing orientation and co-ordination to the activities of relevant actor groups, ST-regimes account for the stability of ST-configuration"	Geels (2002:1260)
Policy	"Diverse activities by different bodies are drawn together into stable and predictable patterns of action which (as often as not) come to be labelled 'policy'" "'Policy' is a general term used to describe a formal decision or plan of action adopted by an actor ... to achieve a particular goal"	(Colebatch, 1998: quoted in Cairney 2015: 2) Richards & Smith (2002 quoted in Cairney 2015: 3)
Policy instrument	Particular tool used by decision makers to achieve a particular policy goal – for example, Feed-in-Tariffs and tax exemptions are policy instruments to achieve the policy goal of increased renewables capacity.	Cairney (2015)
Policy mix	The interactions and interdependencies between different policies as they affect the extent to which intended policy outcomes are achieved	Flanagan (2011)
Policy apparatus	The broader collection of policy mixes constituting a given policy terrain	Authors own definition in this paper.
Incumbent	Incumbent actors within a given technological regime that often have vested interests in maintaining the status quo rather than enabling transitions and will often act to strategically protect their privileged position.	Geels (2014) Wesseling (2015)
Deep incumbency	"A self-reinforcing trajectory in obdurate configurations of actors, practices, interests, infrastructures, institutions and cultures, that dominate in some specific political setting"	Cox et al (2016: 16)

Source: Authors' compilation. **It is important to note that with the MLP acting as a heuristic the niche is always defined in relation to the 'regime', so a niche technology (such as onshore wind) may not always embody the characteristics above, and must be understood in relation to what is defined as the dominant sociotechnical regime in question.*

2.1 Policy mixes

The notion of 'policy mixes' recognizes that policy instruments do not act in isolation, but involve many important interactions within and across different policy domains. These interactions necessitate managing and directing these different instruments towards shared goals (Rogge et al. 2015; Flanagan et al. 2011; Borrás & Edquist 2013; Santos et al. 2006; Magro & Wilson 2013; Kivimaa & Kern 2016;

Rogge & Reichardt 2013; Kern & Rogge 2016). Here, there is an important distinction between the general policy (a decision reached outlining a particular future aim often solidified at the level of the state) and specific ‘policy instruments’ (different tools available to decision making bodies for pursuing these aims).

For example, where a hypothetical overall national policy is to achieve 25% renewables capacity, policy instruments might include feed-in-tariffs, tax exemptions for renewable energy producers, or direct subsidies. Finding the right mix of instruments for implementing R&D expenditure for energy technologies in Europe has been an important area of discussion at the EU level (Nauwelaers et al. 2009). Evaluating more comprehensively the range of policy instruments that can be drawn on to support the deployment of renewable energy sources in the EU has been considered a research priority (Climate Knowledge Hub 2016).

Past research has often focussed on broad innovation policy challenges: around identifying the correct mix of policy instruments to optimise regulatory, economic and financial impacts. In addition, some studies have investigated ‘soft’ policy instruments including campaigns and voluntary schemes not necessarily mandated by governments (Borrás & Edquist 2013). With policies increasingly pitched at different administrative levels, challenges arise in assessing interactions between policy instruments operating at different spatial scales (Magro & Wilson 2013). Given that these different areas often involve very different actors and trade-offs between differing priorities and goals, Quitzow (2015) highlights difficulties in coordinating supply and demand side policy instruments.

Rogge & Reichardt (2013) assess the policy mix around the German *Energiewende* – looking at a range of instruments used to steer this energy transition, including as a crucial aspect of this policy mix, the phasing out of nuclear energy. They distinguish a wide range of ‘technology push’ and ‘demand pull’ options in order to address the question of which policy mix is most effective for successful development of renewables. Perhaps surprisingly, ahead of high-profile policies such as the Feed-in-Tariff and other supportive measures specifically around renewables, their survey revealed that most respondents thought that renewable energy manufacturers considered the most important single instrument in this mix, to be the phase out of nuclear power. This emphasises the practical importance of phase out policies to the development of niche innovations, and highlights the need to attend more carefully to interactions between policies designed to destabilise incumbent actors, with those aimed at promoting renewables. Similar works have explored this dynamic between “supply push” and “demand pull” policy mixes related wind energy development in Denmark and the United States (Sovacool and Sawin 2010), innovations in energy efficiency across Finland and the United Kingdom (Kivimaa and Kern 2016), or biofuel development in China (Ren et al. 2015).

The degree to which there is a balance between creative and destructive policies is likely to be influenced by broader political struggle. However, as Kivimaa and Kern (2016) point out, the politics underlying policy mixes are not always rigorously discussed. Yet, the often-elusive figure of the ‘policymaker’ is implicitly portrayed in policy mixes literatures as if a neutral decision maker with a privileged lofty vantage point over a range of possible policies, whose position is disinterested and whose choice among contending policy actions (including destabilisation strategies) depends only on the qualities of evidence in each respect. It typically remains the case that whether a policymaker considers a certain instrument or technology to be legitimate, is in part also conditioned by institutional logics, vested interests, power relations and broader politics around the policy maker themselves. The degree to which pursuit of sustainability transitions is characterised by creative or destructive policies (and the composition of associated policy mixes), are therefore subject to politics and power dynamics acting around the policy maker in terms of lobbying activities, as well as ‘below’ them in terms of broader societal pressures.

2.2 Sustainability transitions and incumbency

A related strand of research approaches incumbency from the perspective of sustainability transitions (Kungl 2015; Wesseling 2015; Geels 2014; Smink et al. 2013; Markard et al. 2012). These assessments seek to help design policy mixes to address dynamics of incumbency at the ‘regime’ level. Contrasting approaches within this broad field include the functional approach to ‘technological innovation systems (TIS)’ (Markard et al. 2015), ‘transition management’ (Rotmans & Loorbach 2008), ‘strategic niche management’ (Witkamp et al. 2011) and the Multi-Level Perspective (MLP) (Geels 2010).

Despite their differences, a shared feature of all these approaches are the aims of understanding and promoting ways in which new sustainable innovations and infrastructures can be nurtured by policy in order to destabilise unsustainable technological regimes (Kemp et al. 1998). Such processes are difficult because radical reconfigurations of dominant technological systems in which new technologies can ‘break through’ are rare events. New technologies typically do not ‘fit’ with the dominant engineering, institutional, and scientific ‘regime’ constituted by certain ‘rules of the game’ in which existing technologies benefit from ‘economies of scale’ (Klitkou et al. 2015) and ‘increasing returns’ (Arthur 1989), leading to ‘path dependency’ (David 1989) and incremental innovation as the usual state of affairs (Arthur 1994). Yet beyond this, sustainability transitions literatures have until recently only rarely undertaken a direct critical focus on the detailed dynamics that actively produce and reproduce the *stability* of the focal sociotechnical system in question.

Whether normative or analytic, much work in sustainability transitions draws on the ‘multi-level perspective’ (MLP). Based around ‘micro’, ‘meso’ and ‘macro’ levels of development (Schot et al. 1994; Rip & Kemp 1998; Geels 2014), this body of research focusses on how new ‘niche’ level innovations associated with more sustainable forms of production, might best diffuse and replace unsustainable existing technological regimes. With self-reinforcing path dependence well acknowledged at the regime level, the main point for agency to be enacted in order to bring about a ‘regime shift’ is seen in this view to be located at the level of the niche. Notably less attention was traditionally placed on understanding the dynamics that reproduce the apparent stability of the regime itself (Smith et al. 2005). Building on Unruh’s illumination of processes of ‘carbon lock in’ (Unruh 2000) acknowledgements became more common that “*powerful incumbent actors may try and suppress innovations through market control or lobbying*” (Geels 2004: 911). Yet analysis has tended not to proceed further in examining such processes in detail – retaining a focus firmly at the niche level in approaches like strategic niche management (Raven 2005) and transition management (Rotmans et al. 2001).

It is against this background, that the need directly to understand the dynamics of agency at the level of the regime has emerged (Smith 2007). In this, more general issues of power and politics around sustainability transitions have grown in focus (Hess 2015; Avelino 2011; Kuzemko et al. 2016; Geels 2014). Large incumbent firms typically lobby to resist sustainability transitions (Smink 2015; Smink et al. 2015; Smink et al. 2013). For instance, particular attention has been given to lobbying activities by established German utilities (including RWE and E.ON) to slow the pace of the *Energiewende* (Wassermann et al. 2015; Kungl 2015). There has been an emphasis on ‘non market’ strategies on the part of incumbents in response to influence political decision making against the renewables ‘challenge’ (Lauber & Sarasini 2011). The potential for incumbents to change their business narratives to incorporate societal ‘niche’ narratives around ‘sufficiency’ as a survival strategy has been researched (Augenstein & Palzkill 2016), as well as detailed analysis of strategies of incumbent car

manufacturers to resist sustainability transitions both in political actions and efforts to prevent radical innovations (Wesseling 2015).

Sovacool and Scarpaci (2016) identify a different, but by no means less impactful, way that incumbents utilize seemingly progressive policy instruments to entrench incumbent interests. They point to the Yasuní-ITT proposal in Ecuador where the stated aims were to promote renewables and energy efficiency and phase out oil. Instead, the study suggests the proposal was merely a proxy for President Rafael Correa to consolidate political power while securing concessions in other policy realms, and furthering the interests of his party—including an eventual renewed commitment to oil production.

A number of studies in sustainability transitions have addressed wider ways in which incumbents seek to impede rapid deployments of niche technologies through interventions that deliberately set out to destabilise institutional ‘rules of the game’ affecting niches. Such “regime resistance” (Hess 2016; Geels 2014) can prevent the successful emergence of new business models and institutional structures that would enable the more rapid deployment of renewables (Fuenfschilling & Truffer 2014; Coenen et al. 2012; Andrews-Speed 2015; Farla et al. 2012; Hall et al. 2016; Kuzemko 2014). With particular reference to the UK, Geels (2014) has identified ‘regime resistance’ both in the form of conventional lobbying and of more concerted alliances that include not only ‘incumbent actors’ (coal, gas and nuclear) but also policymakers themselves.

In other words, addressing the politics of sustainability transitions does not just require attention to the behaviour of incumbent firms – or indeed entrenched sociotechnical regimes – as apparently discrete entities, ostensibly separate from policy-makers and wider and deeper governance processes. If regime resistance is itself to be countered by deliberate efforts at ‘regime destabilisation’ (Scrase & Smith 2009; Turnheim & Geels 2012; Turnheim & Geels 2013; Bosman et al. 2014; Karltorp & Sandén 2012) then the scope of what constitutes the politics of transitions becomes significantly wider and deeper (Stirling 2011).

2.3 The Politics of Deep Incumbency

A final relevant theme of research deals with “deep incumbency” (Johnstone & Stirling 2015a; Cox et al. 2016). Building on insights in organisation theory (Tushman et al. 1985), practice theory (Shove 2003), multilevel governance (Brondizio et al. 2008), political economy (North 2006b) and historical institutionalism (Steinmo et al. 1992) – as well as management science (Chandy & Tellis 2000), technology studies (Unruh 2000) and energy policy (Finon & Midttum 2005) – the concept of ‘deep incumbency’ contrasts in several important ways with conventional notions of sociotechnical regimes. The central point, is that incumbency is not necessarily as neatly scaled and bounded as required in expedient ambitions to substitute one ‘sociotechnical regime’ for another. This view recognises that incumbency as manifest in any given area of governance, may more persuasively be understood as irreducible aspects of power dynamics that pervade an entire polity taken as whole (Stirling 2014).

Here, incumbency can be defined in general (eg: unscaled) terms as “*a ‘multiplexity’ of dynamics through which a particular trajectory in interacting social, economic, cultural, political, discursive, cognitive, technological and wider material phenomena, is reproduced by – and reinforcing of – associated power gradients*” (Stirling and Johnstone, forthcoming). In this light, it is an assumption in many versions of – and perspectives on – sociotechnical regime theory, that the configuring of these trajectories in the outside world will conveniently map on to the categories that are most favoured in a particular research agenda – for instance to effect a specific kind of ‘sustainability transition’ (Unruh

2000; Robertson 2015; Smith & Raven 2012; Geels 2004; Geels & Kemp 2007; Loorbach 2014; Kern et al. 2014; Geels 2005; Geels & Schot 2007; Geels 2010; Geels 2009). Such assumptions are expedient for purposes of building disciplines or appropriating ‘impact stories’ in the ‘real world’ of policy (Stirling 2014), but they may not be such good descriptions of the ‘real real world’ of technology politics itself (truth to power).

To be fair, however, such “*fallacies of misplaced concreteness*” (Whitehead 1948; Stirling 2011) can often be useful in conventional policy processes. They may allow researchers, analysts and policymakers to each perform their allotted functions (and fulfil their respective interests) without perpetrating inconvenient transgressions. They can be hoped to offer ‘civilizing hypocrisies’ (Elster 2007), through which negative commitments may nonetheless help induce positive effects. By telling unrealistically simplified stories, policy interventions can thus be undertaken according to a particular sectoral remit and subject to prevailing constraints and imperatives, without the unwelcome complexity, uncertainty or intractability of wider, messier politics. So, such fallacies may appear as ‘necessary fictions’ (Žižek, 1989:148-9) that can help enable important agendas like transitions to sustainability. But they may also be destructive, in that associated policy performances can continue in their own self-sufficient fashion, without necessarily effecting any real-world change (Hilgartner 2000). In a field where the stakes are as high as energy transformation, overly simplified understandings may prove a rather precarious basis for policy action.

One further practical consequence of these indeterminacies is that salient research categories cannot be neatly segmented and conveniently scaled into discrete levels, each stratified contiguously side by side. Instead, they may cross-connect, interpenetrate and form recursive “cycles of subsumption” (Woods, 1991) of kinds that defy any easy representation (Stirling 2016; Stirling & Arora 2015). After all, multiplicities of complex entanglements in elite cultures and patronage networks can span and link all these notional horizontal and vertical divisions in ‘rhizomic’ ways (Deleuze & Guattari 1987; Deleuze & Guattari 1987; Stirling 2016; Sovacool and Hess 2017), that may render ostensibly neatly-separable scales, levels and sectors little more than stories (Ernstson 2008; Steinberg 2008; Galloway & Thacker 2007).

Likewise, regimes of any kind or degree may be embedded in institutional fields, political cultures, networks of agency or sociotechnical imaginaries whose distinguishing features may be at least as formative in shaping trajectories as any specific attributes of ‘the regime’ itself (Pesch 2014; Certomà & Tornaghi 2015; Grin et al. 2011; Fischer & Newig 2016). It seems that notions of ‘the regime’ in any given setting, can represent a triumph of expediency over realism – enabling the telling of analytical stories and the construction of requisite policy justification, but perhaps of relatively little value in the constituting of robust understanding (Stirling and Johnstone forthcoming).

Picking up on these kinds of challenge, this work on ‘deep incumbency’ explores a series of notions in political science and international relations, relating to concepts of incumbency whose implications span entire polities, rather than being confined to specific sectors (Johnstone & Stirling 2015a; Cox et al. 2016). These are variously-styled as ‘deep structures’ (Grover & Peschek 2014), ‘dual states’ (Fraenkel 2010), ‘double government’ (Glennon 2015) and (notably around nuclear power) ‘subgovernment’ (Temples 1980). Indeed, it was U.S. President Dwight Eisenhower who coined arguably the most well-known term for an instance of this kind of phenomenon, in his famous identification in the USA of the 1950s, of the pervasive role throughout economy and politics of ‘*the military industrial complex*’ (Hartung 2011; Pavelec 2010).

It is striking when an incumbency is so deep and powerful, that even a US President is prompted to highlight its recalcitrance. In the specific case of the UK, an array of these more pervasive kinds of incumbency have also been identified, variously referred to as the ‘deep state’ (Ramsay 2015; Barnett 2010) ‘warfare state’ (Edgerton 2006) and ‘national security state’ (Hogan 1998). It seems, then, there are many good practical precedents for identifying the most salient defining dimensions of incumbency in any given setting (like the UK), to be constitutive of the encompassing polity as a whole.

2.4 Synthesis

In this article, we tie together each of the three different approaches on policy mixes, transitions, and deep incumbency to focus on destructive as well as creative policies for three different energy systems in the UK. Such an approach shifts attention more towards the dynamics of incumbency given that incumbent resistance will need to be overcome in order to ‘destabilise’ policies for regime-based technological trajectories. Those assisting this ‘destruction’ aspect aim more directly to accelerate the decline of unsustainable incumbent technological trajectories (like fossil fuels). Indeed, the emphasis in prior literatures disproportionately on the ‘creative’ side of this innovation duality, makes it not only especially important to take destruction seriously – but also to redress earlier established patterns of neglect. In both respects, however, the question is raised as to the social and political scope and depth of the particular configurations that are being notionally created or destroyed? To what extent are they bounded at the successively wider scales of particular niches; large-scale technologies; associated sociotechnical regimes; combinations of regimes; or even more complex structures pervading entire polities (Johnstone and Stirling 2015; Stirling and Johnstone forthcoming).

In the next section we bring together analysis of policy mixes in sustainability transitions and attention towards incumbency attentive to broader dynamics beyond that of the focal regime configuration, empirically examining an important period between 2010-2015 when important decisions were taken on renewables and energy efficiency, fracking and nuclear power. Using the distinction between creative and destructive policies, we develop an understanding of the range of policy instruments across these three areas. As well as this, a narrative account of developments in these areas over the five year period is drawn on to open up the analysis to broader dynamics of incumbency that may be at play. The evidence concerning evaluations of each policy area that may have been drawn on by policy makers is also examined in order to ascertain what the likely factors that influenced the emergence of a ‘policy apparatus for incumbency’ discussed in section 4, may be.

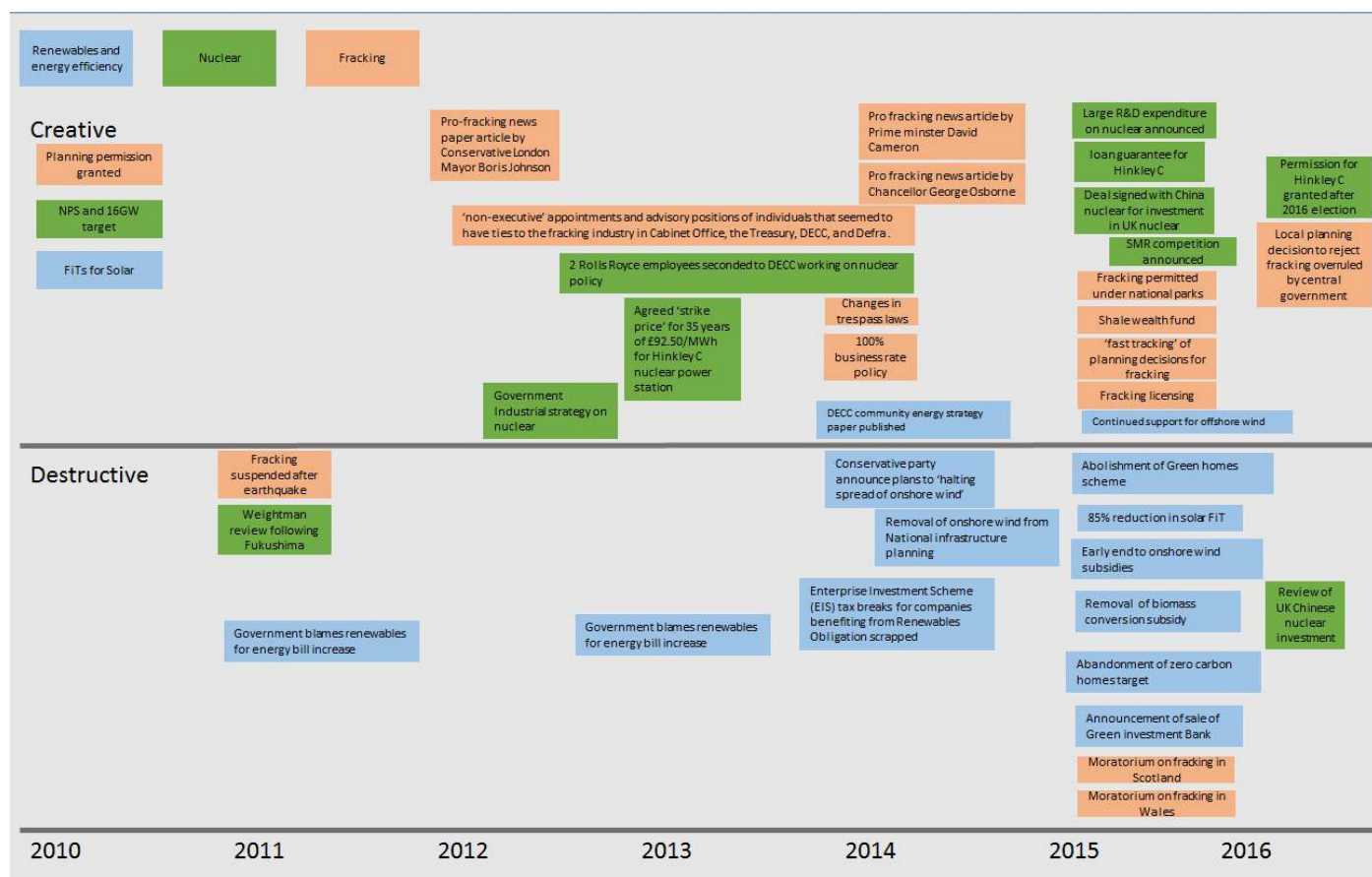
3. “Resetting” UK energy policy: A tale of three policy mixes (2010-2015) and a policy apparatus for incumbency

This section examines three policy mixes related to renewables and energy efficiency, fracking, and nuclear culminating in a UK policy apparatus constituted by both creative and destructive elements. Although the picture is somewhat complicated by the proposed ‘coal phase out’ also announced during this time (DECC 2016b), in early 2017 the effects of these the policy apparatus seems to be emerging: namely, that growth and investment in a range of renewable technologies and energy efficiency measures has been significantly damaged by the policy “resetting” of 2015 with no significant signs of new policy support mechanisms being deployed. Simultaneously, support for

fracking and nuclear remains steadfast with an internationally distinct intensity of support for these two technologies in UK energy policy.

To understand why UK energy policy is moving in a direction towards a ‘policy apparatus for incumbency’ the crucial period between 2010-2015 is looked at in more detail to examine ‘non energy policy’ processes that could be influential in understanding trends in UK energy policy making. We look at three policy mixes around fracking, nuclear and renewables, in terms of a narrative of policy and political decision making that emphasizes the re-legitimization of nuclear and fracking and the de-legitimization of renewables constituting an overall ‘policy apparatus’ discussed in section 3 Figure 1 offers a timeline of these policies and their related developments.

Figure 1: timeline of creative and destructive policy developments for nuclear, renewables and fracking



Source: Authors' compilation.

3.1 A policy mix for renewable energy

At the beginning of 2010, the UK renewables sector had been growing at an impressive rate following the establishment of support mechanisms including Feed-in-Tariffs for solar photovoltaics, subsidies for onshore wind, and Contracts for Difference for offshore wind. The added costs brought on

consumer bills due to these support mechanisms became a matter of controversy within broader debates about the high cost of energy bills more generally (Doward 2013). Although analysis indicates that compared to other European countries such as Germany the fraction of energy bills which are attributed to renewable incentives is small with other factors besides renewables contributing to cost increases (CCC 2014; Rensenn 2014), renewables were often pin pointed by government as the key reason for rising energy bills (Carrington 2011). Also, without the community incentives for wind provided in other European countries (Balch 2015), siting disputes over onshore wind in the planning system also became a key issue (Mason 2015a). The manifesto of the Conservative Party in 2015 outlined the intention to “halt the spread of subsidized onshore wind” (Conservative Party 2015: 57).

Despite the impressive growth of renewables in a short space of time in the UK, there were signs emerging from within Government that action would be taken to reduce support for these technologies. This was seen only a few years after support for renewables was introduced with chancellor George Osborne announcing that support for the green economy was a “burden” and “ridiculous cost” (Harvey 2011). Uncertainty around subsidies for renewables technologies was already brewing in 2012 with significant delays in policy announcements putting investment in doubt (BBC News 2012a).

A year later a symbolic moment emerged in government that signalled the negative views inside government towards renewables with leaked reports of direct orders from the Prime Minister to cut green support mechanisms (Mason 2013). In the budget of 2013 considering the momentum behind the emerging renewables industry in the UK, many renewable groups were expecting the technologies to be promoted in the budget due to the high number of jobs created in the renewables sector and impressive scale of investments (BGT 2013). However, George Osborne emphasised that “Creating a low-carbon economy should be done in a way that creates jobs rather than costing them” (Carrington 2013a). Critics argued such a statement was “making the fundamental mistake of thinking that investment in renewable energy and clean tech ‘costs’ jobs” (Carrington 2013a).

In 2014 further changes emerged reducing in subtle ways support for renewables. In late 2014 it was announced in the budget that Enterprise Investment Scheme (EIS) tax breaks would no longer be granted for companies benefiting from the Renewables Energy obligation or Renewable Heat Incentive schemes (Seager 2014). Already the “chopping and changing” around renewables in the UK was noted by Utility analysts to be making the UK seem “un-investable” in terms of renewables (Seager 2014). The crucial year however was 2015 when a range of policies (indicated in Table 2) were unveiled that substantially reduced incentives for onshore wind, solar power and energy efficiency measures.

Table 2: A UK policy mix for renewables and energy efficiency

Technology or relevant policy area	Brief description of changes
Onshore wind	Early end to subsidies for onshore wind farms with the stated aim to “halt the spread of onshore wind farms”
Solar power	85% reduction in the solar Feed-in-Tariff
Biomass	Removal of guaranteed renewables obligation subsidy for coal or other fossil fuel plants converting to biomass
Green homes scheme	Abolishment of the Green homes scheme
Green tax target	A target set during the last government to keep increasing the proportion of revenue from environmental taxes was dropped in Osborne’s emergency budget

Planning and regulation.	Removal of onshore wind from ‘nationally significant infrastructure’ meaning it is considerably harder to build.
R&D	Increase in total amount of R&D but a decrease in the relative share of overall energy R&D

Sources: Authors’ compilation from (BBC News 2015a; Vaughan 2015a; Vaughan & Macalister 2015).

3.2 A policy mix for shale gas fracking

Interest around fracking in the UK intensified when planning permission was granted for test drilling by Caudrilla in 2010. Enthusiasm for fracking increased when Caudrilla announced results from its test drilling operations indicating that the UK had ‘vast’ quantities of recoverable shale gas of 200 tn cubic feet bringing hopes of a UK fracking ‘boom’ (Macalister 2011).

This progress was interrupted however when an earthquake was triggered by fracking activities near Blackpool leading to all fracking activities being suspended in a major blow to the industry (BBC News 2011). Reports came out at this time highlighting the potential dangers that Fracking posed (Healy 2011).. The government was forced to place a moratorium on fracking activities in November 2011, yet what can be seen was an intensification of quite remarkable levels of support for the technology from central figures in the governing Conservative Party.

This was despite the deeply uncertain nature of the potential benefits of fracking. Lord Browne, chairman of the UK’s leading shale gas company claimed that the costs of fracking were “*unknown*” (Carrington 2013b). The Energy Minister ED Davey concluded that fracking would not reduce energy bills (Gosden 2013), while prominent members of the United Kingdom Energy Research Council (UKERC) stated that “*It is very frustrating to keep hearing that shale gas is going to solve our energy problems – there’s no evidence for that whatsoever... it’s hype*” (Watson quoted in Harrabin 2014). Despite these uncertainties significant media interventions were made by key members of the ruling Conservative Party. London Mayor, Boris Johnson, wrote an important article in 2012, where after describing wind farms as “*satanic mills*”, went on to claim that “*by offering the hope of cheap electricity, fracking would make Britain once again competitive in sectors of industry*” (Johnson 2012). Similar points were made by the Prime Minister, David Cameron in a newspaper article in 2013, outlining that the UK “*couldn’t afford to miss out on fracking*” because it will “*cut energy bills*” (Cameron 2014). Cameron also announced that the UK was “*going all out for shale gas*” (quoted in Withnall 2014). Chancellor George Osborne in 2014 also made a notable intervention promoting fracking as “*the cheapest way possible*” for energy policy by stating that green groups should “*drop their ideological opposition to fracking and nuclear power*” (Watt 2014).

The support was not just rhetorical however, and key policies began to emerge in support of fracking. In 2013 announced a series of tax breaks for shale gas producers (Macalister and Harvey 2013). Plans to change trespass laws to make it easier for fracking companies to gain access to sites (HM Government 2014a). At this time, there is substantial evidence of considerable activity taking place in the highest levels of government. A leaked memo written also by George Osborne was found to be recommending ministers respond to ‘asks’ by key fracking company Caudrilla and intervene in planning applications as a “*personal priority*” (Carrington 2015).

Another key factor in the later stages of the fracking discussion is potential signs of the *suppression of key evidence* within government. While fracking decisions were ongoing at the county level, a key report had been conducted by the *Climate Change Committee* (CCC 2016), was not initially released.

While the report was due to be published in April 2016, the government were accused of “*sitting*” on the report refusing to release it because of the sensitive evidence contained within (Harvey 2016a). The report was finally released on the back of a public campaign organised by NGOs demanding the release of the report, and a “*Freedom of Information battle*” revealed that ministers worked to deliberately “*supress*” the report because they would interfere with ongoing fracking decisions (Worley 2016).

During this period revelations also emerged, again established through FOIs concerning DECC preparing “*lines to take*” regarding fracking to key shale gas organisations including UK Onshore Operators Group (UKOOG) before a publication by a review by Public Health England into potential health effects (Carrington 2014). This issue of collusion and access is an important one. Again, through FOI requests, journalists gained access to the meeting lists of DECC. It was found that between 2010-2014 not only did companies that have active interest in fracking activities have nearly 100 more meetings with civil servants than renewables based companies, but most of these meetings being ‘one-on-one’ closed meetings between firms and government rather than multiple stakeholder open meetings that renewable stakeholders usually participated in (Evans et al. 2015).

Also worthy of note during this period are various ‘non-executive’ appointments and advisory positions of individuals that seemed to have ties to the fracking industry. This included the chairman of Caudrilla Resources, Lord Browne becoming a non-executive director of the Cabinet Office – a brief which allowed him to influence senior appointments in the Treasury, DECC, and Defra (Leftly 2013). An ex-partner in the venture capital firm Riverstone, (which gave significant financial backing to the UK’s lead fracking firm Caudrilla), Ben Moxham became David Cameron’s energy advisor from 2012-2013 (Leftly 2013; Harvey 2013b). After Moxham stepped down, this position was filled by Tara Singh, a former lobbyist for fracking investor, Centrica (Davies 2015). Likewise the prominent fracking advocate John Loughhead (Science Media Centre 2012), was appointed as Chief Scientific Advisor to DECC (HM Government 2014b) and a non-executive director of BG who hold substantial fracking interests in the US who also held substantial interests in fracking, Baroness Hogg, was appointed as a non-executive director in the Treasury (Leftly 2013).

By Autumn 2015 through 2016 support for fracking was solidified with key policy interventions, summarised in Table 3.

Table 3: A UK policy mix for shale gas fracking

Policy area	Policy
Licensing	93 licenses granted by UK government for fracking across the UK
Planning & regulation	<p>Planning applications for fracking ‘fast tracked’ from local decision making to ‘nationally significant infrastructure’.</p> <p>Fracking allowed under national parks.</p> <p>Landmark decision sees <u>Sajid Javid</u> overturns the refusal by Lancashire county council of <u>Cuadrilla's</u> fracking application.</p> <p>The government changes trespass laws to allow underground access to oil and gas drilling companies.</p>
Financial incentives	<p>Enacting policies for councils to keep 100% of business rates from fracking developments</p> <p>Establishment of a ‘shale wealth fund’ to compensate local communities near shale sites.</p>

Sources: Authors’ compilation from (HM Government 2014c; Carrington 2014; Carrington 2015a; Perraudin 2015; HM Government 2015a; Vaughan 2015; Johnston 2016; Vaughan 2016)

3.3 A policy mix for nuclear power

In 2010, the UK government were solidifying ambitious National Policy Statements (NPS) for energy, including an NPS for nuclear outlining a proposed 16GW of new capacity (DECC 2011) constituting the most ambitious nuclear new build agenda in Europe (Vaughan 2009). However as these plans continued to be prepared, global nuclear power faced a major crisis when following a major earthquake a tsunami hit the East coast of Japan, disabling the cooling system of the Fukushima nuclear plant, leading to a triple meltdown. Unlike most other European countries however, the UK remained steadfast in its commitment to nuclear despite the accident. In the period of 2010-2015, new nuclear in the UK was significantly delayed with the final decision to proceed with Hinkley C only made in September 2016, around one year prior to when it had once been claimed Hinkley C would be operating in (Gosden 2015). Key investors pulled out of UK nuclear new build, and substantial cost increases ensued. Yet, across the political spectrum, the UK ‘consensus’ on nuclear in fact strengthened during this period. Here we see dynamics around wider concerns of British nuclear skills coming to the fore. The question is why there is such a priority around the issue of retaining nuclear skills in the UK rather than countries that have much more significant vested interest in global nuclear supply chains and more successful involvement in civilian nuclear new build?

Building on research elsewhere (Cox et al 2016), the wider security-related drivers of these concerns may be relevant. The potential for cross-fertilisation between defence and civil British nuclear skills were highlighted in a key report in 2009 entitled *Engineering the future*. Key stakeholders highlighted the potential skills shortage in nuclear engineering in the defence and civilian sectors, and pointed towards *synergies* and *collaboration* between civil and defence being crucial. These kind of links were arguably strengthened through important developments in UK nuclear during 2010-2015.

During this period concerns that originally emerged in 2004 onwards intensified. A number of Government-led reviews into nuclear skills (HM Government 2013; ONR 2015; BIS 2013a), government-commissioned reports (Bennet et al. 2011; Oxford Economics 2013) and industry-led interventions (NESA 2013; NIA 2012; Sherry 2011; NIRAB 2014) were produced highlighting the skills challenge and calling for increased policy intervention. Some of the most intense concerns around skills related to sustaining nuclear expertise related to the UK's renewal of the Trident nuclear weapons system, and most notably, those pertaining to the construction of UK submarines (Bennet et al. 2011).

Obtained through a Freedom of Information Request (FoI), the official Defence Risk Register by the MoD was disclosed, revealing grave concerns that the renewal of Trident was seriously at risk due the "*national nuclear engineering shortage*" and issues around the "*UK industrial base*" and "*erosion of manufacturing capability*" (Nuclear Information Service 2012). In the same year other important activities arose, with the Ministry of Defence signing a contract in excess of £1 billion for Rolls Royce to supply the reactor cores and propulsion systems for the new class of nuclear submarines (BBC News 2012b).

The UK commitment proceeded to publish a Nuclear Supply Chain action plan (HM Government 2012), outlining how the British supply chain could best be utilised in nuclear new build construction, and the development of an '*industrial strategy*' for the nuclear sector. This followed on the back of the House of Lords reports into nuclear research and development capabilities (House of Lords Science and Technology Select Committee 2011). The Cogent report on defence-related nuclear issues highlighted the issue that the lack of '*drumbeat*' between submarine orders, could mean that the crucial nuclear skills related to submarine construction could be lost (Bennet et al. 2011). As had been expressed by key stakeholders in the UK submarine construction supply chain entry into the civil nuclear market could become a crucial means through which these skills are maintained in order to construct the successor class of submarines (Innovation Universities Science and Skills Committee 2009).

In 2012, shortly after the 1£ billion MoD contract, Rolls Royce announced plans to engage in the UK's civil nuclear market (Harris 2012). A spokesman for Rolls Royce, outlined that "*We are actively pursuing opportunities in the UK new-build programme... This secures our ability to maintain [nuclear] skills within Rolls-Royce*" (Hampton quoted in Harris 2012). Strong interest also emerged during this time in commercially untested 'Small Modular Reactors (SMRS). This was an area previously highlighted as potentially valuable for defence involvement in civil nuclear supply chains due to the similarities between submarine reactors and SMRs (Innovation Universities Science and Skills Committee 2009). Rolls Royce announced in 2013 that it would be pursuing the development of SMRs (Rolls Royce 2013). A number of reports and policy activity related to SMRs were enacted during this period (Fairhall 2012; National Nuclear Laboratory 2014; Energy Technologies Institute 2015). Although there had been minimal interest in these commercially unproven technologies in government prior to this point, in the 2013 nuclear industrial strategy, the Government outlined the priority being given to the development of SMRs (BIS 2013b).

As governmental prioritisation around nuclear skills intensified and enthusiasm for SMRs emerged, an important FOI request highlighted that two employees of Rolls Royce worked in DECC on secondment during this crucial time. First, employed between February 2013 and April 2014 was a Rolls Royce employee with a specific focus on “*nuclear supply chain and skills*” (DECC 2015: 4), and between May 2014 and May 2015 another Rolls Royce employee was seconded to DECC in with the brief of “*nuclear development*” (p.6). This involvement of Rolls Royce at the centre of decision making on nuclear that coincides with a sudden enthusiasm for Small Modular Reactor design from Government is at least worthy of further attention.

In 2015 levels of support for nuclear increased with an unprecedented deal signed with China enabling them to invest in UK nuclear power (Broomby 2015). Coinciding with these decisions, it was announced that Rolls Royce would be awarded key contracts in the Hinkley C nuclear project as a ‘*preferred bidder*’ (BBC News 2015b). So, the policy mix for nuclear power that emerged in Autumn 2015 evolved through a remarkable period of governmental concern, prioritisation and policy effort into nuclear skills related both to defence and civil. Table 4 offers an overview of this policy mix.

Table 4: A UK policy mix for Nuclear power

Policy area	Policy
Legislation	Prime Minister David Cameron signing deal with China for investment in Hinkley C including permission for China to also build its own nuclear reactor at Bradwell in Essex.
R&D	£250 million of R&D announced for nuclear equalling half of all energy R&D for that 5 year period with particular focus on Small Modular Reactors (SMRs).
Financial incentives	Approval of a £2 billion loan guarantee for nuclear construction for Hinkley C.

Source: Authors’ compilation from (UK Government, 2015; World Nuclear Association, 2015; Gani, 2015)

The British chancellor George Osborne delivered his Autumn statement announcing the government’s “*commitment to Small Modular Reactors*” (Osborne 2015) with large investments of energy R&D into nuclear. Shortly after this statement, a competition for the development of SMRs was announced (HM Government 2016). Rolls Royce came forward as one of the key bidding teams as part of the SMR competition later basing their competitive advantage as resting on boosting the UK supply chain through building on existing submarine reactor construction expertise in the UK (Rolls Royce 2016). The benefits and synergies between the civil and defence sectors has increasingly been highlighted. For example in evidence submitted to the House of Lords highlighting the importance SMRs could play in “*...de-risking future defence programmes by sustaining UK engineering and design skills and jobs*” (House of Lords Science and Technology Select Committee 2017, written evidence PNT006, 334).

3.4: An emerging policy apparatus for incumbency

Taken together, the three distinct policy mixes described above—for renewables and energy efficiency, shale gas fracking, and nuclear power—result in a policy *apparatus for incumbency*. By apparatus, we mean a collection or integration of disparate policy mixes into an overall environment that restricts what incumbent interests hold to be undesirable change.

Before considering this emerging policy apparatus two considerations remain. First, is to question whether this is in fact an example of *destructive recreation*. In short, has the growth of UK renewables been harmed by the “policy reset” culminating in 2015? The second key question is, whether the activities described in the nuclear and fracking sections influenced the policy process or are ‘policy makers’ overseeing the policy apparatus for incumbency simply responding to a strong evidence base regarding the potential of fracking and nuclear to contribute to best contribute to the rationales of climate change mitigation, energy security, and low costs?

With regard to the first question, it can be noted that due to the perceived reduction in support for renewables and energy efficiency and increasing support for nuclear and fracking, the change of direction in energy policy has been described variously as “*bewildering*” (Carrington 2015b), “*confusing*” (Harvey 2015b), and “*baffling*” (Bennet 2015), with former US presidential nominee being “*puzzled*” by the 2015 policy reset (Harvey 2015a). Representatives from the renewables industry and environmental NGOs announced that this juncture could potentially damage parts of the renewable energy sector particularly solar and onshore wind and lead to lack of confidence and withdrawal of investment (Harrabin 2015a). The changes to onshore wind were criticised by the UN chief scientist who stated that it seemed the UK was moving away from renewables when the rest of the world was shifting towards them (Harrabin 2015b).

There are grave uncertainties around onshore wind and solar power in terms of their long-term future following the changes made in 2015 and 2016. Cuts to on shore wind support schemes only came into force in May 2016 so at the time of writing effects may not be clear and are developing, but some signs are emerging of the longer-term effects of the policy “reset” of 2015. For example, although during the short period where renewables had been substantially supported by the UK government between 2010-2015 the country had often topped the *renewable energy attractiveness index*, in 2016 the UK slid to 14th place, an all-time low (Recai 2016). The author of the report described that “*The [UK’s] current approach is going against the grain of almost universal global support for renewables*” (quoted in Harvey 2016b). Bloomberg Energy Finance (2016) claimed the changes made the UK seem “*unfriendly*” and investment in UK renewables was about to “*fall off a cliff*” (quoted in Bawden 2016); The Energy and Climate Change Committee and the Scottish Affairs Committee claimed that the changes “*spooked*” investors (Harrabin 2016; House of Commons Scottish Affairs Committee 2016).

A report indicated that 12,000 jobs have been lost in the solar industry in just one year as a result of the 2015 changes (PricewaterhouseCoopers 2016), and a report by the Green Alliance suggests a 95% reduction of investment in renewables in the UK by 2020 from 2016-17 levels (Green Alliance 2016). Further changes seem to be emphasising the destruction of small-scale renewables more recently. Proposals for charging business rates for rooftop solar installations is being considered which is expected to contribute to further reductions in uptake of solar installations (Stocker 2017). The government seems to be going through with the controversial sale of the Green Investment Bank (Mason 2017). The policy mix formed in 2015 then, potentially will have a serious effect on renewables in terms of investment at a time when costs were falling and rapid deployment were ‘*taking off*’.

However, there remains the question over whether fracking and nuclear may in fact provide a superior function in catering for the stated aims of UK energy policy. A key report by the Shale Gas Task Force found that shale gas had a crucial role to play as an “*interim base load energy source in the UK*” and that “*renewables cannot meet the UK’s short term energy needs*” (Task Force on Shale Gas 2015). In an important ministerial statement from DECC on the basis of this report it was stated that fracking is necessary because of the three pillars of UK energy strategy: “*keeping the lights on, keeping the bills down, and moving to a clean energy future*” (Leadsom 2015). Crucially this centres on the notion that fracking gas will be a crucial “bridging” technology towards renewables, playing a crucial function in replacing coal-fired generation set to end in 2025 (Mason 2015b). Similarly, nuclear is a low carbon technology and crucially was deemed necessary to ensure energy security and climate change mitigation “*significantly before 2025*” (DECC 2011). So the question is the extent to which the ‘creative’ policies towards fracking and nuclear are justifiable based on official rationales of government policy.

It is important to assess the evidence base then, for each technology in terms of meeting the three pillars of UK energy policy. In making such decisions, economics, international experience, historical experience, technological feasibility, and public opinion to which politicians may also legitimately respond, are all valid types of evidence that can be drawn on to evaluate the prospects of a certain technological trajectory meeting the criteria underpinning UK energy. In Tables 5-7, an overview of key evidence regarding fracking, nuclear and renewables are outlined.

Table 5: Fracking evidence base related to the three pillars of UK energy strategy.

Economics	“unknown” costs of UK shale production in the UK” (UKERC 2015)
Current International experience.	In Europe, a more comparable case for geological and regulatory reasons than the USA where fracking is a widespread activity, hopes for fracking have all but dissipated in almost every country except for the UK (Nelsen 2016). Currently no commercial fracking activity in Europe (Inman 2016).
Historical UK experience.	Limited onshore experience of Hydraulic fracturing in the UK however, 50 years of experience in the oil and gas sector more broadly.
Current knowledge on technical feasibility.	Deeply uncertain. There is currently limited fracking taking place in the UK and the main firm involved in UK fracking Caudrilla, admit that fracking is unlikely to be commercially operable until after 2030, which puts into question the ‘bridging’ argument in relation to the 2025 coal phase out.

Sustainability	Less CO ₂ emissions than coal but both the Climate Change Committee and UKERC state that continuing with fracking is likely to be incompatible with the UK's climate change goals (CCC 2016; Bradshaw et al 2014)
Public opinion	In the latest public tracker survey by DECC, only 19% of respondents supported Fracking (DECC 2016c), representing a 'new low' for public opinion on the technology. There is a widespread protest movement against Fracking in the UK.

Source: Authors' compilation.

Table 6: Nuclear evidence base related to the three pillars of UK energy strategy

Current economics	<p>Electricity price for new nuclear at £92.50/MWh, double the current market price for electricity with nuclear in the UK potentially the most expensive in the world (IEA-NEA 2015).</p> <p>Costs of nuclear new build in the UK have risen sharply from an original estimate of £18 billion for two EPR reactors, to £24 billion and potentially higher (Macalister 2016).</p> <p>In 2016 it was revealed that the government's own projected costs showed new nuclear to be more expensive than projected costs for solar or onshore wind (National Audit Office 2016; DECC 2016a).</p> <p>Globally, investors in UK nuclear including EDF and Toshiba facing significant financial difficulties putting in to question whether relying on such investments to provide future security of such investments for a considerable share of future energy production (Reuters 2017).</p>
Climate and broader sustainability issues	<p>Nuclear is a 'low carbon' technology and therefore can contribute to climate change mitigation.</p> <p>However the original rationale was that "...new nuclear power stations need to be developed significantly earlier than the end of 2025" (DECC</p>

	<p>2011: 7). With the final decision to proceed with Hinkley C being made only one year before the original completion date (Sky News 2016), the original stated 'need' is in doubt.</p> <p>The UK still has no site for the disposal of high - level radioactive waste, putting into doubt the broader sustainability credentials of this technology at present (Watson 2016).</p>
Current International experience.	<p>No Generation III or Small Modular reactor currently operating commercially anywhere in the world. All current Generation III are majorly over budget and behind schedule, with some projects cancelled (Goodall 2015; Wynn Kirby 2014; IAEA 2016)</p>
Historical experience.	<p>Consistent failures to meet announced capacity targets including 8 reactors announced in 1979 with only 1 built (Hansard 1979), the fast breeder reactor programme (Cochrane et al and the 1965 nuclear new build programme which did not meet projected capacity targets.</p> <p>Cost overruns, major technical difficulties, and accidents associated with UK nuclear infrastructures (Cox et al 2016).</p> <p>Recent economic challenges such as the failed experiment of privatising UK nuclear with the financial collapse of British energy in 2002 (Taylor 2007).</p>
Technical feasibility	<p>Current nuclear power contributes 19% to the UK electricity generating mix (DUKES 2016).</p> <p>At the time of writing there is no Generation III reactor of a European Pressurized Reactor (EPR) or AP1000 design that is operating anywhere in the world and all construction projects face serious delays and cost overruns (Green 2017).</p> <p>Small Modular Reactors commercially unproven.</p> <p>No Advanced Boiled Water Reactor (ABWR) construction taking place anywhere in the world</p>

	at present. Four ABWRs that operated in Japan pre-Fukushima beset by technical difficulties and low or fluctuating load factors (PRISM 2017); ABWR construction cancelled in Taiwan and projects abandoned in the USA. .
Public opinion	In the latest, DECC indicators survey, 36% of people answered that they were in favour of new nuclear power (DECC 2016c).

Source: Authors' compilation.

Table 7: Renewables evidence base related to the three pillars of UK energy strategy

Current economics	Onshore wind - £49-90/MWh Solar - £65-92/MWh Offshore wind - £81-132/MWh (DECC 2016d). Onshore cheaper than Hinkley C according to the government's own figures (DECC 2016d). Onshore wind the cheapest form of electricity production in the UK (Bawden 2017).
Current international experience	Investment in renewables outstripping investment in nuclear and fossil fuels combined. Rapidly falling costs of wind and solar worldwide (Frankfurt School-UNEP 2016).
Historical experience	Slow growth of renewables in UK during 1990s due to lack of policy support. Increasing growth due to Renewables Obligation during the 2000s. Rapid acceleration between 2010-2015 with introduction of new support mechanisms
Technological feasibility	In 2015 renewables, generated 25% of electricity compared to 8% in 2010 (Energy UK 2016; IEA 2017). So the technology shows reliable construction rates in recent times. The UK has the best wind and tidal resource in Europe
Public opinion	In the latest, DECC survey of public opinions of energy technologies 81% of respondents expressed support for renewables and only 4%

	were opposed to their development (DECC 2016c)
--	--

Source: Authors' compilation.

From this summary, it can be concluded that it is difficult to understand why there is such an intensity of support in the UK policy apparatus for fracking and nuclear at the behest of renewables from the perspective of officially stated rationales of the three pillars of UK energy policy.¹

It is also important to emphasize that the UK is an outlier in Europe both in relation to the intensity of its support for fracking and nuclear power. A few years ago, there was much hype surrounding the potential of a *“European shale gas revolution”* (Osterath 2015). However it is now even acknowledged by the European Gas Union that *“there will be no shale gas revolution in Europe”* (quoted in Anderson 2015). Many countries have banned or placed moratoriums on fracking activities (as noted in table 8). It has been noted that *“shale gas companies appear to have lost hope of an energy revolution in most countries in Europe”* (Nelsen 2016). A ‘nuclear renaissance’ in Europe was also widely anticipated (European Commission 2009). Yet following the major nuclear accident at Fukushima in Japan in 2011, Belgium, Germany, and Switzerland made decisions oriented towards nuclear phase out, with Scotland also strengthening its plan for discontinuing nuclear power. The UK is an exceptional case in the European context in terms of the scale of its commitment to new nuclear power ambitions. Tables 8 and 9 highlight the distinctiveness of UK energy policy.

Table 8: Nuclear energy policy mixes in the European Union

Nuclear Policy Mix	Country
Ambitious nuclear new build	UK
Tentative new build plans (1 or 2 reactors planned)	Bulgaria, Finland Hungary, Lithuania, Poland, Romania, France
Uncertain/ obfuscation	Netherlands, Spain Sweden
Phase-out/ discontinuation	Belgium, Germany, Switzerland Scotland
Abandonment of new build plans	Italy

¹ There is another argument however, that must be briefly discussed in relation to nuclear (a to a lesser extent fracking) and renewables. Even if nuclear may be considered more expensive than other low carbon alternatives, with major delays, unresolved waste issues, and a poor track history on many counts, it is often stated that nuclear is “essential” as a ‘baseload’ technology to keep the lights on (DECC 2013). However it is increasingly questioned whether the baseload model of electricity generation still has credibility. Although the notion still features prominently in justifications for the direction of UK policy making, the idea of ‘baseload’ is now widely contested with numerous peer-reviewed studies showing how near 100% renewables scenarios could be deployed rapidly and cost-effectively (European Renewable Energy Council 2010; Elliston et al. 2012; Krajačić, Duić & Carvalho 2011; Connolly et al. 2011; Krajačić, Duić, Zmijarević, et al. 2011; Ćosić et al. 2012; Mathiesen et al. 2011; Lund & Mathiesen 2009; Elliston et al. 2013; Delucchi & Jacobson 2011; Jacobson & Delucchi 2011; Elliot & Finney 2013). The attachment to this concept seems particularly strong in the UK context although this may be changing. The former head of the National Grid for example in 2015 stated that the idea of baseload was ‘outdated’ (Beckman 2015).

Source: Authors' compilation from (World Nuclear Association 2017).

Table 9: Shale gas fracking policy mixes in the European Union

Fracking Policy Mix	Country
Strong policy support for fracking	UK
remains legal but financial withdrawal from fracking activity	Spain, Denmark, Ireland, Poland, Ukraine, Lithuania, Belarus,
Fracking declared 'economically unviable'	Norway, Sweden
Heavily restricted	Germany, Austria
Bans or moratoriums on fracking	Belgium, Bulgaria, Czech Republic, France, The Netherlands, Scotland, Wales.

Source: Authors' compilation from (Nelson 2016; Imnan 2016)

To summarise, the UK seems to be pursuing a distinct energy policy in terms of a policy apparatus constituted by three policy mixes, where the *'destructive'* policies seem to be oriented towards some renewable and energy efficiency schemes, while the *'creative'* policies are oriented towards the incumbent technological trajectories of fracking and nuclear. Commentators note that *"the U.K. is often an energy outlier in the EU, advocating nuclear power and shale gas sources shunned by others"* (Stefanini 2016).

4. Incumbency, Democracy and Transitions

If both fracking and nuclear power are considered to be part of the incumbent sociotechnical regime in the UK energy sector, then it seems that the UK is a context where "regime resistance" has been particularly successful. It may be then, that crucial aspects through which incumbency is maintained and solidified are not so much related to strengths and weaknesses in a focal regime configuration, but broader pervasive dynamics of incumbency that were elaborate on here.

4.1 Strategies of Incumbency

Although it may be unique to the UK case, it is possible to identify some consistent patterns in the kinds of strategies utilized by incumbency in order to promote prior commitments shale gas fracking and nuclear power. Interestingly, while the net result is the same—an apparatus that constrains renewables but seeks to expand shale gas and nuclear power—there are meaningful variations within the incumbent policy mixes. We use the notions of *'securitization'*, *'masking'*, *'reinvention'*, and *'capture'* to describe these strategies—the underlying dynamics or mechanisms that help cement incumbency.

Figure 2: Visualizing strategies of incumbency in the UK energy sector

Masking



Hiding, socializing, or externalizing the full costs of an incumbent regime or sociotechnical system

Capture



Placing stakeholders with vested interests in positions of political or regulatory power

Reinvention



Changing the frame of an incumbent system or regime so that it appears new or innovative

Securitization



Connecting an incumbent to a pressing national security issue, topic, or compelling threat

Source: Authors.

The policy mix for nuclear power in the UK can be read as promoting the dual logics of *securitization* and *masking*. The strategy of securitization connects the national policy discourse of nuclear power with key national security threats and issues such as nuclear weapons and submarines, most notably Trident in terms of broader skills based concerns. While there are many forces at play in decision making, previous and ongoing research (Stirling and Johnstone forthcoming; Cox et al 2016; Johnstone & Stirling 2016; Stirling & Johnstone 2015) has augmented the picture in this study of securitization, in illuminating considerable further evidence that UK commitments to civil nuclear power are significantly driven by the desire to retain national capabilities to manufacture and operate nuclear-propelled submarines. Without the stealth, robustness and endurance of these formidable machines as platforms, UK nuclear weapons capabilities would be far less militarily credible – thus jeopardising the cherished status of a major global power and permanent member of the UN Security Council, “*punching above its weight*” on the world stage (Ross 2016).

A second strategy of incumbency is masking. The problem is that the costs of maintaining this military infrastructure and its associated research, skills, design, regulatory and industrial manufacturing capabilities, would simply be unaffordable on its own. After all, key parts of this highly sensitive industry cannot be contracted out to foreign suppliers. Nor are there significant direct international export markets for many of the highly specialised products. Without a large national civil nuclear programme, it would not be feasible to sustain this seemingly crucial part of a currently dominating form of UK political identity (House of Lords Defence Select Committee 2006). It is for this reason, that

a former senior executive in the lead firm for the UK nuclear submarine programme – the multinational defence contractor BAE Systems – acknowledged in a report for the Royal United Services Institute in 2007, that more should be made of established practice in other military markets (like aerospace), and the costs of nuclear submarine construction *masked* in civilian nuclear supply chains (Ireland 2007). As with other externalities – like nuclear waste, decommissioning and risks of nuclear accidents – the incentives to mask adverse aspects of nuclear commitments are evidently highly compelling.

Also serving to reinforce incumbency, the policy mix for shale gas displays its own forms of *masking*. Salient here are allegations reported in this study, that a crucial report by the Climate Change Committee was suppressed by government that contained data contrary to an expedient positive public image of shale gas—essentially concealing evidence concerning the unfavourable costs. But to this are added two subtly contrasting techniques: *reinvention* and *regulatory capture*. The strategy of reinvention involves active efforts by the natural gas industry and its associated regime to reframe a particular gas resource—shale—as a low-carbon, sustainable energy option. This was highlighted by the framing of fracking as crucial to bridging the low carbon gap by 2025, a rhetoric taken on board by key members of the ruling government to justify fracking. The final mode of incumbent strategic action that comes to the fore here, is the relatively well-known practice of regulatory capture: the entanglement of ostensibly independent regulatory agencies in the interests that they are supposed to be regulating. This is in keeping with a general propensity to ‘revolving doors’ dynamics, which even the UK Parliament has acknowledged to be a distinctive feature of UK policy cultures (House of Commons Public Administration Select Committee 2009; Wilks-Heeg 2015).

Issues of note here involve the use of ‘non-executive’ roles to insert fracking advocates directly into the heart of the Treasury detailed above. But it must be emphasised that rather than seeing this as a process of the state being lobbied by fracking companies, there is evidence that individuals with ties to fracking were placed in the centre of government itself through executive appointments. This combined with the high level rhetoric and media promotion pursued by leading members of the government, allude to notions that distinctions between government representing the public interest and private companies externally attempting to influence this public body are blurred – an increasing phenomenon that has been written about elsewhere (Beetham 2015). It seems UK energy incumbents hold few inhibitions – and are subject to relatively little restraints – in the opportunities afforded to regime resistance.

4.2 Incumbency, Transitions and Democracy

The characteristics of incumbency explored in this paper raise a number of potential implications for democracy in the widest sense. The evidence concerning the three policy areas examined in this paper raise serious questions over whether UK government decisions are being made on the basis of officially stated rationales. It is also evident that the obdurances of high-level UK policy commitments to natural gas and nuclear power are (when contrasted with other broadly comparable countries), to some significant extent characteristic of the UK polity taken as a whole. The boundaries of exactly what might constitute ‘sociotechnical regimes’ associated with provision of services from nuclear or gas technologies and resources, are evidently highly complex, dynamic, ambiguous – and dependent on context and perspective. Notional divides are blurred, between ‘incumbent actors’ and ‘policymakers’. Key mechanisms involved in the sustaining of incumbency in these fields tend to implicate agency, practices, institutions and interests outside these notional ‘regimes’ as much as they do those inside.

A question therefore arises concerning the specific implications of research around ‘policy mixes’ as a means to challenge sociotechnical incumbency and counter ‘regime resistance’? This is salient because (returning to the framing at the start of this paper), accelerating transitions in order to meet the increasingly challenging sustainability goals in which policy mixes focussed on destructive as well as creative policies no doubt play an important role, is unlikely to occur at the desired rate if wider incumbent interests remain unquestioned.

Any approach that seeks analytically to confine incumbency to a notionally discrete ‘regime’ (however bounded) may (to the extent described above) risk quite seriously missing some of the most important constituting processes that influence energy trajectories and strategies of incumbency discussed above (Stirling and Johnstone forthcoming). Categories apparently emerging from associated case studies may be more reflective of the subjects, than of the objects of scrutiny (Haraway, 2004). After all, if research aimed at challenging incumbency tends to address this phenomenon in terms that are more circumscribed than the phenomenon itself, then this analysis may be worse than simply ineffective. By neglecting crucial aspects of incumbency (whilst at the same time actively being presented as challenging it), such unduly constrained research may actually be counterproductive. Incumbency is rarely more reinforced than when it is rendered invisible.

The main point is that incumbency may be expected to be a bigger phenomenon than can be addressed in terms of ‘policy’ alone. If research is not itself to become (if unintentionally or unwittingly) an expedient instrument of justification and legitimation, then incumbency must be addressed as being not just about ‘policy’, but irreducibly also about politics in the broadest and deepest of senses (Swyngedouw, 2009; Žižek, 1999). As we noted, governance research tends to be preoccupied with apparently neat partitionings of ostensibly self-evident categories of ‘regime’, ‘level’, ‘niche’, ‘system’ or ‘function’ – of kinds that are arguably better recognised as expansive mutually-entangled configurations of relations and processes extending across an entire polity. Nowhere is this general point more acute than when the focus of attention is on incumbency itself.

But there does exist an obvious alternative basis for analysis and action. This arises in many expansive literatures on wider conditions of ‘post-politics’ and ‘democratic crisis’ that arguably encompass the specific dynamics of incumbency discussed here (Bühlmann et al., 2011; Crouch, 2004; Latour, 2007). Such dimensions are well recognised where research takes more sociologically-informed (Barnett & Bridge, 2013; Marres, 2007; Hendriks, 2009; Shove & Walker, 2007) or political-economic (Hess & Mai, 2014; Jhagroe & Loorbach, 2014) perspectives on the constituting of incumbency. And there are ways to formulate this very specifically in relation to the circumstances and dynamics of the energy sector (Stirling, 2014b). Both analytically and normatively, this basis for challenging incumbency of all kinds, lies – purely and simply – in overtly political forms of democratic struggle (Johnstone & Stirling 2015b; Stirling and Johnstone forthcoming).

At root, then, incumbency of all kinds may be seen (in the general sense defined in the present paper), to be about concentration of power. And if power is understood relationally and processually (and in all its multifarious dimensions and contexts) as *‘asymmetrically structuring agency’* (Stirling 2014), then it can readily be observed that these concentrations take place not just around set-piece categories like ‘the regime’ and ‘the niche’, but in fractal rhizomic patterns at every scale of political analysis or social action (Stirling 2016). To order analysis with ostensibly neat ‘levels’ or ‘phases’ may allow felicitous academic stories and provide instrumental political resources. But this risks subordinating the messy realities of power to the simpler expediencies of justification. With democratic struggle instead to the fore – both analytically and normatively - the response to incumbency can be recognised as being at least as straightforward and operational as any of the alternative theoretical categories.

The challenging of incumbency around commitments like shale gas and nuclear power, then, does not have to be all about polite policy etiquettes in which ostensibly neutral decision-makers are respectfully petitioned to deliver top-down programmes in the form of depoliticised policy mixes. This can at the same time provide important legitimacy resources for sustaining precisely the larger-scale patterns of incumbency that give rise to these commitments in the first place. Such instrumental dynamics can play out at every political level, geographical scale and temporal timeframe. If these dangers of circumscribed policy-analytic approaches are to be avoided, what is required is a new form of more holistic analysis, whose aim is not to inform orderly policy interventions – even in the form of ‘policy mixes’ – but holds instead the ‘goal of invigorating unconstrained, unruly democratic struggle’ (Stirling 2016; Stirling and Johnstone, forthcoming).

5. Conclusions

Using a variety of theories from political science, institutional theory, innovation studies, science and technology studies (STS), and building around notions of *deep incumbency* developed elsewhere (Cox et al. 2016)(Stirling and Johnstone forthcoming), this study offers a more relational understanding of the intersection of incumbency, policy mixes, and a policy apparatus. This understanding takes into account broader political, institutional and cultural dynamics, such as those evidenced in the UK. Comprehending the different ways through which patterns of incumbency around particular technologies are reproduced, helps reveal some of the less considered actors, locations, and motivations of particular networks of incumbency which appear to transcend various categorisations of particular sectors or policy domains as well as the conventional dividing lines between ‘industry’ and ‘policymakers’.

Rather than thinking of policy mixes being ‘selected’ by ostensibly responsive and neutral policymakers, we have demonstrated that policy making actors and structures themselves are arguably subsumed in seamlessly deeper and wider ‘multiplex’ of ‘deep incumbency’ that transcends any particular sociotechnical regime – evidently extending far more widely across different sectors of governance and penetrating the deepest levels of the State. Moreover, we have sketched four different strategies that incumbent actors utilize to promote their agendas: by recasting their goals in terms of national security (*‘securitization’*), obscuring the full social or economic costs of a regime (*‘masking’*), reframing an old or polluting technology as new or innovative (*‘reinvention’*), or placing incumbent stakeholders in positions of political or regulatory power (*‘capture’*).

In this light, it seems that the countering of regime resistance may require interventions that go far beyond the domesticated policy repertoires of sustainability transitions studies or policy mix theory – to implicate the main political institutions, cultures and arenas of contemporary polities. Rhizomically penetrating in unscaled ways through the matrix of governance processes as a whole, the daunting political loads entailed in disembedding of entrenched sociotechnical incumbencies evidently require equally profoundly grounded cultural pivots and institutional levers. At a time when this is arguably under its greatest threat for many decades, what seems to be indispensable (but sadly neglected in much theorising) is the full engagement of democracy itself.

6. Acknowledgements

This work was supported by ESRC Grant RES-588-28-0001 (The STEPS Centre), the RCUK Energy Program Grant EP/K011790/1 (Center on Innovation and Energy Demand), and “Smart Energy Transitions” (Academy of Finland, grant no. 293405). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the ESRC, RCUK, or the Academy of Finland. Also, although one of the authors of this paper is an editor for *Energy Research & Social Science*, he was not involved in managing the peer review or editorial process for this article.

7. References

- Anderson, R., 2015. No shale gas revolution in Europe. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/business-32993104> [Accessed June 3, 2015].
- Andrews-Speed, P., 2015. Applying institutional theory to the low-carbon energy transition. *Energy Research and Social Science*, 13, pp.216–225.
- Arthur, W., 1994. *Increasing Returns and Path-dependency in the Economy*, Ann Arbor: University of Michigan Press.
- Arthur, W.B., 1989. “Competing Technologies, Increasing Returns, and Lock-in by Historical Events.” *The Economic Journal*, 99(394), pp.116–131.
- Augenstein, K. & Palzkill, A., 2016. The Dilemma of Incumbents in Sustainability Transitions: A Narrative Approach. *Administrative Sciences*, 6(1), p.1.
- Avelino, F., 2011. *Power in transition: Empowering Discourses on Sustainability Transitions*. Netherlands: University of Rotterdam.
- Balch, O., 2015. Energy co-ops: why the UK has nothing on Germany and Denmark. *The Guardian Online*. Available at: <https://www.theguardian.com/public-leaders-network/2015/oct/02/energy-cooperatives-uk-germany-denmark-community>.
- Barnett, A., 2010. Is there a UK “deep state”? *Open Democracy*, July, pp.2–4.
- Bawden, T., 2016. UK renewable energy industry is about to “fall off a cliff”, says new research. *The Independent online*. Available at: <http://www.independent.co.uk/news/uk/home-news/britains-renewable-energy-industry-is-about-to-fall-off-a-cliff-says-new-research-a6818186.html>.
- BBC News, 2011. Fracking tests near Blackpool “likely cause” of tremors. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/uk-england-lancashire-15550458> [Accessed July 12, 2016].

- BBC News, 2012a. Renewable energy: Onshore wind subsidy to be cut by 10%. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/business-18979330> [Accessed July 12, 2016].
- BBC News, 2012b. Rolls-Royce awarded £1bn contract for UK nuclear submarines. *BBC News webpages*. Available at: <http://www.bbc.co.uk/news/uk-18491299> [Accessed June 18, 2012].
- BBC News, 2015a. Earlier end to onshore wind subsidies. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/business-33177025> [Accessed December 18, 2016].
- BBC News, 2015b. Rolls-Royce in line for big Hinkley nuclear contracts. *BBC News webpages*. Available at: <http://www.bbc.co.uk/news/business-34342784> [Accessed January 12, 2017].
- Beckman, K., 2015. Head of UK's National Grid says "idea of large power stations for baseload is outdated." *Renewable Economy*.
- Beetham, D., 2015. Moving beyond a narrow definition of corruption. In Whyte, D (ed). *How Corrupt is Britain?* University of Chicago Press: Chicago. pp 41-46
- Bennet, P., 2015. "Bafflingmistake" which "flies in the face of common sense": Industry reacts to onshore RO plans. *Solar Portal website*. Available at: http://www.solarpowerportal.co.uk/news/baffling_mistake_which_flies_in_the_face_of_common_sense_industry_reacts_34 [Accessed January 5, 2017].
- Bennet, S. et al., 2011. *The Renaissance series 3: Skills for Nuclear Defence*, London: COGENT.
- Berkhout, F., Smith, A. & Stirling, A., 2004. Socio-technical Regimes and Transition Contexts. In B. Elzen, F. W. Geels, & K. Green, eds. *System Innovation and the Transition to Sustainability: Theory, Evidence, and Policy*. Cheltenham: Edward Elgar, pp. 48–75.
- BIS, 2013a. *The UK 's Nuclear Future*, London: London. The Stationary Office.
- Borrás, S. & Edquist, C., 2013. The choice of innovation policy instruments. *Technological Forecasting and Social Change*, 80(8), pp.1513–1522.
- Bosman, R., Loorbach, D. & Frantzeskaki, N., 2014. Environmental Innovation and Societal Transitions Discursive regime dynamics in the Dutch energy transition. *Environmental Innovation and Societal Transitions*, 13, pp.45–59.
- Bradshaw, M. Bridge, G. Bouzarovski, S. Watson, J. Dutton, J. 2014. *The UK s Global Gas Challenge - Research Report*, London. UKERC.
- Brondizio, E.S., Ostrom, E. & Young, O.R., 2009. Connectivity and the Governance of Multilevel Social-Ecological Systems: The Role of Social Capital. *Annual Review of Environment and Resources*, 34(1), pp.253–278.
- Bromley, P.S., 2016. Extraordinary interventions: Toward a framework for rapid transition and deep emission reductions in the energy space. *Energy Research and Social Science*, 22, pp.165–171.
- Broomby, R., 2015. Questions about UK scrutiny of Chinese nuclear tie-up. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/uk-politics-30778427> [Accessed January 15, 2015].
- Cairney, P., 2015. *Policy and policy making in the UK*, Available online at: <https://paulcairney.wordpress.com/policymaking-in-the-uk/>.
- Cameron, D., 2014. We cannot afford to miss out on shale gas. *The Daily Telegraph*. Available at: <http://www.telegraph.co.uk/news/politics/10236664/We-cannot-afford-to-miss-out-on-shale-gas.html>.

Carrington, D., 2016. Fracking “will break UK climate targets unless rules are made stricter.” *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2016/jul/07/fracking-uk-climate-targets-rules-stricter>

Carrington, D., 2015a. George Osborne urges ministers to fast-track fracking measures in leaked letter. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/jan/26/george-osborne-ministers-fast-track-fracking>.

Carrington, D., 2015b. Government finally admits it is subsidising nuclear - while cutting help for renewables. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/damian-carrington-blog/2015/oct/22/hinkley-point-uk-energy-policy-is-now-hunkering-in-a-nuclear-bunker>.

Carrington, D., 2014. Fracking trespass law changes move forward despite huge public opposition. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2014/sep/26/fracking-trespass-law-changes-move-forward-despite-huge-public-opposition>.

Carrington, D., 2013a. Budget 2013: George Osborne commits to UK shale gas boom. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2013/mar/20/budget-2013-george-osborne-shale-gas-boom>.

Carrington, D., 2013b. Lord Browne: fracking will not reduce UK gas prices. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2013/nov/29/browne-fracking-not-reduce-uk-gas-prices-shale-energy-bills>.

Carrington, D., 2011. George Osborne reveals his true colours on emissions – and they aren’t green. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/damian-carrington-blog/2011/oct/03/george-osborne-carbon-emissions-conservatives>.

Certomà, C. & Tornaghi, C., 2016. Political gardening . Transforming cities and political agency. , 9839(April).

Chandy, R.K. & Tellis, G.J., 2000. The Incumbent’s Curse? Incumbency, size and radical product innovation. *Journal of Marketing*, 64, pp.1–17.

Climate knowledge hub, 2016. Renewable energy support policies in Europe. *Climate knowledge hub website*. Available at: <http://climatepolicyinfohub.eu/renewable-energy-support-policies-europe> [Accessed January 1, 2017].

Coenen, L., Benneworth, P. & Truffer, B., 2012. Toward a spatial perspective on sustainability transitions. *Research Policy*, 41(6), pp.968–979.

CCC, 2014. *Energy prices and bills – impacts of meeting carbon budgets*, London: Committee on Climate Change. Available at: http://hmccc.s3.amazonaws.com/ENERGYbill12/1672_CCC_Energy-Bills_bookmarked.pdf.

CCC, 2016. *Onshore Petroleum: the compatibility of UK onshore petroleum with meeting the UK’s carbon budgets*, London: Committee on Climate Change.

Connolly, D. et al., 2011. The first step towards a 100% renewable energy-system for Ireland. *Applied Energy*, 88(2), pp.502–507.

Conservative Party, 2015. *The Conservative Party Manifesto 2015*, London: The Conservative Party.

- Ćosić, B., Krajačić, G. & Duić, N., 2012. A 100% renewable energy system in the year 2050: The case of Macedonia. *Energy*, 48(1), pp.80–87.
- Cox, E., Johnstone, P. & Stirling, A., 2016. *SWPS 2016-16 (September) Understanding the Intensity of UK Policy Commitments to Nuclear Power*, Brighton.
- Davies, H., 2015. Cameron gives top job to oil man ahead of major climate talks. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/sep/17/cameron-gives-top-environment-policy-job-to-oil-man-ahead-of-major-climate-talks>
- DECC, 2016a. new direction for UK energy policy. *Department for Energy and Climate Change webpages*. Available at: <https://www.gov.uk/government/news/new-direction-for-uk-energy-policy> [Accessed March 16, 2016].
- DECC, 2016b. *Hinkley C Value for Money Argument*, London. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/556917/3_-_Value_for_Money_Assessment.pdf
- DECC, 2016c. *Public Attitudes Tracker – Wave 17*, London. Available at: <https://www.gov.uk/government/statistics/public-attitudes-tracking-survey-wave-17>
- DECC, 2015. RE: Freedom of Information request – 15/02666. *Department of Energy and Climate Change response to Freedom of Information request – 15/02666*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409310/02666.pdf [Accessed January 6, 2017].
- DECC, 2014. DECC appoints new chief scientific advisor. *DECC webpages*. Available at: <https://www.gov.uk/government/news/decc-appoints-new-chief-scientific-advisor> [Accessed October 12, 2016].
- DECC, 2013. *Leading the way; the UK's new nuclear renaissance*, London. Available at: <https://www.gov.uk/government/speeches/leading-the-way-the-uks-new-nuclear-renaissance>
- DECC, 2011. *National Policy Statement for Nuclear Power Generation (EN-6) Volume I of II*, London: The Stationary Office.
- Deleuze, G. & Guattari, F., 1987. *A Thousand Plateaus: capitalism and schizophrenia*, Minneapolis: University of Minnesota Press.
- Delucchi, M.A. & Jacobson, M.Z., 2011. Providing all global energy with wind, water, and solar power, Part II: Reliability, system and transmission costs, and policies. *Energy Policy*, 39(3), pp.1170–1190.
- Doward, J., 2013. Energy bills rise by 37% in three years. *The Guardian Online*. Available at: <https://www.theguardian.com/money/2013/nov/16/energy-prices-rise>.
- ECCC, 2016. *2020 Renewable Heat and Transport Targets*, London: The Stationary Office, Crown Copyright.
- Edgerton, D., 2006. *Warfare State: Britain, 1920-1970*, Cambridge: Cambridge Univ Press.
- Elliot, D. & Finney, D., 2013. *Pathways to 2050 : Three possible UK energy strategies: high renewables pathway*, London: British Pugwash.
- Elliston, B., Diesendorf, M. & MacGill, I., 2012. Simulations of scenarios with 100% renewable electricity in the Australian National Electricity Market. *Energy Policy*, 45, pp.606–613. Available at: <http://dx.doi.org/10.1016/j.enpol.2012.03.011>.

- Elliston, B., MacGill, I. & Diesendorf, M., 2013. Least cost 100% renewable electricity scenarios in the Australian National Electricity Market. *Energy Policy*, 59, pp.270–282. Available at: <http://dx.doi.org/10.1016/j.enpol.2013.03.038>.
- Elster, J., 2007. *Explaining Social Behaviour: more nuts and bolts for the social sciences*, Cambridge: Cambridge Univ. Press.
- Energy Technologies Institute, 2017. *System Requirements For Alternative Nuclear Technologies*, Brighton. Available at: http://www.eti.co.uk/wp-content/uploads/2015/10/ANT-Summary-Report_ETI-website.pdf.
- Energy UK. 2017. Electricity Generation. Available at: <http://www.energy-uk.org.uk/energy-industry/electricity-generation.html>
- European Commission, 2015. *Energy Union Package: A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy*, Brussels. Available at: http://ec.europa.eu/priorities/energy-union/docs/energyunion_en.pdf.
- European Commission, 2009. *Preparing Europe for a New Renaissance A Strategic View of the European Research Area*, Brussels: European Commission.
- European Renewable Energy Council, 2010. *Rethinking 2050: an 100% Renewables Vision*, Brussels: EREC.
- Evans, R. Bengsston, H. Carrington, D. Howards, E. , 2015. Shell and BP alone eclipse renewable energy sector on access to ministers. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/apr/28/fossil-fuel-lobby-given-far-more-access-to-uk-ministers-than-renewables-analysis>.
- Fairhall, G., 2012. *Small Modular Reactors Their potential role in the UK*, Warrington.
- Farla, J. et al., 2012. Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change*, 79(6), pp.991–998.
- Finon, D. & Midttum, A., 2005. *Reshaping European Gas and Electricity Industries: regulation markets and business strategies*, Amsterdam: Elsevier.
- Fischer, L. & Newig, J., 2016. Importance of Actors and Agency in Sustainability Transitions : A Systematic Exploration of the Literature.
- Flanagan, K., Uyarra, E. & Laranja, M., 2011. Reconceptualising the “policy mix” for innovation. *Research Policy*, 40, pp.702–713.
- Fouquet, R., 2016. Historical energy transitions: Speed, prices and system transformation. *Energy Research and Social Science*, 22, pp.7–12.
- Fraenkel, E., 2010. *The Dual State: A Contribution to the Theory of Dictatorship*. Lawbook Exchange.
- Frankfurt School-UNEP, 2016. *Global Trends in Renewable Energy*, Frankfurt: Frankfurt School of Finance and Management gGmbH 2016. Available at: <http://www.unep.org/pdf/GTR-UNEP-FS-BNEF2.pdf>.
- Fuenfschilling, L. & Truffer, B., 2014. The structuration of socio-technical regimes—Conceptual foundations from institutional theory. *Research Policy*, 43(4), pp.772–791.
- Gani, A., 2015. Xi Jinping signs nuclear deal as UK and China clinch £40bn of contracts. *The Guardian Online*.

- Geels, F.W., 2014. Regime Resistance against Low Carbon Transitions: introducing politics and power into the multi-level perspective. *Theorym Culture and Society*, 31 (5), pp.21-40.
- Geels, F.W., 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, 39(4), pp.495–510.
- Geels, F.W., 2009. Foundational ontologies and multi-paradigm analysis, applied to the socio-technical transition from mixed farming to intensive pig husbandry (1930–1980). *Technology Analysis & Strategic Management*, 21(7), pp.805–832.
- Geels, F.W. & Kemp, R., 2007. Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. *Technology in Society*, 29(4), pp.441–455.
- Geels, F.W. & Schot, J., 2007. Typology of sociotechnical transition pathways. *Research Policy*, 36(3), pp.399–417.
- Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6–7), pp.897–920.
- Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, 31(8–9), pp.1257–1274.
- Glachant, J.-M., Finon, D. & Pahle, M., 2010. Germany's dash for coal: Exploring drivers and factors. *Energy Policy*, 38(7), pp.3431–3442.
- Glennon, M.J., 2015. *National Security and Double Government*. Oxford: Oxford University Press.
- Goodall, C., 2015. Nugen's AP1000 nuclear reactor - is it any better than the EPR? *The Ecologist*.
- Gosden, E., 2015. Hinkley C new nuclear plant: the story so far. *The Daily Telegraph online*. Available at: <http://www.telegraph.co.uk/business/0/hinkley-point-c-new-nuclear-plant-timeline-of-the-story-so-far/> [Accessed 5th January 2017]
- Gosden, E., 2013. Fracking won't lower energy bills, says Davey. *The Daily Telegraph*. Available at: <http://www.telegraph.co.uk/news/earth/energy/fracking/10296274/Fracking-wont-lower-energy-bills-says-Davey.html>. [Accessed 4th January 2017]
- Green, J., 2017. Not just Toshiba - the global nuclear industry is in crisis everywhere. *the Ecologist*. Available at: http://www.theecologist.org/News/news_analysis/2988607/not_just_toshiba_the_global_nuclear_industry_is_in_crisis_everywhere.html [Accessed February 3, 2017].
- Green Alliance, 2016. *The UK's infrastructure priorities: Private sector divestment from high carbon assets is not being matched by investment in low carbon*, London: Green Alliance.
- Grin, J., Rotmans, J. & Schot, J., 2011. On patterns and agency in transition dynamics: Some key insights from the KSI programme. *Environmental Innovation and Societal Transitions*, 1(1), pp.76–81.
- Grover, W.F. & Peschek, J.G., 2014. *The Unsustainable Presidency: Clinton, Bush, Obama and beyond*.
- Hall, S., Foxon, T.J. & Bolton, R., 2016. Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom. *Energy Research and Social Science*, 12, pp.5–15.
- Harrabin, R., 2016. Renewables subsidy cuts could increase energy bills. *BBC News Online*. Available

- at: <http://www.bbc.co.uk/news/business-35706645> [Accessed January 1, 2016].
- Harrabin, R., 2015a. UK energy policy “deters investors.” *BBC News Online*. Available at: <http://www.bbc.co.uk/news/business-34786128> [Accessed January 1, 2017].
- Harrabin, R., 2015b. UN scientist Jacquie McGlade raps UK over renewables. , (October).
- Harrabin, R., 2014. Ministers’ shale gas “hype” attacked. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/uk-politics-30013668> [Accessed June 12, 2016].
- Harris, S., 2012. Rolls-Royce looks to civil nuclear after MoD contract. *The Engineer*. Available at: <https://www.theengineer.co.uk/issues/june-2012-online/rolls-royce-looks-to-civil-nuclear-after-mod-contract/> [Accessed March 12, 2015].
- Hartung, W.D., 2011. *Prophets of War: Lockheed Martin and the making of the military industrial complex*. New York: National Books.
- Harvey, F. 2016a. Pressure mounts over ‘suppression’ of UK fracking impacts report. *The Guardian online*. Available at: <https://www.theguardian.com/environment/2016/jun/14/pressure-mounts-over-suppression-of-uk-fracking-impacts-report>
- Harvey, F., 2016b. UK’s attractiveness for renewables investment plummets to all-time low. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2016/may/10/uks-attractiveness-for-renewables-investment-plummets-to-all-time-low>.
- Harvey, F., 2015a. Al Gore puzzled by UK cuts to renewable energy support. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/sep/22/al-gore-puzzled-by-ukcuts-to-renewable-energy-support> [Accessed September 22, 2016].
- Harvey, F., 2015b. Confusing government policy biggest threat to UK clean energy, says top academic. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/oct/05/confusing-government-policy-biggest-threat-to-uk-clean-energy-says-top-academic>.
- Harvey, F., 2011. Autumn statement: George Osborne slams “costly” green policies. *The Guardian Online*. Available at: <https://www.theguardian.com/uk/2011/nov/29/autumn-statement-george-osborne-green-policies>
- Healy, D., 2012. *Hydraulic fracturing or ‘fracking’: a short summary of current knowledge and potential impacts*. Environmental Protection Agency. London.
- Hess, D.J., 2015. The politics of niche-regime conflicts: Distributed solar energy in the United States. *Environmental Innovation and Societal Transitions*, 19, pp.42–50.
- Hess, D.J., 2016. *Undone Science: social movements, mobilized publics, and industrial transitions*, Cambridge MA: MIT Press.
- Hilgartner, S., 2000. *Science on stage : expert advice as public drama*, Stanford, Calif.: Stanford University Press.
- Hogan, M.J., 1998. *A Cross of Iron: Harry S. Truman and the origins of the national security state, 1945-1954*, Cambridge: Cambridge University Press.
- HM Government, 2016. Small Modular Reactors Competition Phase One. *HM Government Webpages*. Available at: <https://www.gov.uk/government/publications/small-modular-reactors-competition-phase-one> [Accessed March 17, 2016].

HM Government, 2015a. New onshore oil and gas licences offered. *UK Government websites*. Available at: <https://www.gov.uk/government/news/new-onshore-oil-and-gas-licences-offered> [Accessed December 17, 2016]

HM Government, 2015b. £2 billion support for Hinkley Point. *UK Government webpages*. Available at: <https://www.gov.uk/government/news/2-billion-support-for-hinkley-point-c> [Accessed January 10, 2017].

HM Government, 2014a. Government proposals to simplify deep underground access for shale gas and geothermal industries. *HM Government webpages*. Available at: <https://www.gov.uk/government/news/government-proposals-to-simplify-deep-underground-access-for-shale-gas-and-geothermal-industries>.

HM government, 2014b. DECC appoints new scientific advisor. *HM Government Webpages*. Available at; <https://www.gov.uk/government/news/decc-appoints-new-chief-scientific-advisor>

HM Government, 2014c. Local councils to receive millions in business rates from shale gas developments. *UK Government webpages*. Available at: <https://www.gov.uk/government/news/local-councils-to-receive-millions-in-business-rates-from-shale-gas-developments> [Accessed December 5, 2016].

HM Government, 2013. *A Review of the Civil Nuclear R & D Landscape in the UK*, London.

HM Government, 2012. *The Nuclear Supply Chain Action Plan*, London.

House of Commons Public Administration Select Committee, 2009. *Lobbying: Access and influence in Whitehall*, London: The Stationary Office. Available at: <http://www.publications.parliament.uk/pa/cm200809/cmselect/cmpubadm/36/36i.pdf>.

House of Commons Scottish Affairs Committee, 2016. *The renewable energy sector in Scotland: First Report of Session 2016-17*, The Stationary Office: London, Crown Copyright. Available at: http://www.uneca.org/sites/default/files/PublicationFiles/renewable_energy_sector_in_north_africa_en_0.pdf.

House of Lords Science and Technology Select Committee, 2017. *Nuclear research and technology: breaking the cycle of indecision, oral and written evidence*. The Stationary Office: London, Crown Copyright. Available at: <https://www.parliament.uk/documents/lords-committees/science-technology/Nuclear-research-technologies/Nuclear-research-technologies-evidence.pdf>

House of Lords Science and Technology Select Committee, 2011. *Nuclear Research and Development Capabilities*,

IAEA, 2017. PRIS Reactor Database. *IAEA Reactor Database*. Available at: <https://www.iaea.org/PRIS/home.aspx> [Accessed July 12, 2016].

IEA 2017. UK energy Statistics. Available at: <http://www.iea.org/statistics/>

IEA, 2016. *Energy Technology Perspectives 2016*, Paris. Available at: <https://www.iea.org/newsroom/news/2016/june/etp2016-cities-are-in-the-frontline-for-cutting-carbon-emissions.html>.

IEA-NEA, 2015. *Projected Costs of Generating Electricity*, Paris: International Energy Agency & the Nuclear Energy Agency.

- IIASA, 2012. *Global Energy Assessment: towards a sustainable future*, Cambridge: Cambridge University Press.
- Inman, M., 2016. Can fracking power Europe? *Nature*, 531, pp.22–24.
- Innovation Universities Science and Skills Committee, 2009. *Engineering the future: turning ideas into reality*, London: The Stationary Office.
- Ireland, G., 2007. Beyond artful: *The Challenges Facing the UK Submarine Base*. London: RUSI.
- Jacobson, M.Z. & Delucchi, M.A., 2011. Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials. *Energy Policy*, 39(3), pp.1154–1169.
- Johnson, B., 2012. Ignore the doom merchants, Britain should get fracking. *The Daily Telegraph*. Available at: <http://www.telegraph.co.uk/comment/columnists/borisjohnson/9733518/Ignore-the-doom-merchants-Britain-should-get-fracking.html>.
- Johnston, I., 2016. Fracking allowed in Lancashire in landmark Government ruling. *The Independent*. Available at: <http://www.independent.co.uk/news/uk/home-news/fracking-lancashire-cuadrilla-sajid-javid-planning-permission-overturned-a7347576.html>.
- Jefferson, M., 2008. Accelerating the transition to sustainable energy systems. *Energy Policy*, 36(11), pp.4116–4125.
- Johnstone, P. & Stirling, A., 2015a. Comparing Nuclear Power Trajectories in Germany And the UK : From “ Regimes ” to “ Democracies ” in Sociotechnical Transitions and Discontinuities. *SPRU Working Paper Series (SWPS)*, 18, pp.1–86. Available at: www.sussex.ac.uk.
- Johnstone, P. & Stirling, A., 2015b. *Comparing Nuclear Power Trajectories in Germany and the UK: from “regimes” to “democracies” in sociotechnical transitions and discontinuities*, Brighton: Science Policy Research Unit, University of Sussex.
- Karltorp, K. & Sandén, B., 2012. Explaining regime destabilisation in the pulp and paper industry. *Environmental Innovation and Societal Transitions*, 2, pp.66–81.
- Kemp, R., Schot, J. & Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, 10(2), pp.175–198.
- Kern, F. & Rogge, K.S., 2016. The pace of governed energy transitions: Agency, international dynamics and the global Paris agreement accelerating decarbonisation processes? *Energy Research and Social Science*, 22, pp.13–17.
- Kern, F. et al., 2014. From laggard to leader: Explaining offshore wind developments in the UK. *Energy Policy*, 69, pp.635–646.
- Khanam, T. Rahman, A. Mola-Yudego, B. Pelkonen, P. Perez, Y. Pykäläinen, J. 2017 Achievable or unbelievable? Expert perceptions of the European Union targets for emissions, renewables, and efficiency, *Energy Research & Social Science*, 34, pp 144-153
- Kivimaa, P. & Kern, F., 2015. *Creative Destruction or Mere Niche Creation ? Innovation Policy Mixes for Sustainability Transitions*, Brighton.
- Kivimaa, P. & Kern, F., 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Research Policy*, 45(1), pp.205–217.
- Klitkou, A. et al., 2015. The role of lock-in mechanisms in transition processes: The case of energy for

- road transport. *Environmental Innovation and Societal Transitions*, 16, pp.22–37.
- Krajačić, G., Duić, N., Zmijarević, Z., et al., 2011. Planning for a 100% independent energy system based on smart energy storage for integration of renewables and CO2 emissions reduction. *Applied Thermal Engineering*, 31(13), pp.2073–2083.
- Krajačić, G., Duić, N. & Carvalho, M. da G., 2011. How to achieve a 100% RES electricity supply for Portugal? *Applied Energy*, 88(2), pp.508–517.
- Kungl, G., 2015. Stewards or sticklers for change? Incumbent energy providers and the politics of the German energy transition. *Energy Research and Social Science*, 8, pp.13–23. Available at: <http://dx.doi.org/10.1016/j.erss.2015.04.009>.
- Kuzemko, C., 2014. Depoliticisation , Institutions and Political Capacity : Explaining Sedate Energy Transition in the UK. , (April).
- Kuzemko, C. et al., 2016. Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research and Social Science*, 12, pp.96–105.
- Lauber, V. & Sarasini, S., 2011. The responses of incumbent utilities to the challenge of renewable energy. In B. Sandén, ed. *System Perspectives on renewable power*. Göteborg: Chalmers University of Technology, pp. 393–403.
- Leadsom, A., 2016. Andrea Leadsom speech to Utility Week Energy Summit. *Gov.UK Webpages*. Available at: <https://www.gov.uk/government/speeches/andrea-leadsom-speech-to-utility-week-energy-summit> [Accessed July 6, 2016].
- Leadsom, A., 2015. Shale gas – an inconvenient truth for the anti-fracking lobby. *Department of Energy and Climate Change websites*. Available at: <https://decc.blog.gov.uk/2015/09/23/shale-gas-an-inconvenient-truth-for-the-anti-fracking-lobby/> [Accessed January 1, 2015].
- Leftly, M., 2013. Revealed: Fracking industry bosses at heart of coalition. *The Independent online*. Available at: <http://www.independent.co.uk/news/uk/politics/revealed-fracking-industry-bosses-at-heart-of-coalition-8707589.html>.
- Loorbach, D., 2014. *To Transition! Governance panarchy in the new transformation*. Rotterdam. DRIFT Research Institute.
- Lund, H. & Mathiesen, B. V., 2009. Energy system analysis of 100% renewable energy systems-The case of Denmark in years 2030 and 2050. *Energy*, 34(5), pp.524–531.
- Macalister, T., 2016. Hinkley Point: new UK chancellor determined to start building. *The Guardian Online*. Available at: <https://www.theguardian.com/uk-news/2016/jul/14/hinkley-point-c-new-uk-chancellor-determined-start-building-philip-hammond>.
- Macalister, T. & Harvey, F., 2013. George Osborne unveils “most generous tax breaks in world” for fracking. *The Guardian online*. Available at: <https://www.theguardian.com/politics/2013/jul/19/george-osborne-tax-break-fracking-shale-environment> [Accessed January 12, 2017].
- Macalister, T., 2011. Vast reserves of shale gas revealed in the UK. *The Guardian online*. Available at: <https://www.theguardian.com/business/2011/sep/21/gas-field-blackpool-dallas-sea> [Accessed January 3rd 2017]
- Magro, E. & Wilson, J.R., 2013. Complex innovation policy systems: Towards an evaluation mix. *Research Policy*, 42(9), pp.1647–1656.

- Markard, J., Hekkert, M. & Jacobsson, S., 2015. The technological innovation systems framework: Response to six criticisms. *Environmental Innovation and Societal Transitions*, 16, pp.76–86. Available at: <http://dx.doi.org/10.1016/j.eist.2015.07.006>.
- Markard, J., Raven, R. & Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41(6), pp.955–967. Available at: <http://linkinghub.elsevier.com/retrieve/pii/S004873331200056X> [Accessed July 9, 2014].
- Mason, R., 2017. MPs tell Theresa May to halt sale of Green Investment Bank. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2017/jan/11/green-investment-bank-theresa-may-macquarie-caroline-lucas>.
- Mason, R., 2015a. UK to close all coal power plants in switch to gas and nuclear. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/nov/18/energy-policy-shift-climate-change-amber-rudd-backburner>.
- Mason, R., 2015b. Six in 10 UK onshore windfarms rejected, says report. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/jan/21/six-in-10-uk-onshore-wind-farms-rejected-report>.
- Mason, R., 2013. David Cameron hints at further cuts to green energy. *The Daily Telegraph*.
- Mathiesen, B.V., Lund, H. & Karlsson, K., 2011. 100% Renewable energy systems, climate mitigation and economic growth. *Applied Energy*, 88(2), pp.488–501.
- Murray, J., 2015. UK energy policy reset - the reaction. *Business Green*. Available at: <http://www.businessgreen.com/bg/analysis/2435180/uk-energy-policy-reset-the-reaction> [Accessed December 12, 2016].
- National Audit Office, 2016. *Nuclear power in the UK*, London.
- National Nuclear Laboratory, 2014. *Small Modular Reactors (SMR) Feasibility Study December 2014*,
- Nauwelaers, C. et al., 2009. *Policy Mixes for R&D in Europe*, Brussels: European Commission.
- Nelsen, A., 2016. The rise and fall of fracking in Europe. *The Guardian online*. Available at: <https://www.theguardian.com/sustainable-business/2016/sep/29/fracking-shale-gas-europe-opposition-ban>.
- NESA, 2013. *Nuclear Energy Skills Alliance Annual Review 2012/13*, London. Available at: <https://www.gov.uk/government/policy-advisory-groups/nuclear-energy-skills-alliance>.
- NIA, 2012. *Capability of the UK nuclear supply chain: delivering a nuclear future for the UK*, London.
- NIRAB, 2014. *NIRAB Annual Report 2014*. Available at: <http://www.nirab.org.uk/media/6211/nirab-annual-report-2014.pdf>
- North, D.C., 2006. *Institutions, Institutional Change and Economic Performance*, Cambridge: Cambridge Univ. Press.
- Nuclear Information Service, 2012. *Defence Nuclear Programme Risk Register 2012 - 2060*, London.
- ONR, 2015. *ONR's Contribution to the Public Sector Nuclear Skills Challenge*, London.
- Osborne, G., 2015. Chancellor George Osborne's Spending Review and Autumn Statement 2015 speech. *HM Government Webpages*. Available at: <https://www.gov.uk/government/speeches/chancellor-george-osbornes-spending-review-and-autumn-statement-2015-speech> [Accessed January 12, 2016].

- Osterath, B., 2015. What ever happened with Europe's fracking boom? *Deutsche Welle website*. Available at: <http://www.dw.com/en/what-ever-happened-with-europes-fracking-boom/a-18589660> [Accessed January 1, 2017].
- Oxford Economics, 2013. *The economic benefit of improving the UK's nuclear supply chain capabilities*, Oxford: Oxford Economics Institute.
- Pavelec, S.M. ed., 2010. *The Military-Industrial Complex and American Society*, Santa Barbara: ABC-Clio.
- Perraudin, F., 2015. Fracking under national parks approved by MPs amid acrimony. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/dec/16/fracking-under-national-parks-approved-by-mps-amid-acrimony>.
- Pesch, U., 2014. Tracing discursive space : Agency and change in sustainability transitions. *Technological Forecasting & Social Change*, 90, pp.15–19.
- PricewaterhouseCoopers, 2016. *Seeing through the gloom*, London: PricewaterhouseCoopers. Available at: <https://www.pwc.co.uk/power-utilities/assets/solar-report-2016.pdf>.
- Quitow, R., 2015. Assessing policy strategies for the promotion of environmental technologies: A review of India's National Solar Mission. *Research Policy*, 44(1), pp.233–243. Available at: <http://dx.doi.org/10.1016/j.respol.2014.09.003>.
- Ramsay, R., 2015. *Book Review: The American deep state: Wall Street, big oil and the attack on U.S. democracy by Peter Dale Scott*, London: Rowman and Littlefield.
- Raven, R., 2005. *Strategic niche management for biomass: A comparative study on the experimental introduction of bioenergy technologies in the Netherlands and Denmark*, Eindhoven: Eindhoven University Press.
- Recai, 2016. *Renewable energy country attractiveness index*, London. EY.
- Ren, J, L Dong, L Sun, ME Goodsite, L Dong, X Luo, and BK Sovacool. 2015 'Supply Push' or 'Demand Pull?': Strategic Recommendations for the Responsible Development of Biofuel in China. *Renewable & Sustainable Energy Reviews* 52, pp. 382-392.
- Rensenn, S., 2014. Five reasons why energy bills are so high – and still rising. *The Guardian Online*. Available at: <https://www.theguardian.com/big-energy-debate/five-reasons-energy-bills-high>.
- Rip, A. & Kemp, R., 1998. Towards a theory of sociotechnical change. Available online at: <http://kemp.unu-merit.nl/docs/Rip%20and%20Kemp.pdf>
- Robertson, S., 2015. A longitudinal quantitative-qualitative systems approach to the study of transitions toward a low carbon society. *Journal of Cleaner Production*.128, pp. 221-233.
- Rogge, K. & Reichardt, K., 2013. *Towards a more comprehensive policy mix conceptualization for environmental technological change: a literature synthesis. policy mix concept*. Fraunhofer ISI Working Paper Series. S3/2013.
- Rogge, K.S. Breitschopf, B. Mattes, K. Catner, U. Graf, H. Germann, J. Kalthaus, M. Lutz, C. Wiebe, K. 2015. *Green change: renewable energies, policy mix and innovation*, Karlsruhe: Fraunhofer ISI.
- Rolls Royce, 2013. Rolls-Royce joins NuScale in bid to commercialize small modular reactors. *Rolls Royce Webpages*. Available at: <http://www.rolls-royce.com/country-sites/northamerica/news/yr-2013/0182013-small-modular-reactors.aspx> [Accessed July 12, 2015].

- Rolls Royce, 2016. *Small Modular Reactors - once in a lifetime opportunity for the UK*, Derby. Available at: <https://www.rolls-royce.com/~media/Files/R/Rolls-Royce/documents/customers/nuclear/smr-booklet-28-sep.pdf>
- Rotmans, J., Kemp, R. & Asselt, M. van, 2001. More Evolution than Revolution: transition management in public policy. *Foresight*, 3(1).
- Rotmans, J. & Loorbach, D., 2008. Transition Management: reflexive governance of societal complexity through searching, learning, and experimenting. In *Managing the transition to renewable energy: theory and practice from local, regional, and macro perspectives*. Cheltenham: Edinburgh University Press, pp. 15–46.
- Ross, T., 2016. Former Labour defence chief George Robertson warns Jeremy Corbyn not to scrap Trident. *The Daily Telegraph*. Available at: <http://www.telegraph.co.uk/news/uknews/defence/12155420/Former-Labour-defence-chief-George-Robertson-warns-Jeremy-Corbyn-not-to-scrap-Trident.html> [Accessed 4th January 2017]
- Santos, R. et al., 2006. Stakeholder participation in the design of environmental policy mixes. *Ecological Economics*, 60(1), pp.100–110.
- Science Media Centre, 2012. Expert reaction to resumption of fracking in the UK. *Science Media Centre*. Available at: http://www.sciencemediacentre.org/expert-reaction-to-resumption-of-fracking-in-the-uk/?upm_export=print [Accessed August 12, 2016].
- Schot, J., Hoogma, R. & Elzen, B., 1994. Strategies for shifting technological systems. The case of the automobile system. *Futures*, 26(10), pp.1060–1076.
- Schumpeter, J., 1942. *Capitalism, socialism, democracy*, New York: Harper and Brothers.
- Scrase, I. & Smith, A., 2009. The (non-)politics of managing low carbon socio-technical transitions. *Environmental Politics*, 18(5), pp.37–41.
- Seager, A., 2014. George Osborne is preparing to kill off Britain's renewable energy revolution. *The Guardian Online*. Available at: <https://www.theguardian.com/business/economics-blog/2014/mar/20/george-osborne-budget-kill-renewable-energy-revolution-tax-break>.
- Sherry, J., 2011. *Dalton Nuclear Institute: Research, Skills, Impact*, Manchester.
- Shove, E., 2003. *Comfort, Cleanliness and Convenience: the social organisation of normality*, Oxford: Berg.
- Sky News, 2016. Hinkley Point: A decade of delays and rising costs. *Sky News Website*. Available at: <http://news.sky.com/story/hinkley-a-decade-of-delays-and-rising-costs-10577016> [Accessed September 15, 2016].
- Smink, M. et al., 2015. How mismatching institutional logics hinder niche-regime interaction and how boundary spanners intervene. *Technological Forecasting and Social Change*, 100, pp.225–237. Available at: <http://dx.doi.org/10.1016/j.techfore.2015.07.004>.
- Smink, M., 2015. *Incumbents and institutions in sustainability transitions*, Utrecht: University of Utrecht.
- Smink, M.M., Hekkert, M.P. & Negro, S.O., 2013. Keeping sustainable innovation on a leash? Exploring incumbents' institutional strategies. *Business Strategy and the Environment*, early onli, pp.1–16. Available at: <http://doi.wiley.com/10.1002/bse.1808> [Accessed June 12, 2014].

- Smith, A., 2007. Translating Sustainabilities between Green Niches and Socio-Technical Regimes. *Technology Analysis & Strategic Management*, 19(4), pp.427–450. Available at: <http://www.tandfonline.com/doi/abs/10.1080/09537320701403334> [Accessed December 11, 2014].
- Smith, A. & Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy*, 41(6), pp.1025–1036.
- Smith, A., Stirling, A. & Berkhout, F., 2005. The governance of sustainable socio-technical transitions. *Research Policy*, 34(10), pp.1491–1510. Available at: <http://linkinghub.elsevier.com/retrieve/pii/S0048733305001721> [Accessed August 9, 2013].
- Sovacool, BK and JL Sawin. "Creating Technological Momentum: Lessons from American and Danish Wind Energy Research," *Whitehead Journal of Diplomacy and International Relations* 11(2) (Summer/Fall, 2010), pp. 43-57.
- Sovacool, B.K., 2016. How long will it take? Conceptualizing the temporal dynamics of energy transitions. *Energy Research and Social Science*, 13, pp.202–215. Available at: <http://dx.doi.org/10.1016/j.erss.2015.12.020>.
- Sovacool, BK and J Scarpaci. "Energy Justice and the Contested Petroleum Politics of Stranded Assets: Policy Insights from the Yasuní-ITT Initiative in Ecuador" *Energy Policy* 95 (August, 2016), pp. 158-171.
- Sovacool, BK and D Hess. "Ordering theories: Typologies and conceptual frameworks for sociotechnical change," *Social Studies of Science* (in press, 2017).
- Spencer, T. et al., 2016. *State of the Low-Carbon Energy Union: Assessing the EU's progress towards its 2030 and 2050 climate objectives A sectoral approach to deep decarbonisation in the EU progress needs strong reinforcement and scaling up*. Grenoble.
- Stefanini, S., 2016. 5 ways Brexit would transform European energy. *Politico.eu*. Available at: <http://www.politico.eu/article/uk-brexit-renewable-energy-hinkley-nuclear-interconnectors-gas-climate-emissions-paris/> [Accessed September 15, 2016].
- Stirling, A., 2016. Knowing Doing Governing: Realizing Heterodyne Democracies. In J.-P. Voß & R. Freeman, eds. *Knowing Governance: The Epistemic Construction of Political Order*. Basingstoke: Palgrave Macmillan.
- Stirling, A., 2014. Transforming power: Social science and the politics of energy choices. *Energy Research & Social Science*, 1, pp.83–95.
- Stirling, A., 2011. Pluralising progress: from integrative transitions to transformative diversity. *Environmental Innovation and Societal Transitions*, 1 (1), pp 82-88.
- Stirling, A. Arora, S. 2015. From Multiple Levels to Entangled Streams of Practice: dynamics of structuration in sociotechnical transformations. In *paper to the International Sustainability Transitions Conference*. Brighton.
- Stirling, A. Johnstone, P. forthcoming. How deep is incumbency? Illuminating submerged drivers of political entrenchment around UK civil nuclear power, SPRU working paper, forthcoming 2017
- Stocker, L., 2017. Small business union adds to calls for solar business rates reprieve. *Solar power portal*. Available at: http://www.solarpowerportal.co.uk/news/small_business_union_adds_to_calls_for_solar_business_rates_reprieve [Accessed January 5, 2017].

Stratton, E., 2011. Energy policy role at No 10 for former BP man. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2011/mar/10/energy-policy-no-10-bp>.

Task Force on Shale Gas, 2015. Task Force on Shale Gas Launches Third Report on Climate Change. *Task Force on Shale Gas Website*. Available at: <https://www.taskforceonshalegas.uk/news-and-events/task-force-on-shale-gas-launches> [Accessed January 1, 2016].

Taylor, S., 2007. *Privatisation and financial collapse in the nuclear industry*. Routledge: Oxon.

Temples, J.R., 1980. The Politics of Nuclear Power: a SubGovernment in Transition. *Political Science Quarterly*, 95(2), pp.239–260.

Thelen, K. & Steinmo, S., 1992. *Structuring politics: historical institutionalism in comparative analysis* S. Steinmo, K. Thelen, & F. Longstreth, eds., Cambridge: Cambridge Univ. Press.

Turnheim, B. & Geels, F.W., 2012. Regime destabilisation as the flipside of energy transitions: Lessons from the history of the British coal industry (1913–1997). *Energy Policy*, 50, pp.35–49.

Turnheim, B. & Geels, F.W., 2013. The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British coal industry (1913-1967). *Research Policy*, 42(10), pp.1749–1767.

Tushman, M.L., Tushman, R.L. & Elaine Romanellianelli, E., 1985. Organizational Evolution: a metamorphosis model of convergence and evolution. *Research in Organizational Behavior*, 7, pp.171–222.

UNEP-

Unruh, G.C., 2000. Understanding carbon lock-in. *Energy Policy*, 28 , pp.817–830.

Vaughan, A., 2009. Miliband paves the way for the most ambitious fleet of nuclear reactors in Europe. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2009/nov/09/energy-policy-nuclear-coal>

Vaughan, A., 2016. Fracking given UK go-ahead as Lancashire council rejection overturned. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2016/oct/06/uk-fracking-given-go-ahead-as-lancashire-council-rejection-is-overturned>.

Vaughan, A., 2015. Government kills off flagship green deal for home insulation. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/jul/23/uk-ceases-financing-of-green-deal>.

Vaughan, A. & Macalister, T., 2015. The nine green policies killed off by the Tory government. *The Guardian Online*. Available at: <https://www.theguardian.com/environment/2015/jul/24/the-9-green-policies-killed-off-by-tory-government>.

Verbong, G. & Geels, F., 2007. The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy*, 35(2), pp.1025–1037.

Wassermann, S., Reeg, M. & Nienhaus, K., 2015. Current challenges of Germany's energy transition project and competing strategies of challengers and incumbents: The case of direct marketing of electricity from renewable energy sources. *Energy Policy*, 76, pp.66–75.

Watson, J., 2015. Don't dash for shale gas without thinking about the alternatives. *The Guardian Online*. Available at: <https://www.theguardian.com/commentisfree/2015/jan/27/shale-gas-alternatives-environmental-economic-impact-fracking>.

- Watson, G., 2016. Hardest sell: Nuclear waste needs good home. *BBC News Online*. Available at: <http://www.bbc.co.uk/news/uk-england-35096566> [Accessed January 18, 2016].
- Watt, N., 2014. George Osborne wants climate change tackled as cheaply as possible. *The Guardian Online*. Available at: <https://www.theguardian.com/politics/2014/feb/20/george-osborne-climate-change-cheaply>.
- Wesseling, J.H., 2015. *Strategies of Incumbent Car Manufacturers in Sustainability Transitions*,
- Wilks-Heeg, S., 2015. Revolving door politics and corruption. In *How Corrupt is Britain?*. London: Pluto Press, pp. 135–144.
- Withnall, A., 2014. David Cameron goes “all out for shale” with tax boost for councils willing to approve projects. *The Independent Online*. Available at: <http://www.independent.co.uk/news/uk/politics/david-cameron-promises-fracking-tax-boost-for-councils-willing-to-approve-projects-9055280.html>.
- Witkamp, M.J., Raven, R.P.J.M. & Royakkers, L.M.M., 2011. Strategic niche management of social innovations: the case of social entrepreneurship. *Technology Analysis & Strategic Management*, 23(6), pp.667–681.
- Woods, W., 1991. Understanding subsumption and taxonomy: A framework for progress. In J. Sowa, ed. *Principles of Semantic Networks: Explorations in the Representation of Knowledge*. San Mateo: Morgan Kaufmann publishers, pp. 45–94.
- World Bank, 2014. *Turn down the heat: confronting the new climate normal*, Washington: International Bank for Reconstruction and Development.
- World Nuclear Association, 2015. UK sets aside funds for “ambitious” nuclear research and development program. *World Nuclear Association website*. Available at: <http://www.world-nuclear-news.org/NP-UK-sets-aside-funds-for-ambitious-nuclear-research-and-development-program-26111501.html> [Accessed November 26, 2015].
- Worley, W., 2016. Ministers suppressed damaging fracking report until after crucial vote. *The Independent online*. Available at: <http://www.independent.co.uk/news/uk/home-news/fracking-report-blocked-suppressed-minister-vote-parliament-a7439496.html>.
- Wynn Kirby, P., 2014. Europe’s new nuclear experience casts a shadow over Hinkley. *The Guardian Online*. Available at: <http://www.theguardian.com/environment/2014/mar/25/europes-new-nuclear-experience-casts-a-shadow-over-hinkley>.
- Žižek, S., 1989. *The sublime object of ideology*, London: Verso.