Working Paper Series
SWPS 2016-16 (September)
(this version: 26/09/2016)

Understanding the Intensity of UK Policy Commitments to Nuclear Power

Emily Cox, Phil Johnstone, Andy Stirling

University of Sussex

SPRU Working Paper Series (ISSN 2057-6668)

The SPRU Working Paper Series aims to accelerate the public availability of the research undertaken by SPRU-associated people, and other research that is of considerable interest within SPRU providing access to early copies of SPRU research.

Guidelines for authors

Papers should be submitted to swps@sussex.ac.uk as a PDF or Word file. The first page should include: title, abstract, keywords, and authors' names and affiliations. The paper will be considered for publication by an Associate Editor, who may ask two referees to provide a light review. We aim to send referee reports within three weeks from submission. Authors may be requested to submit a revised version of the paper with a reply to the referees' comments to swps@sussex.ac.uk. The Editors make the final decision on the inclusion of the paper in the series. When submitting, the authors should indicate if the paper has already undergone peer-reviewing (in other series, journals, or books), in which case the Editors may decide to skip the review process. Once the paper is included in the SWPS, the authors maintain the copyright.

Websites

UoS: www.sussex.ac.uk/spru/research/swps

SSRN: http://www.ssrn.com/link/SPRU-RES.html

IDEAS: ideas.repec.org/s/sru/ssewps.html

Research Gate: www.researchgate.net/journal/2057-6668_SPRU_Working_Paper_Series

UNDERSTANDING THE INTENSITY OF UK POLICY COMMITMENTS TO NUCLEAR POWER

the role of perceived imperatives to maintain military nuclear submarine capabilities

Emily Cox, Phil Johnstone and Andy Stirling
Science Policy Research Unit (SPRU)
University of Sussex
Original version: 21/09/2016. This version: 26/09/2016[1]

Contents

[1] This is a revised version that corrects an errata that identified plutonium stockpiles at Sellafield as 'weapons grade'. This has been changed to 'reactor grade'.

Abstract

The UK Government has long been planning to build up to 16 GWe of new nuclear power – a proportional level of support unparalleled in other liberalised energy markets. Despite many challenging developments, these general nuclear attachments show no sign of easing. With many viable alternative strategies for efficient, secure, low-carbon energy services, it is difficult to explain these commitments solely in terms of officially-declared policy rationales.

A variety of possible reasons are suggested for the persistent intensity of UK attachments to civil nuclear power. Each is taken here as a basis for systematic hypothesis testing. And one additional hypothesis is also interrogated that has hitherto been virtually entirely neglected – about maintaining national capabilities to build and operate nuclear-propelled submarines.

To explore and test this idea, this paper analyses linkages between UK military and civilian nuclear sectors in terms of high-level policy processes around supply chains, skills and expertise. Especially interesting is the critical juncture between 2003-2006, when stated policy moved radically from nuclear power as 'unattractive' to calls for a 'nuclear renaissance'. In this period, especially intense activity can be observed around UK nuclear submarine capabilities.

Among many factors, we conclude it is difficult fully to comprehend the persistent intensity of official UK attachments to nuclear power, without also considering aims to maintain nuclear submarine capabilities. Yet this aspect is entirely undocumented anywhere in UK energy policy literatures. To acknowledge this, is not to entertain a conspiracy theory. It can be understood instead, in terms of more distributed and relational dynamics of power. Building on literatures in political science, we refer to this as a 'deep incumbency complex'. Such an evidently under-visible phenomenon would hold important implications not only for UK nuclear strategies, but also the wider state of British democracy.

Keywords

Civil nuclear power; nuclear energy strategies; UK energy policy; nuclear weapons; nuclear-propelled submarines; incumbency; lock-in; renewable energy; technological discontinuation; sociotechnical transformation; theories of power; institutional theory; political science; science and technology studies.

Section 1: Introduction and Summary

With current controversies around the Hinkley Point C project simply one further specific twist in the plot (Ruddick & Grierson 2016), the story of UK nuclear power is a fascinating one. Albeit in many changing ways, the UK Government has long professed to be planning to build up to 16 GWe of new nuclear electricity generation capacity - a proportional level of support for new nuclear power unparalleled in any other liberalised energy market (World Nuclear Association 2016e; Kee 2015). Despite many challenging developments, these general attachments show no sign of easing.

With many alternative (arguably preferable) strategies available for delivering economically viable, politically and technically secure, low-carbon energy services (Liebreich 2016; National Audit Office 2016; Environmental Audit Committee 2006; IRENA 2016; Frankfurt School-UNEP 2016), it is difficult satisfactorily to explain the historic intensity of these commitments solely in terms of officially-declared policy rationales (Phil Johnstone & Stirling 2015a).

A variety of reasons have been proposed in policy and academic discussions for the persistence of these distinctively strong UK policy attachments to civil nuclear power (BERR 2008; DECC 2011c; Thomas 2016; Ruz 2015). Each of these is taken in this study as a basis for systematic hypothesis testing. Among these possible explanations, however, this paper interrogates one hypothesis that has hitherto been almost entirely neglected. This is, that the unusual intensity of UK commitments to civil nuclear power are especially understandable in light of a parallel but distinct policy aim that also deeply pervades elite British political cultures. This is the goal of maintaining national capabilities to build and operate nuclear-propelled submarines (House of Commons Defense Committee 2007; HM Government 2006). It is these highly demanding feats of engineering that are widely seen to present the only militarily credible platform for strategic nuclear weapons – thus (in some strongly held views) supporting a place for the UK at the 'top table' of global affairs (HM Government 2015; Barckham & Norton-Taylor 2010).

To explore and test this hypothesis, this paper carefully analyses linkages between UK military and civilian nuclear sectors, using an 'innovation systems' focus on supply chains, skills, expertise and associated high-level policy processes (Edquist, 1997). Augmented by key informant interviews, systematic document and web analysis methods are used to explore a large body of evidence from UK policy documents and Parliamentary inquiries. Despite acknowledged incentives to "mask" them (Ireland 2012), strong interconnections emerge between the UK civilian and military nuclear engineering interests . Yet these linkages are notable for their lack of visibility, equally in academic, policy and critical journalistic discussions of what are conventionally taken to be effectively separate UK civil and military nuclear commitments.

In further investigating these dynamics, a particular focus is directed at the period 2003-2006 – widely recognised as a recent critical juncture for UK civil nuclear policy (Taylor 2016; Thomas 2016; Environmental Audit Committee 2006). It is shown how this episode constituted an unprecedented turnaround in official characterisations of civil nuclear power (reversing from an "unattractive" option to a basis for "nuclear renaissance") (DTI 2003; DTI 2006a). This is also an episode during which a marked increase in assertive pressures can be identified originating not primarily in the civilian nuclear sector, but in military strategy circles – especially around maintaining nuclear submarine capabilities (Pung et al. 2005; Schank et al. 2005; Raman et al. 2005; Ministry Of Defence 2005; MoD 2006; KOFAC 2006). Again, these dynamics are not declared in any official UK energy policy discussions.

The conclusions of this research affirm that the picture is highly complex with many different formative processes at work. All hypotheses examined here are found to be likely have some role to play in assisting understanding. But it is evident that it is difficult fully to comprehend the persistent intensity of official UK attachments to nuclear power, without also considering the role of parallel commitments to maintaining national military nuclear submarine capabilities. That these military pressures have hitherto remained entirely unacknowledged in official UK energy policy documents (and effectively invisible in wider policy discourse) reinforces the importance that they be taken seriously.

These findings should not be taken simplistically to suggest a singular deliberate 'conspiracy'. What seems instead to be illuminated, are perhaps better understood in more processual, distributed and relational ways – involving emergent intentionalities and distributed flows and gradients of power that evidently pervade core institutions and

elite cultures spanning disparate technological systems and penetrating some of the highest and deepest parts of the UK State and strategic national industry (Stirling 2014; 2016). By reference to an established body of analysis in political science and institutional theory (Grover & Peschek 2014; Fraenkel 2010; Glennon 2014; Temples 1980; Wedel 2014; Skogstad 2008; Feenberg 1999; Söderbaum 2004; Stone 2002; Jordan 1990), the study argues that such a phenomenon might be termed a 'deep incumbency complex'.

In illuminating the importance of these undeclared non energy-related drivers in official UK commitments to civil nuclear power, the findings of this study may be judged to hold some policy salience in this important policy area. The fact that these evidently formative factors have for so long remained so remarkably under-discussed in wider UK energy debates, might be thought to extend this significance beyond the energy field alone: also raising important questions about nuclear commitments more widely – and the general condition of UK politics and democracy.

Section 2: Why Undertake This Study?

2a. Grounds for Queries over the Intensity of UK Nuclear Commitments

Over recent years, the UK has become quite internationally distinct in the depth and extent of official policy commitments to nuclear power (World Nuclear Association 2016e). Against the grain of worldwide trends (Schneider & Froggatt 2016; World Nuclear Association 2016a), successive UK administrations have become the main global governmental proponents of what is repeatedly referred to as an impending "*nuclear renaissance*" (DECC 2013a). Challenged on the flagship UK national radio news programme in March 2016, for instance, former British Energy Minister Amber Rudd clearly expressed the intensity of this position, in stating that "[*investing in nuclear is what this Government is all about for the next twenty years*" (Rudd, quoted on the BBC Today Programme, 2016). The present Energy Minister, Greg Clarke has said in the past that there is "*no limit*" on how much new nuclear capacity the Conservative Party would be prepared to build in the UK (Greg Clarke quoted in Collins 2010).

With an envisaged programme of 16 GWe over coming decades (HM Government 2016a; DECC 2011a), the nuclear proportion of firmly-planned new UK electricity generating capacity is uniquely ambitious on the world stage (Schneider & Froggatt 2016; Vaughan 2010; World Nuclear Association 2016e). Yet with diverse candidate reactor designs coming to the fore in quick succession, the envisaged means to deliver this plan remain surprisingly ambiguous and volatile (National Audit Office 2016). Since 2006, the US-Japanese AP1000 Pressurized Water Reactor (ONR 2016a), a French-led EPR-1600 pressurised water reactor (ONR 2012), the Japanese Advance Boiled Water Reactor (ABWR) (ONR 2016b), the Chinese HPR-1000 advanced light water reactor (World Nuclear News 2014) and (most recently) disparate configurations of as-yet undeveloped US or UK small modular reactors (HM Government 2016b) have all variously featured.

A striking attribute of the strength of these official UK nuclear attachments, is how starkly at odds they are with prevailing global trends in international supply chains for electricity generating plants (Frankfurt School-UNEP 2016). Over recent years, annual global capital investments in new nuclear power have (at around 20 $billion/y) remained at levels far lower than has been the case in the past, and massively lower than those for other electricity supply technologies [ibid]. Indeed, worldwide capital equipment investments in renewable electricity generation have since 2013 (at 250 $billion/y), not only massively exceeded investments in nuclear, but (at 125 $billion/y) in all fossil fuel generating capacity put together [ibid][1] . Not only then, is this difficult to square with ideas of a '*nuclear renaissance*' (World Nuclear Association 2015), but if there is to be talk of any kind of 'renaissance' in global electric power generation, it is manifestly the case that this can far more easily be recognised around renewable energy, than nuclear power (IEA 2015c).

These contemporary discrepancies are amplified when consideration is given to trends over time. Worldwide nuclear generating costs are tending to rise markedly (Lévêque 2015). Costs for key renewable technologies are continuing to fall rapidly (Mitchell 2016; IEA 2015c). The market performance of nuclear power (as compared with other low-carbon energy), is thus generally diminishing around the world (Schneider & Froggatt 2016; Liebreich 2016). UK Government-issued contracts for nuclear and renewable electricity also reflect this wider picture (DECC 2016a), confirming a large tranche of the available UK renewable energy resource to be competitive with nuclear power, with the advantage tending to grow (National Audit Office 2016). Yet for some reason, elite British nuclear commitments hold firm (see the 2015 manifestos of the main political parties in the UK: The Labour Party 2015; Conservative Party 2015; Liberal Democrats 2015) with prominent members of traditional political parties on all sides of the parliamentary spectrum exerting their own pressures in favour of uncompetitive nuclear power (rather than renewable energy – for example Tim Yeo quoted in (Macalister 2016c) and John Hutton (Hutton 2016). Even in the restricted context of the UK, then, the strongest evidence for the idea of a 'nuclear renaissance', lies in the potentially (apparently aspirationally) self-fulfilling potential of this high-level rhetoric itself (Bradford 2013).

Of course, some other western democracies are also planning new nuclear power as part of their electricity generating mix. But the UK is unique in so actively pursuing such an ambitious form of '*nuclear renaissance*' (Vaughan 2009). Elsewhere in the world, other important and fast-growing economies are also undertaking nuclear programmes that are even bigger in absolute terms (IAEA 2015b). But – in cases like China (World Nuclear Association 2016b; Guo & Guo 2016) and India (Garg 2012; World Nuclear Association 2016c) – this typically takes place against the backdrop of significantly larger rates of growth in other energy technologies (Chabot 2016; Frankfurt School-UNEP 2016; IEA 2015c). So, compared to other European countries [2] – and with the prevailing general picture around the world [3], the relative scale of UK commitments to nuclear power by contrast with other low-carbon energy options, does remain quite strikingly distinctive. And, as we discuss further in section 6a, other ambitious nuclear new build plans around the world are also understandable in relation to the present analysis. But we will come to this.

For now, a notable particular comparison is that between the UK and Germany, an otherwise in many ways similar national context where current electricity investment polices take a striking different form (Strunz 2014; Johnstone & Stirling 2015a). Here, despite complications (Lütkenhorst & Pegels 2014) and contestations (Vasagar 2015), high level policy commitments continue to an '*Energiewende*' involving a wholesale shift away from nuclear power and towards renewable energy (Morris & Pehnt 2012; Agora Energiewende 2015; Federal Ministry of Economics and Technology 2011). Crucially, this is taking place in a country hosting a nuclear engineering industry that has been far more successful on the world stage than has that of the UK (World Nuclear News 2011; IAEA 2016b; Birmingham Policy Comission 2012; Environmental Audit Committee 2006), with far greater share in relevant worldwide intellectual property (Lévêque 2010; Berthélemy 2012). As partly illustrated in Figures 1 and 2 (for more detail see: (Johnstone & Stirling 2015a), industrial interests associated with the operation and maintenance of nuclear power are also significantly larger in Germany compared with the UK, both in absolute (Fig.1) and relative (Fig.2) terms. So the distinctive levels of official nuclear enthusiasm in the UK cannot obviously be explained as simply reflecting evidence-based lobbying on the part of a manifestly internationally successful domestic nuclear industry.

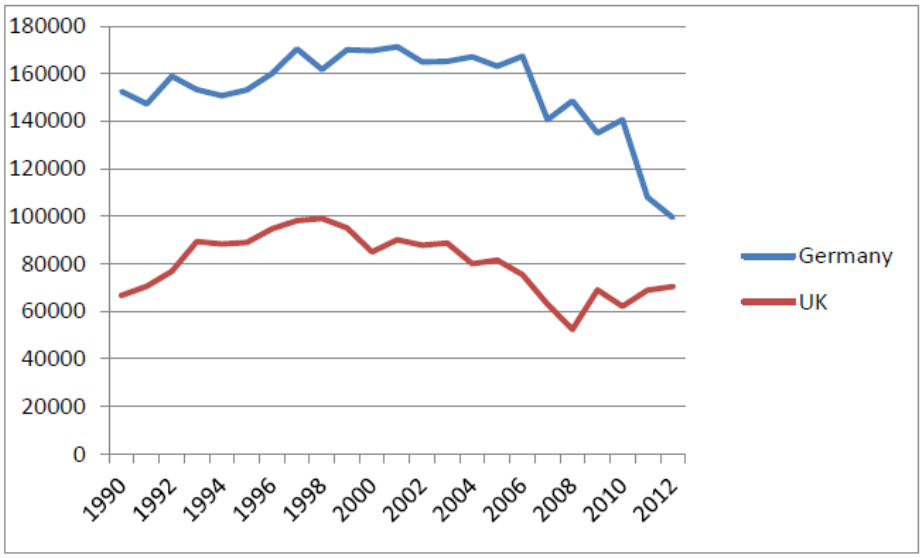


Figure 1: Electricity production from nuclear power (GWh) (IEA 2015b; IEA 2015a)

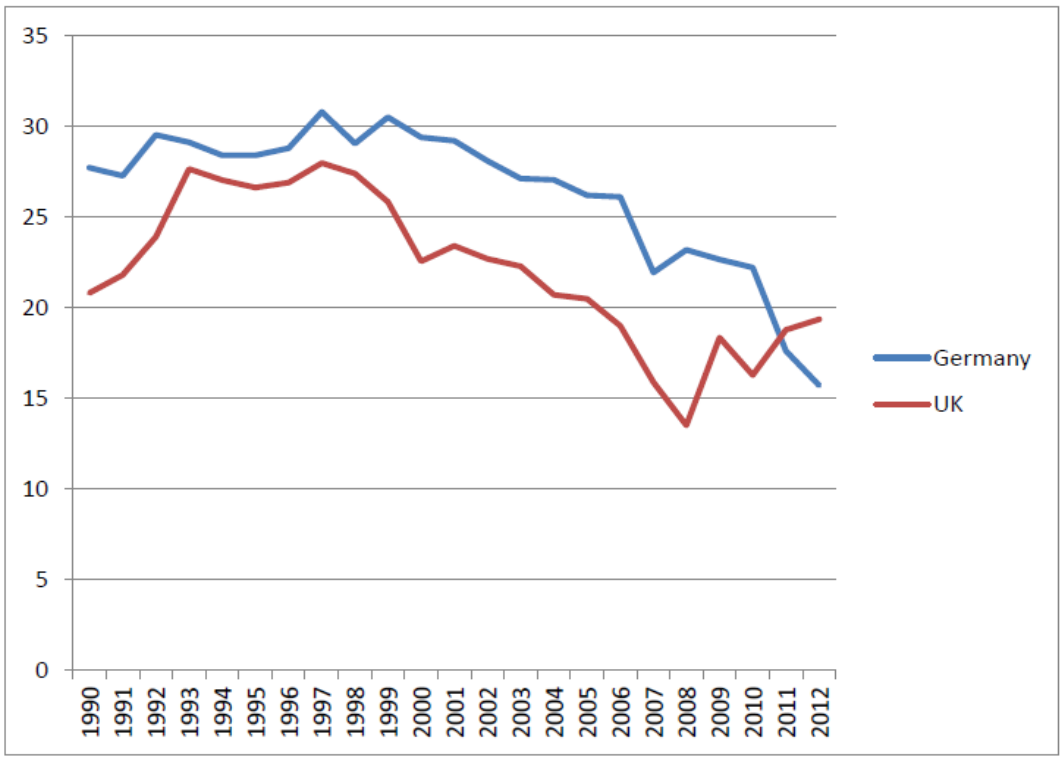


Figure 2: Share of nuclear energy in electricity generation mix (%) (IEA 2015b; IEA 2015a)

Nor does the particular history of UK civil nuclear activities yield a compelling explanation for the sustained intensity of high-level enthusiasms (Thomas 2010; Aldred & Starkey 2013; Taylor 2016; Hall 1986). Indeed, repeated cautionary indications are readily apparent, in the ways in which earlier ambitious nuclear programmes actually turned out to be recognised on all sides of debate as massively expensive failures (Hill 2013; Taylor 2016; Environmental Audit Committee 2006) This is true separately of the advanced gas-cooled reactor design (Aldred & Starkey 2013) and the fast breeder reactor programme (Patterson 2007; Cochran et al. 2010) of the 1960s and 1970s, and the thermal oxide reprocessing plant of the 1980s and 1990s (Walker 2000; Brown 2008), for instance. Each has been acknowledged later, even by the responsible official UK bodies (CEGB quoted in Aldred & Starkey 2013), to have individually featured among the UK's largest industrial policy disasters [4]. It is very difficult to find any notable story of success in UK nuclear activities, on any economic scale that compares with that of the envisaged 'nuclear renaissance' (Pemberton 2016).

Of particular relevance, is the fate of earlier ambitious plans for nuclear power in the deregulated UK electricity market (Meek 2014; Mackerron 1996; Taylor 2007; Winskel 2002). Failed attempts to privatise nuclear power in 1989 dealt one of the most damaging and embarrassing blows to an earlier Conservative government (Aubrey 1991; Meek 2014). So it is not as if historic UK experience offers an obvious driver for the distinctive intensity of current official UK commitments under a later Conservative administration to a new and even more ambitious nuclear programme. Yet to date, current UK Government support for the nuclear programme as a whole remains implacable (Macalister 2016b). And this remains so despite: significant cost escalations (DECC 2016b); grave difficulties in securing finance for the envisaged new programme (Macalister 2016a); revelations concerning very serious defects in pressure vessel castings for the first planned power station at Hinkley Point C (Lichfield 2015); and the unravelling support for this plant even on the part of Electricite de France (Gosden 2016; Stothard 2016), who (as the intended builders), might be expected to champion it most strongly. Whatever position one takes on the overall pros and cons of nuclear power, it is difficult to deny the grounds for serious questions.

With regard to the most recent developments in this area at the time of writing, consent for investment in the specific project at Hinkley C by the EDF board was eventually won by a majority of 10-7 on the 28th of July 2016 (Ruddick &

Grierson 2016). However for reasons that remain unclear at the present moment, the new UK Government led by Prime Minister Teressa May, more recently decided to postpone a final decision on this (Gosden. 2016). According to some reports, this was due to Teresa May's concerns regarding security issues arising from the large Chinese involvement (Boffey 2016). But it is repeatedly emphasised that these are quite specific concerns, with the particular Hinkley C project being quite distinct from wider UK commitments to nuclear power in general.

Either way, these mismatches between the manifest levels and persistence of UK Government commitments to nuclear power (on the one hand) and any obviously sufficient policy reasons (on the other hand) are further accentuated, when it is considered that the UK enjoys resource endowments for alternative low-carbon options that are internationally-enviable in their scale, quality and cost-effectiveness (DECC 2013b; Held 2010). The UK has the best wind energy resource in Europe for example (Renewable Energy Association 2015). Contract prices for the most competitive tranches of renewable energy are significantly below those for Hinkley Pont C, with the discrepancies growing over time (DECC 2016a; National Audit Office 2016). Yet proportional rates and degrees of exploitation of this renewable resource are far less than those of many other less well-endowed countries (European Environmental Agency 2016). Again then, UK Government attachments to nuclear power cannot easily be explained as a reflection of the presumptively limited nature of other low-carbon alternatives.

Of probably lesser (but nonetheless possibly conceivable), relevance to this picture, are other potential industrial policy considerations (RenewableUK 2015; Norris 2016). For instance, the UK hosts a significant offshore construction industry (UK Trade and Investment 2012; Kern et al. 2014; Toke 2011) of a kind that might benefit strongly from large programmes in renewable technologies (UK Trade and Investment 2015). While significant, roles for the UK engineering sector in the envisaged national civil nuclear programmes are restricted to second tier contractors and below (Oxford Economics 2013; BIS 2013). With the respective relative scales and directions of growth in global markets for nuclear and renewables (IRENA 2016; IEA 2015c; Frankfurt School-UNEP 2016), it might be expected that an effective industrial policy would prioritise seeking to capitalise on the unusually favourable UK renewable resource endowment (Ernst & Young 2016) in order to compete for a global lead for national firms in this sector as potential first tier suppliers. At the very least, it is not self-evident how UK industrial policy interests taken in the round, would necessarily lead to a conclusion that disproportionately favours a nuclear over a renewable strategy (Harvey 2015).

Another area for raising prima facie questions about the established pattern of developments, lies in national security considerations (Broomby 2015). A series of officially-sanctioned voices have raised concerns about the dangers that such critical UK infrastructure should depend so strongly as is envisaged in the projected nuclear programme, on foreign companies (Vander Weyer 2016). Such concerns are expressed especially acutely, with respect to the role in the UK nuclear programme of Chinese firms (including key national military suppliers. It is also notable that nuclear power is implicated (albeit rarely comment on) in all four 'top tier' security threats identified in UK defence strategy – relating to potentially catastrophic industrial disaster, sabotage and terrorism, possibility for cyberattack and vulnerability as a military target (BBC News 2015). Although different perspectives are possible, the distributed nature and relatively low catastrophic potential of renewable supply infrastructures make it difficult not to see these as significantly more resilient in these respects. Again, then – while different points of view are of course manifestly tenable – it does not seem plausible that the intensity of UK Government commitments specifically to nuclear power, can be regarded as self-evidently explicable in security terms.

2b. Curious Levels of Neglect in Questioning UK Nuclear Commitments

Of course, the background picture sketched here is complex and begs many questions. These can be interpreted from many different standpoints – in ways that will be addressed in detail in this paper. It will remain possible to approach the variabilities and uncertainties from divergent evaluative perspectives and draw contrasting interpretations over the general pros or cons of nuclear power. Indeed, to raise such questions need in no way be taken to imply a blanket negative position on nuclear power. It is perfectly possible to advocate or accept a case for nuclear power as part of a low-carbon electricity supply mix, and yet at the same time ask about the distinctive intensity of the UK position. Indeed, understanding this pattern might be thought especially salient for nuclear proponents, seeking to understand the conditions under which their favoured technology might prosper (Guyer & Golay 2015). But when all the above factors are considered together, it is difficult not to conclude that the distinctive intensity of UK government commitments to civil nuclear power is at least a phenomenon that requires some kind of attention and explanation. And, as we shall see, the more that is known about the historical, political, economic and technological background, the more salient such questions become. It is therefore not the posing of such questions that would be partisan, but their denial or avoidance.

So, the key questions are:

1) Exactly why have official UK nuclear commitments remained so disproportionate and persistent when contrasted with many other comparable countries over the years?
2) Why has this support extended so relatively widely (by international comparisons), across such an otherwise divided political spectrum?
3) Why have these attachments proven so resilient in the face of such repeatedly serious economic and political disappointments in the domestic nuclear sector?
4) Why have contemporary international market trends and policy initiatives in other countries evidently tended to exert such little influence on UK Government energy strategies?

Despite their broad salience, these questions are all the more remarkable, for being so relatively neglected in UK policy literatures (Toke 2013). This is so, equally in policy documents themselves and in academic analysis or even some critical commentaries (Atherton 2014). Official policy rationales refer to evaluative frameworks and appraisal data that are very difficult to reconcile with the intensity of prevailing commitments, yet other explanations are not forthcoming. Authoritative independent analyses are often clear as to the discrepancies between prevailing understandings of the relative merits of alternatives, and established high-level commitments to a major '*nuclear renaissance*' (Birmingham Policy Commission 2012). But these generally fail to ask very seriously, what the actual policy drivers might be.

For its part, much mainstream academic analysis tends to approach the subject of UK nuclear commitments, by taking prevailing official statements simply as given, and then (depending on its the supportive or critical orientation in question) focussing either on critiquing official data or rationales, or on seeking instrumentally to be "realistic" in second guessing what kinds of analysis might in this light have a reasonable chance of being taken seriously under prevailing policy positions. Either way, despite the large volume and very high quality of available analysis, the specific material drivers behind the elite UK nuclear commitments remain remarkably under-interrogated in relevant scholarly literatures.

Even UK organisations that were formerly quite distinctively identified by their critical positions on nuclear power, seem to many commentators to have at very least reduced the priority that they attach to this issue in the UK (Porritt, 2015). It seems the unremitting intensity of official UK commitments to nuclear power have

served in some quarters to suppress the kind of active critical NGO engagements that were experienced in the past (Purdue et al. 1984; Welsh 2001; Wynne 2010; Patterson 1979) – or which continue to be evident in other countries (Deutsche Welle 2011). Although there are exceptions (Ecotricity 2016; BBC News 2011), some of the most visible and effective challenges to UK civil nuclear policy in recent years have come from within environmental movements based in Germany and other countries (World Nuclear News 2015; Neslen 2015) – sometimes driven by overseas branches of organisations that also operate in the UK in ways that are less actively critical of nuclear power (Reuters 2015).

So, conventional responses to the internationally-distinctive persistence and intensity of elite UK nuclear commitments, tend to take this overbearing official bias for granted. Analysts may disagree with the stated policy rationales. But so strong is the UK policy climate under which criticism of nuclear is taken to be unacceptable, that it is more expedient simply to accept these at face value, resigned to an understanding that the real motivations lie in deeper and less visible policy imperatives that simply remain a political 'fact of life'. To expend efforts probing the nature of these underlying imperatives, can seem rather abstract or futile. It is this assumption that this paper seeks to challenge – hopefully illuminating in the process, a range of implications equally for prevailing theoretical understandings and for the practice of policy in this crucial field.

Having said this, it is essential to acknowledge the crucial importance of a relatively small body of independent critical analysis and commentary on UK nuclear strategies (see the Nuclear Consulting Group 2016 for more details), that has collectively achieved a huge amount in the face of this pattern of sustained general policy exclusion, academic marginalisation, media disinterest and civil society inertia. For a country of the size, history and claimed democratic standing of the UK, it is remarkable under the circumstances outlined above, that this community and its associated literatures should remain so comparatively marginalised. But – as is shown in the acknowledgements to this paper – the present authors in particular, owe a huge debt to the penetrating questions, illuminating insights and nuanced understandings that can be found in this corpus of analysis. Without this, it would not have been possible to develop the present entirely new hypothesis concerning the possible role in sustaining distinctive UK policy attachments to nuclear power, of commitments to capabilities to maintain nuclear submarines capabilities.

2c Overview of this Paper

Based on the picture sketched above concerning the distinctive intensity and persistence of UK policy attachments to civil nuclear power, a very simple question lies at the heart of this study. How can we best understand the drivers of this apparently anomalous pattern of commitment to nuclear power, as distinct from available viable alternative bases for low carbon energy strategies? In asking this, this research relates to a wider ESRC-funded project as part of a European research consortium concerned with investigating a more general question about the ways in which sociotechnical systems (Geels 2002) of all kinds become 'locked in' – and how governance might reasonably seek deliberately to discontinue such potentially damaging kinds of entrenchment (Stegmaier et al. 2014). Accordingly, the distinctive intensity of official UK commitments to nuclear power in the face of alternatives, constitutes an especially relevant focus for analytical attention (Johnstone & Stirling 2015a). In undertaking this task, this paper builds on a separately-produced review of the general international political and economic circumstances of nuclear power and a specific investigation of the striking contrast between the particular cases of the UK and Germany (Stirling and Johnstone 2015).

In seeking to answer this central question, then, the discussion in the present paper is sequenced as follows. In **Section 2** (above), we substantiated the *prima facie* relevance of some central questions (and the reasons for at least posing them), concerning the internationally distinctive intensity of current official UK commitments to nuclear power. We also identified the curious levels of neglect of these questions in official UK energy policy. In **Section 3** (which follows next), we will show in more detail, how each of a series of particular hypotheses relate to different theoretical and disciplinary literatures bearing on the maintaining of incumbent interests in sectoral innovation systems or sociotechnical regimes such as that exemplified by the UK nuclear power industry. It is these literatures that bear most strongly on the topic of the wider research project of which this study is a part, concerning how governance might in general seek (depending on prevailing policy values and interests) alternatively to support or to discontinue particular technological trajectories.

In **Section 4**, we present in more detail, the four broad hypotheses that emerge as possible ways to help understand the answers to these questions. These are: *(i) the 'face value' UK nuclear policy hypothesis* (which we index as 'H1'); *(ii) the UK nuclear power entrenchment hypothesis* (H2); *the elite policy actor and networks hypothesis* (H3); and *the UK deep incumbency hypothesis* (H4). Of course, these contrasting elements of understanding such a complicated situation are not mutually exclusive, nor are they discrete – since they decompose and interact in various ways. Each will likely display contrasting merits in addressing specific aspects of the complex and ambiguous political dynamics around nuclear policy making in the UK. A range of different formative factors will surely remain salient in principle, variously applying to greater or lesser extents in contrasting specific historic or political settings, or under divergent analytical perspectives.

But – to anticipate the argument for purposes of clarity in this introduction – it does emerge quite strongly from this analysis, that the fourth hypothesis (which is very specific and novel) offers a relatively more persuasive general basis for understanding key particularities of UK nuclear power policy than do any of the others on their own. This particular hypothesis posits that the unusual intensity of official UK commitments to civil nuclear power are especially understandable in the light of a parallel imperative that deeply pervades elite British policy cultures: to maintain national capabilities to build and operate nuclear-propelled submarines. The salience of this hypothesis is all the more acute, for its striking neglect in past analysis and commentary.

Given the novelty and focal importance of the deep incumbency hypotheses (H4) for this analysis (in the context of the wider project of which it is part on 'technological discontinuation'), the bulk of this paper (Sections 5, 6, 7 and 8) will be devoted specifically to testing this particular hypothesis in various ways. For this purpose, H4 is further subdivided into four propositions (to be summarised here but explained in more detail in the methods discussion in Section 4). The first of these propositions will be examined in **Section 5** of this

paper. This serves as a test for crucial twin foundations for the hypothesis, checking in detail that the UK Government is indeed committed both to a '*nuclear renaissance*' and to the maintaining of military nuclear capabilities associated with national infrastructures for building and operating nuclear-propelled submarines.

Section 6 then tests the proposition that substantive linkages can be documented between UK Government commitments to renewing civil nuclear power and the priority of maintaining national capabilities to sustain nuclear propulsion infrastructures for military submarines. This will help ascertain that the hypothesis is not simply abstract, but relates to empirical evidence, even if only circumstantial. But off course, even this circumstantial evidence is shown to exist, it need cannot be taken to imply the direction of any formative drivers.

Section 7 will further investigate on this basis, whether observed linkages do suggest any particular kind of formative relationship between these two areas of policy. **Section 8** then focuses on the specific critical juncture already mentioned – the period of the radical turnaround in UK Government civil nuclear policy occurring in 2003-6. This analysis tests the proposition that if UK civil nuclear commitments are indeed dependent on officially-perceived imperatives to maintain nuclear submarine capabilities, then it would be in this period that these dependencies might be expected to be *most* visible. Crucially, this offers an opportunity for hypothesis falsification. If these processes cannot be observed in relation to this period, then they are correspondingly unlikely to be very significant in more general terms and our central hypothesis would effectively have been refuted.

Having in this way discussed the detailed empirical evidence bearing on the above carefully-differentiated propositions together constituting the *'UK deep incumbency complex hypothesis* (H4)', **Section 9** will examine in less detail, the comparable evidence base relating to the other three hypotheses, pointing also to analysis in other literatures, in which grounds for these contrasting hypotheses are all variously quite well explored.

This leads to the final part of this working paper: **Section 10**. This will offer a short concluding critical comparative discussion of the relative pros and cons of all the different hypotheses (and their variants and constituting propositions) when considered together. Acknowledging that many explanatory factors inevitably remain relevant, with different aspects coming to the fore in different settings and perspectives, this will nonetheless substantiate a judgement as to the apparent overall relative salience of all the different approaches in seeking to better understand the remarkable questions with which this paper began.

On this basis, some interpretive conclusions will be offered at the end of this paper, concerning more general implications of the idea of the postulated 'deep incumbency complex'. These will be explored equally in relation to current theoretical frameworks concerning the general governance of technological discontinuities; for specific understandings of UK nuclear policy processes; and for onward research agendas in both these areas. Possible implications will also be pointed to, concerning wider debates over the current condition of UK politics and democracy.

Section 3: Theoretical Background – Contrasting Understandings of Incumbency

3a Theoretical Approaches to Power

As justified in the last section, the central question in this study, concerns how best to understand the evidently internationally-unusual intensity of UK policy commitments to civil nuclear power. So, the aim is to comprehend the course of high-stakes developments in elite policy making involving highly structured interests. First and foremost, then, the main focus of any attempt like this is on the dynamics of power.

But power is a very tricky business. And this is so, in many different senses of this phrase – no less in understanding than in action. For it is inherent to the distinctive 'double hermeneutic' in social research (Giddens 1984), that power is not just at the object end of academic enquiry, but can also condition the subject. Power of different kinds can not only drive, steer and constrain the kinds of actions that are taken, but shape the understandings that inform and respond to these actions – the sorts of assumptions that tend to be made, those interpretations that are prioritised and even which questions are asked (and not asked) in ostensibly neutral analysis. Not least, these pressures in policy analysis can tend to discourage too much attention to power itself – perhaps on grounds it is too complex, too difficult… or just too impolite to talk about (Stirling 2015). If credibility is to be maintained in conventional policy debates, particular pressures bear against representations of power dynamics that might be caricatured to represent a 'conspiracy theory' (Sunstein 2014; Runciman 2016; Fredheim 2016; Jewell 2015). With it long recognised that the word 'power' holds a double meaning in the phrase 'nuclear power' (Woods 2006), an understanding of the dynamics of political and economic power around long-lived, large-scale technological infrastructures, is particularly pronounced in this field (Stirling 2014).

A large literature on variously-named general socio-political phenomena around "*nuclearity*" (Hecht 2010), "*nuclear culture*" (Loeb 1986), "*the fissile society*" (Patterson 1977) and nuclear "*sociotechnical imaginaries*" (Jasanoff & Kim 2009) explores how the global nuclear sector is a particular arena within which these conditioning effects by power are especially intense, pervasive – and under-attended to in mainstream policy debate (Temples 1980). So it could be that such pressures are implicated in the noted relative dearth of critical scrutiny for the central question of this present study? This remains to be substantiated. Either way, it is for the moment, doubly important to frame this enquiry with careful consideration for the nature of the dynamics of power.

Arguably "*one of the most palpable facts of human existence*" (Dahl 1957) and "*a central concept for the social sciences*" (Cerbaro 2011), power is surely "*one of the most central yet problematic concepts in sociological theory*" (Martin 1971). Undoubtedly actually a diverse, complex and dynamic "*ecology*" of social phenomena (Massumi 2009), it can be addressed in many notoriously diverse ways. For instance, vigorous debates persist in political science over differences between views of "*power over*" (Harrison et al. 2015), "*power to do*" (Arendt 1970), … or variously power… "…*through*..." (Smeed et al. 2009); "…*between*…" (Abensour 2011); "…*under*…" (Spencer-Wood 2004); "…*from within*…" (Mansbridge 2001) – and so on. Significant distinctions can be drawn between kinds of power as: "*sovereign*" (Foucault 1977) or "*communicative*" (Bohman 2016); "*productive*" or "*repressive*" (Lukes 2005); "*soft*" or "*hard*" (Nye 2004); "*pre-emptive*" (Massumi 2015) or "*countervailing*" (Galbraith 1993); about "*strategy*" or "*tactics*" (De Certeau discussed in Feenberg 1999, p.112); "*constitutive*" or "*constituted*" (Agamben in de la Durantaye 2009, p.234); "*dispositional*" (Guzzini 2009) or "*compensatory*" (Galbraith 1996); about "*deference*" or "*efficacy*" (Collins 2004). Without the space here to detail the specific implications of each of these (or others), all these "*faces of power*" (Bachrach & Baratz 1962)

can be seen in principle to be potentially relevant to this inquiry. All represent aspects of ways in which interests and commitments in nuclear power (as distinct from alternative infrastructures) are constituted, asserted and reproduced (Jasanoff & Kim 2009).

Power can also be enacted in many permutations of ways – for instance by means of: agency (Lukes 2002); structures (Lukes 1977); structuration (Geels 2014); relations (Powell & Depelteau 2013; Depelteau & Powell 2013); fields (Fligstein & McAdam 2012); modes (Scott 2008); gradients (Stirling 2005; 2016); flows (Swyngedouw 2004); practices (Hargreaves et al. 2011) or discourses (Berenskoetter & Williams 2007). It can variously be recognised not only to be "*complex, heterogeneous and multifaceted*" (Clegg et al. 2006), but multidimensional (Guzzini 2005), messy (Law 2004) and fractal in its nature (this last in the sense that similar patterns can be reproduced at every scale) (Stirling 2014). Again, it is clear that – as with other political interests in and about technological infrastructures – power dynamics around nuclear power play out in all these socio-political media (Law 1991; Feenberg 1992; Pfaffenberger 1992; Allen & Hecht 2001; Hess 2013; Leach et al. 2010).

Power can also of course be constituted in many social forms, including in institutions (Barnett & Duvall 2005); networks (Rambukkana 2015); cultures (Edwards 2007); organisations (Clegg & Hardy 1999), practices (Pinch & Swedberg 2008) and imaginations (Felt et al. 2007). Each possibly acting in different directions in any given setting, every one of these aspects, in some way or another, also seems relevant in principle to the political dynamics that bear on the current inquiry. But all in all, though there emerge many highly salient insights, social and political theory taken as a whole seem to hold very few self-evidently compelling implications for practical analysis of policy processes underlying commitments like those of UK Governments to nuclear power. The sorts of framework adopted at the outset can exert important repercussions over the forms of the findings that emerge at the end. Yet these starting points typically rely more on (sub)disciplinary affiliations of the subjects in the research process, than on any intrinsic features of the objects.

It is important to do whatever is possible, then, to mitigate this syndrome of 'epistemic blinkers' (Joseph & Roberts 2004) or 'cognitive lock-in' (Pestre 2007). Here, one general canonical strand in social and political thought that variously forms a precursor, descendant, constituent or relational counterpoint for all the specific approaches identified above to the topic of power, is the classical heuristic dualistic contrast between structure and agency (Giddens 1984; Archer 2010; Parker 2010). Immanent across many otherwise diverse dimensions in all the above notions of power, this distinction offers one concrete starting point for a broad straightforward characterisation of the most central features of power dynamics that are widely recognisable across all approaches of relevance to the present study – so one that might be considered to threaten least to prejudge the kinds of answers that are obtained in an enquiry like this. This is, that power in all its forms and contexts involves various kinds of ***asymmetry***. So arguably the most usefully distinguishable and applicable 'principal components' (Parsons 1954, p.239; Gilbert & Conte 1995, p.137) in the manifold constitutings of these asymmetries, may heuristically be apprehended in terms of structuring of – or by – agency. Thus emerges a relatively straightforward and operational general notion of power, as: '*asymmetrically structuring agency*' (Stirling 2014). It is through asymmetries in societal agencies and structures of all kinds (and in their mutually constituting relations) that any form of entrenched political or economic interest (like those around nuclear power) is established, maintained and – eventually – dissolved (Stegmaier et al. 2012).

In these terms, power is a plural, multidimensional, relational process, in which agencies of many kinds and in many contexts are at the same time structuring, whilst also themselves being structured. Seen like this, power is 'polythetic' – in the sense that it will manifest in any given view or setting, in far more plural ways than can adequately be captured by the concepts used to try to understand it (Needham 1975). Conditions for maintenance or challenge of nuclear technologies, for instance, may vary radically from setting to setting – collectively displaying a number of dimensions which no one case may manifest in full (Koopmans & Duyvendak 1995; Baigorri et al. 2012). So any given categorical scheme for understanding power will always

miss crucial 'rhizomic' connections, exceptions and sources of surprises (Deleuze & Guattari 1987). But despite these complexities and abstractions, one practical implication that arises in all contexts for apprehension of power, is inherent to the above diagnostic property of asymmetry. Whatever happen to be the salient 'gradients of asymmetry' in the relevant social parameters in any given social context, will serve to give analytic or normative dimensionality to the contemplation of patterns in properties of ***orientation*** in power asymmetries – like an orientation for or against a particular normative commitment such as that to nuclear power or its alternatives.

Whilst it cannot be expected that the multiple orientations of power asymmetries in any given setting will be aligned, the '*patterns of alignments*' may nonetheless be of interest (Martin 2011, p.305). So a useful focus for an inquiry like the present one, may therefore centrally lie in mapping the patterning of many possible aspects and orientations in these implicated kinds and degrees of *asymmetry*. Indeed, it is with one such putative asymmetry between the patterns of performance and prioritisation of nuclear power in UK energy policy, that this enquiry began (as reviewed in Section 2). Another *prima facie* asymmetry was argued in that section to lie in the distinctiveness of UK nuclear policy when compared with those of many other countries. A third also discussed there is the apparent neglect for posing these very questions. From such a start, then, a series of further hypotheses may be explored to test these initial premises and test further finer-grain asymmetries.

Before turning to more specific implications of these hypotheses for the present case of UK nuclear commitments, it is worth noting one further rather general but still concrete feature of power on which a practical policy analysis like this might focus. This is, that there are strong grounds for expecting that power asymmetries of all kinds (when left undisturbed to their own devices), will tend to be ***self-reinforcing***. As the well-worn aphorism has it: "*the rich get richer and the poor get poorer*" (Watts 2011). Known in other areas as "*the Matthew effect*" – such phenomena of political positive feedback (Greener 2005) and institutional increasing returns (North 2006a) are analytically and empirically well documented (Urry 2003; Arthur 1990; 1995). So this expected propensity of power to self-reinforcement also offers a further potentially useful starting point for the present study. For it is notions of self-reinforcement that lie in turn at the core of a final specific idea in political science that offers particular value in efforts to answer the present research question: the concept of ***incumbency*** (Unruh 2000; Lockwood et al. 2016). And it is, in further turn, the normative and purposive orientation of any given incumbency, that expresses the overall patterns in underlying gradients of asymmetry in various relevant forms of power. Notions of incumbency are thus at the centre of our enquiry.

3b Exploring The Dynamics of Incumbency

Whether deliberate or inadvertent (and constituted in all the ways discussed in the last section) it is dynamics of incumbency, then, that arguably constitute the most relevant and specific *a priori* focus for the questions at the heart of this study concerning UK Government commitments to nuclear power. In one way or another, hypothetically unusual patterns of intensity in elite policy commitments of any kind, can by definition in the broadest of senses be usefully interrogated as possible manifestations of some form of incumbency (Lawrence et al. 2016). Of course, if these patterns of intensity are found to be justified in the substantive terms declared in policy documents, then a clear concept of incumbency is likewise equally important in defining what would thereby effectively be found to be *absent* (or unnecessary to invoke) as a formative force. It is by means of such systematic hypothesis testing, that this analysis seeks to escape the kind of self-fulfilling dynamic noted above.

So, the first hypothesis mentioned in the previous section for informing the framing of this study – '*the 'face value' UK nuclear policy hypothesis* (H1)' – interrogates exactly this point, asking about the degree to which extant official UK energy sector policy evidence and analysis actually do serve to justify the observed pattern of commitments. *If this can be held to be adequate, then it is not necessary to invoke any effects of incumbency*. This hypothesis thereby offers a crucial safeguard in this study, in seeking to falsify the central proposition.

The theoretical background to hypothesis H1 is well trodden turf in policy analysis and political science. Extensive literatures continue to pore over the relative importance and specific applicabilities of various notions of 'rational satisficing' (Simon 1983) or 'muddling through' (Lindblom 1959) in policy making – including specifically around nuclear power (Collingridge 1983; Collingridge 1984; Stirling 1994). This posit starkly contrasting explicit political and policy mechanisms for arriving at the best approximations to optimal outcomes in the public interest. But for the purposes of the present analysis, the differences between these (or with other strands of theory) are secondary (Bendor 2010; Elster 1986). More important, is that instantiations of either extreme kind of finding under this specific application of this hypothesis to the case of UK nuclear policy may resonate with significant bodies of wider support. The hypothesis holding, would reflect a widely distributed assumption in policy analysis that extant policy outcomes may demonstrably be held to reflect explicit extant justifications (Gigerenzer & Selten 2002; Foxon 2007). The hypothesis not holding would reflect equally widely held understandings that political commitments are often manifestly distinct from associated legitimatory claims (Habermas 1976; Wynne 1975; Wynne 2002).

If this 'face value' hypothesis is found to hold, then, the core proposition of this study is refuted – the notion of incumbency would be effectively irrelevant to understanding the persistence of UK civil nuclear commitments. If it does not hold, a series of additional questions apply – to which there are, of course, no shortages of possible answers. The first further general question that arises in this case, would ask '*what exactly is incumbency?*' in this particular setting, such that it might help understand the mismatch between policy evidence and political commitments. In seeking to answer this, diverse particular notions of incumbency are recognisable in organisation theory (Tushman et al. 1985), practice theory (Shove 2003), multilevel governance (Young 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) – all pointing at factors to look out for. Taking all these together in a way that reflects all the diverse dimensions of the above discussion of the kinds of patterns in power asymmetries that constitute incumbency, a summary characterisation to start out with, might be that '*incumbency is a self-reinforcing trajectory in obdurate configurations of actors, practices, interests, infrastructures, institutions and cultures, that dominate in some specific political setting'*. It is the particular nature of this configuration then – the orientation of the trajectory, the specific constituting of obduracies and the identifiable self-reinforcing drivers – that this present study is seeking to interrogate in the case of UK policy commitments to civil nuclear power.

The key further question then becomes, how might the operation of such a phenomenon of incumbency be identified and explored in the present context? More specifically, how might this concept be used to help resolve answers to the present practical research questions concerning exactly what it is that is formatively conditioning the evidently anomalous intensity of UK policy commitments to civil nuclear power (that are duly interrogated in the first hypothesis test [H1])? In typical academic terms, perhaps the most obvious next step in this regard, would be to seek to identify relevant configurations of incumbency in terms of the very category on which the analysis itself focuses, directly as given in the question itself: 'nuclear power'?

This would be the broad kind of approach, for instance, in many different versions of sociotechnical regime theory (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). In short, this would give rise to the '*UK nuclear power entrenchment hypothesis* (H2)', also mentioned in the last section. The answer to our question here effectively takes it for granted (because this is the ontology of the question) that the category 'nuclear power' (or some notion of an associated 'sociotechnical regime') is the constituting locus for the most relevant power gradients and processes involved in asserting and reproducing incumbency. Exactly what might form the constituting media or boundaries of any 'individual regime' are notoriously ambiguous in this literature. But the labels are nonetheless typically clear in specifying a focus to the specific envisaged 'sociotechnical regime' in question. In effect a particular categorical representational label is held unproblematically to map onto an underlying represented phenomenon. To assume this, is obviously expedient to analysis. But to do this uncritically would be to perpetrate a "*fallacy of misplaced concreteness*" (Whitehead 1948; Stirling 2011). In short, why should it necessarily be assumed – other than simply because of the contingent interests of the analyst – that the formative processes stabilising incumbency around nuclear power are necessarily specific to civil nuclear infrastructures themselves – or even energy regimes more generally? Might these not also be seen as a function of wider or deeper structures or agency?

So, the notion of 'misplaced concreteness' may seem a little esoteric, but the implications are very practical. It is common sense of a kind that can often elude elaborate analytical theorising, that – as discussed above – this sort of academic answer to a policy question may simply adopt a version of the terms of the question itself. A query categorised in terms of 'civil nuclear power' (no matter how nuanced, partitioned or aggregated), will likely shape an answer phrased around essentially the same terms. So the main thing apparently learned, may actually be more about the predispositions of the questioner, than any real characteristics of the thing that is questioned. A crucial supplementary query that is often unduly neglected in academic inquiry, then, is to ask whether the cherished disciplinary or policy categories in which the questions are posed, are really also the ones that are most relevant to the framing of answers? Otherwise, academic analysis can too easily be reduced by epistemological lock-in discussed above, under which "*what goes in, is what comes out*".

So, one practical consequence of an avoidance strategy against this syndrome for the present study, might be to take seriously a further alternative hypothesis also mentioned in the last section: that it not necessarily be assumed to be a category called a 'regime' around nuclear power itself, that might automatically be held primarily responsible for maintaining the power asymmetries constituting this particular pattern of intensity of commitment to nuclear power. Instead a quite distinct configuration might be posited as highlighted in another of the hypotheses mentioned earlier, involving '*elite policy actors and their networks*' (H3). Although possibly cross-cutting the structural category of a 'nuclear regime' in various ways, these potential objects of research attention may alternatively be much more circumscribed and opaque, or extensive and visible (Moore & Westley 2011; Tran 2014; Farla et al. 2012; Garud & Karnøe 2003). And they also afford a crucial opportunity to avoid a fixation with different 'levels of structure' and interrogate instead the roles of different kinds of agency that may not necessarily be determined by any kind of recognisable structure at all.

In these terms, there exist many different approaches to incumbency that emphasise roles for agency, rather than the ostensibly inanimate categorical 'structures' in which these are notionally embedded (Pesch 2014;

(Certomà & Tornaghi 2015; Grin et al. 2011; Fischer & Newig 2016). Of course, what may count as 'agency' in this view may also be much more complex and transcendent than often assumed (Knappett & Malafouris 2008; Latour 2005; Callon 1991; Feenberg 1999). But perhaps most significant in this regard, are various kinds of elite social agency, for instance including: advocacy coalitions (Weible et al. 2011); knowledge networks (Stone 2002); policy networks (Skogstad 2008); and policy communities (Jordan 1990). Crucially, these elite networks often span even the broadest notion of what might count as a 'sociotechnical regime'. Indeed this can be a diagnostic functional characteristic of deeper and more extensive forms of this phenomenon like power elites (Wedel 2014) and shadow networks (Söderbaum 2004). Either way, such configurations of agency and their onward linkages may 'rhizomically' conflate and subdivide the usual ontologies of regimes (Ernstson 2008; Steinberg 2008; Galloway & Thacker 2007) – defying conventional prior assumptions about neatly-partitioned 'levels', 'scales', 'systems', 'sectors' or 'regimes' (Stirling 2016; Stirling & Arora 2015).

It is in this way, that hypotheses about the nature of incumbency can avoid undue fixation with structure, anad also address agency. But there is a still further (and for present purposes, final) broad kind of answer that might be looked for to the question of why UK Governments remain so persistently attached to nuclear power. This moves beyond the potentially-reified and often unduly circumscribed structural categories of 'regimes' (in H2) or configurations of agency in 'networks' (in H3), to combine elements of both in ways that are also more open to the polythetic, processual and relational features of power discussed at the beginning of this section. It is this possible answer to the question that is addressed by the fourth hypothesis mentioned earlier, '*the UK deep incumbency hypothesis* (H4)'. Drawing on aspects that also feature in structural-categorical and agency-network understandings, this can additionally highlight the often-neglected aspects of power dynamics as polythetic, processual and relational – extending in principle across an entire political structure and culture, yet often formatively confined in its dynamics, intimate in its settings and so opaque to easy scrutiny.

Few might be expected to be more aware of this particular form of manifestation of incumbency, than those actors most closely implicated in it. So it is interesting that a basic model for this kind of answer to the question was so clearly outlined in President Dwight Eisenhower's famous identification of '*the military industrial complex*' (Hartung 2011; Pavelec 2010) in 1950s USA. Spanning different industrial sectors, pervading wider cultures and penetrating far more deeply into the elite levels of the state than is typically achieved by any individual 'sociotechnical regime', the phenomenon noticed by President Eisenhower (although not elaborated in any of the present ways) offers a fruitful framework for thinking about the potentially pervasive polythetic, relational and processual features of incumbency – encompassing both structural-categorical and agency-network characteristics.

In considering the possible relevance of this kind of 'deep incumbency complex' for the present study, it is important to note, that there is no shortage of prior recognition for similar possible phenomena elsewhere. Essentially converging ideas are increasingly emerging in various branches of political science, including notions of 'deep structures' (Grover & Peschek 2014), 'dual states' (Fraenkel 2010), 'double government' (Glennon 2014) and (especially around nuclear power) 'subgovernment' (Temples 1980). What is thus distinctive and innovative in these notions, is that they allow avoidance of prior assumptions (of kinds that can be self-fulfilling in research) – that incumbency is a single phenomenon; or that constituting processes, relations and asymmetries in power gradients are necessarily restricted to specific industrial sectors, institutional structures or technological infrastructures. Under this view, it is acknowledged that they may subsume, transcend or rhizomically cross-cut notions of particular networks of agency or structural categories like sociotechnical regimes.

Nor should it somehow be thought eccentric to consider applying such notions of 'deep incumbency complex' specifically to the UK. Academic commentators and analysts over the years have repeatedly pointed to dynamics of incumbency in this setting that they variously refer to as the 'deep state' (Ramsay 2015)(Barnett 2010), 'warfare state' (Edgerton 2006) and 'national security state' (Hogan 1998). In each case, trajectories of

incumbency are recognised to span public, private and academic sectors, including (crucially) the highest levels of government, civil service and corporate ownership. Mediated by opaque elite networks and agency, these are nonetheless embodied in – and conditioned by – many kinds of structure cross-cutting typical notions of individual sociotechnical regimes. So, although the hypothesis of a 'deep incumbency complex' is novel and innovative in precisely the terms presented here, it is nonetheless grounded in a considerable body of prior empirical research specifically focusing on the UK, as well as on other geopolitical settings.

As such, it can be argued at least for the purposes of prima facie hypothesis development, that a concept of 'deep incumbency' allows balanced attention informed by the full variety of views on power more generally, for instance around organisational fields (Smith & Stirling 2008; Schubert et al. 2013), corporate strategy (Valikangas 2010), firm behaviour (Bessant et al. 2005) or communities of practice (Schiavone 2014) – and whether viewed under the 'multilevel perspective' or more general 'regime theory' (Stegmaier et al. 2012). It includes, but transcends, specific kinds of path dependency (Pierson 2000), both within organisations (Sydow et al. 2009; Schreyögg 2011) and innovation systems (Edquist 1997). For the latter, it avoids privileging a particular national (IRENA 2014), regional (Späth & Rohracher 2010), sectoral (Malerba 2004) or functional (Hekkert & Negro 2009) view of 'the system'. Accordingly, it allows unbiased methodological scrutiny of diverse self-reinforcing mechanisms in 'sociotechnical systems' (Meadowcroft 2009) variously referred to as: 'autonomy' (Winner 1977), 'lock-in' (Arthur 1989), 'obduracy' (Hommels 2005), 'endogenous renewal' (Berkhout et al. 2004), 'entrenchment' (Collingridge 1979), 'momentum' (Hughes 1983) and 'entrapment' (Walker 2000). Thus equipped with an understanding of the theoretical background to the four hypotheses introduced here, it is possible now to proceed to consider the appropriate methodologies by which they might best be interrogated.

It is in all these ways, that a more than usually pervasive, relational and processual concept of 'incumbency' (in the deep incumbency hypothesis considered here – H4) can go beyond misplaced concreteness in more circumscribed notions of sociotechnical regimes (as represented here in the nuclear entrenchment hypothesis – H2). This idea of 'deep incumbency' does not depend on the drawing of sharp boundaries between a few ostensibly discrete and notionally contrasting different 'levels of structuration' (Turnheim et al. 2015). Instead, it recognises that essentially similar 'fractal' processes of self-reinforcement may characterise otherwise diverse asymmetries of power in every imaginable level and context (Stirling 2010). As such, conceiving instead a continuum in contrasting depths of incumbency allows consideration of relations and processes that may radically span (and rhizomically infiltrate – Stirling & Arora 2015) supposedly separate levels or categorical divides – for instance between notionally different regimes (Stirling 2016).

In this way, the concept of deep incumbency can at the same time and equally mobilise ideas of 'structure' and 'agency'. With underlying notions of power dynamics seen in similarly integrative processual terms as 'asymmetrically structuring agency' (Stirling 2014), the particular structures or networks of agency that are most salient in any given context, need not be expediently assumed to be coterminous with whatever happen to be the (apparently concretely) named empirical categories of 'system' or 'sector' (like 'nuclear power'). Constituting relations and processes can instead be recognised intimately to connect highly specific parts of otherwise sharply distinct phenomena (like 'military' and 'energy' systems), without requiring any assumption that these disparate-but-connected systems are thereby somehow thereby being aggregated in their entirety. And in its deepest forms, a concept of 'deep incumbency' (like that hypothetically envisaged here as spanning aspects of military and civilian nuclear commitments), might be expected to penetrate not only the highest levels of Government and deepest foundations of the State, but also (as with notions of global 'regime complex' – Fine 2007; Baker et al. 2014; Raustiala & Victor 2004; Keohane & Victor 2011; Biermann et al. 2009; Carcelli et al. 2014; Mallard 2014) – potentially also even more widely relevant international orders.

Section 4: Methodological Approach Employed in this Study

4a: Overview of the Main Hypotheses Framing this Analysis

As outlined in general terms in the introduction and discussed in the previous section, the hypotheses considered for this study are drawn by reference to diverse frameworks for understanding different notions of incumbency variously developed in political science (Baumgartner & Leech 1998; Pierson 2000), political economy (North 2006b), policy analysis (Roe 1994), management science (Chandy & Tellis 2000), organisation theory (Tushman et al. 1985), institutional theory (Steinmo et al. 1992), multilevel governance (Young et al. 2008), practice theory (Shove 2003), energy policy (Finon & Midttum 2005), innovation research (Walker 2000), technology studies (Unruh 2000) and transition management (Geels 2004). With each hypothesis informed by a number of frameworks, each displays different strengths and weaknesses. A few are quite obvious. Many are relatively well explored in other studies. All are likely to play at least some role in the processes under scrutiny. With an emphasis on the most innovative and neglected aspects, all will be systematically tested in this working paper. This section will outline the methods used to investigate each hypothesis in this study.

As discussed above, the '*face value UK nuclear policy hypothesis*' (H1) is a 'default' perspective, under which official British governmental prioritisations of civil nuclear power are taken at face value – and seen as a straightforward reflection of careful administrative processes of 'rational satisficing' in the face of complex policy challenges. In other words, elite official UK support for nuclear power is here seen simply to reflect good faith official interpretations of available evidence for the relative performance of this energy option under stated criteria concerning issues like competitiveness, security and environment. Testing this primarily involves careful evaluation of available evidence under declared policy criteria. The purpose is to build up a general picture across a range of different priority policy areas, as to whether it is a manifest superiority of nuclear performance that warrants the intensity of policy commitment. With some key issues already foreshadowed in the introduction, these aspects will be reviewed in Section 9.

The second hypothesis posits that this longstanding official UK preference for nuclear power reflects pressures from an especially powerful and deeply entrenched national civil nuclear energy industry. As reviewed in the last section, this relates to prominent kinds of structural analysis in institutional theory, notions of 'lock-in' in innovation systems literatures, ideas about the workings of 'sociotechnical regimes' in transitions research and 'sociotechnical imaginaries' in science and technology studies. Here, the basic central argument is that the entrenched structural interests around nuclear power are somehow more influential in elite British policy making than they are in some other countries (like Germany) where this sector may in fact be larger or more successful. This is why it is called the *'entrenched UK nuclear power regime hypothesis*' (H2). Testing this involves using diverse kinds of documentation and elicitation to examine the inner structural workings of the sociotechnical system around nuclear power (Yang & Miller 2008)(Babbie 2013).

The third hypothesis is less overt and structural – and relatively more covert and relational. This holds UK nuclear policy to have been strongly influenced largely "*behind closed doors*" (Taylor 2016), either by particular well-placed or persuasive individual elite policy actors, or by small networks of organisations in a wider (for example) 'advocacy coalition' (Sabatier & Weible 2007) expressing especially strong value commitments or material interests in nuclear power. Pejoratively (and somewhat emptily and misleadingly) caricatured as a kind of a 'conspiracy theory' (Sunstein 2014; Runciman 2016; Clarke 2015), this sort of explanation is often referred to in retrospective anecdotes in policy debates about UK nuclear power (Jewell 2015). Contrasting variants, for instance, place emphases on supposedly formative roles played by lobbying by key individual

nuclear proponents, or an enthusiastic government Chief Scientist, or the French state electricity supplier EDF. A possible amplifying factor in such understandings involves the particular nature of elite UK policy cultures, in that these may in comparative terms present an especially conducive environment for this kind of elite interpersonal networking and negotiation (Jasanoff 2005). This is why it is called the *'elite policy actors and networks hypothesis'* (H3). Leaving less of a necessary imprint in formal policy documentation, testing this would rely much more on the testimony of elite informants – incurring all the intractable difficulties of 'studying up' (Forsythe 1980; Abbink & Salverda 2013).

The fourth and final major hypothesis centres on a body of wider analysis in political science and institutional theory reviewed in the last chapter, concerning a more deeply-structured phenomenon in the high-level dynamics of power, variously referred to in terms such as a UK "deep state" (Barnett 2010). Addressing political configurations notionally extending beyond the nuclear power industry alone (and so different from H2 or H3), this is therefore called the *'UK deep incumbency complex hypothesis'* (H4). This involves elements equally of formal structures and less formal agency, so implicating evidence for testing of all kinds mentioned so far. Although involving covert elite interpersonal processes, it also implicates much more overtly structured interests at the largest of political scales (Heyman 2004).

In this particular case, the focus in this latter regard – and associated evidence under scrutiny – is actually highly specific and very concrete: it is about the perceived policy imperative to retain what a burgeoning UK defence policy literature calls 'nuclear submarine capabilities' (Schank et al. 2007). With nuclear-propelled submarines held (as shall be shown) to serve an essential function in making wider British strategic nuclear weapons capabilities militarily credible, this arguably reflects a wider perceived political imperative that arguably deeply pervades elite British policy cultures: to maintain a distinctive British geopolitical and military identity on the world stage. It is important to emphasise that this hypothesis is *not* about vague general links between military and civilian nuclear technologies (for example such as those often discussed historically around fissile materials). As will also be shown, this has been quite well explored in the past. What is in focus here, very specifically concerns capabilities to build and operate nuclear submarines in particular.

As already mentioned, it is not argued that these hypotheses are individually definitive or collectively comprehensive in any explanatory sense. In line with a classical strand in the epistemology of sociology and political science, circumstances render it necessary they be seen more as aids to interpretive understanding of formative processes (*verstehen*) than as deterministic causal explanations (*erklaren*) (Hollis & Smith 1991) (Hasenclever et al. 1997). For the purposes of policy analysis in such a hotly contested, complex – and often confidential – area, then they are developed simply as a heuristic means to structure a systematic, transparent and accountable research process. The hope is, that this framework will facilitate criticism and thus help foster more robust onward understandings in the most general of senses. As discussions proceeds, further details on the nature and rationales behind these hypotheses will be illuminated.

4b: Testing the 'Deep Incumbency Hypothesis'

In order to interrogate the evidence in support or in opposition to the *UK deep incumbency complex hypothesis* (H4), this focal argument can – for purposes of analytical rigour – be divided into a series of successively more precisely-defined propositions. Carefully and systematically revisiting in more detail all the key points made in the introduction above, doing this should ease the clarity of the analysis in the following sections of this paper.

The most basic of these component propositions is that the UK Government is indeed committed both to a '*nuclear renaissance*' and to the maintaining of military nuclear capabilities associated with national infrastructures for building and operating nuclear-propelled submarines. Saying nothing in itself about the direction of any formative effects, this might be referred to as the '*UK civil and military nuclear policy imperatives proposition'* (proposition H4a). It will be explored in Section 5. To test this proposition, we conducted a comprehensive and systematic literature review of academic, policy and grey documentation bearing on each of these areas. In order to identify key long-run policy processes and lineages in political aims, we devoted particular attention to tracing a historical timeline of perceived imperatives declared in major civil and military nuclear policy documents running from the immediate post-war period to present-day policy-making. Reducing vulnerabilities to particular conditioning factors and general background 'noise' attending individual policy interventions, this should more clearly illuminate the nature of the long-run declared policy priorities.

Having established whether these twin UK civil and military policy priorities do indeed exist (at least as declared imperatives), the next step in the analysis is to substantiate the nature of any relationships between them. Crucially in this step, the dearth of high profile acknowledgements of any linkages, will not necessarily be accepted at face value. This is because it is at least possible that policy imperatives can exist, but be seriously under-declared in public documentation. So, this part of the analysis involves testing a proposition that there are substantive formative linkages between UK Government commitments to renewing civil nuclear power and the priority of maintaining of national capabilities to sustain nuclear propulsion infrastructures for military submarines, of kinds and intensities that are not fully and openly declared in public policy debates. This proposition will be called the '*the under-visible UK civil / military linkages proposition* (H4b)'. It will be explored in Section 6.

A number of steps are required in order to test whether these formative linkages exist (despite the fact that they are virtually entirely un-mentioned either in UK energy policy documentation itself or in wider critical commentary). The first step was to undertake a systematic document search in order to identify find all significant industry, policy and consultancy documents relating to either civilian or military UK nuclear activities. These documents were found by means of a snowballing process, involving the location of other relevant documents mentioned in (or associated with actors mentioned in) each paper. Within the resulting large concourse of documents, a number of key word searches were then carried out in order to find any passages potentially relating to cross-overs between the civilian and military nuclear sectors.[5]

In a second specific step after this, we interrogated the extent to which particular companies implicated in this documentation in the civilian nuclear supply chain are also involved in the military supply chain (and vice versa). The relative opacity of this field required the use of various online resources and policy and industry publications, in order to find as many companies as possible involved in the supply chain for UK nuclear submarines and UK nuclear power stations, as well as all companies that have been offered contracts for the new Hinkley C power plant. Involving a total of 46 companies, this information was triangulated using the Orbis database (OECD-Orbis 2016), which was also used to check for ownership structures and subsidiaries of the companies involved.

A third and final step relevant to this stage of the methodological design – as well as to the broad validation and stress-testing of other elements of the analysis – was the conduct of a small set of semi-structured scoping interviews with four key experts from the UK nuclear sector to target specific queries arising in the document review. Selected on the basis of their involvement with key organisations that have been centrally active in both civilian and military nuclear activities, these interviews were in no sense comprehensive or exhaustive. It is in the nature both of elite interview methods in general (Richards 1996), as well as in this specific field of enquiry in particular, that serious questions can be raised over the extent to which respondents may be able (or wish) to be fully candid (Gillham 2000; Halperin & Heath 2012; Bogner et al. 2009). This is a dilemma widely recognised in the literature on 'studying up', where even access to interviews is not to be taken for granted, let alone what is said (Schneider 2012). This applies especially on issues of such intense political contestation as the present topic and even more so where there are (as here) strongly-perceived industrial or national security imperatives for secrecy. So no argument may fully or confidently be based either way, on information gathered by means of such interviews.

Nonetheless, the interviews were very useful in deductively triangulating questions and inductively shaping interpretations that emerged in more systematic and readily documentable ways from the literature analysis (Somekh & Lewin 2005; Berg 2001; Charmaz 2006). The interviews were also very useful in an abductive mode, suggesting new aspects of hypotheses that may have been previously unconsidered. So, we are accordingly extremely grateful to our anonymous interviewees, for the detail and candour with which they did feel able to engage under the circumstances. Also very helpful in all these regards were a very large number of wider and less formally structured conversations with other experts from many disciplines and perspectives, made possible during the long process of this research in response to five seminars given by members of the research team and in to 4 blogposts (Johnstone & Stirling 2015a; Johnstone & Stirling 2015b; Stirling & Johnstone 2016; Phil Johnstone & Stirling 2015b) and one article for *The Spokesman* (Johnstone & Stirling 2016). Although for reasons of research ethics and rigorous transparent analysis, neither interviews nor wider conversations can bear a loadbearing role in the resulting analysis, the evidence and experience provided by these means has nevertheless been invaluable to us in cautiously testing, triangulating and further developing more nuanced questions and fine grain interpretations than would otherwise have been possible. Unfortunately, only some of these informants can be identified in our acknowledgements, but we remain extremely grateful to all of them.

Moving on from establishing and exploring the nature of any apparent linkages between civil and military nuclear commitments in a broad sense, then, we then investigated evidence suggesting any more substantive kinds of formative relationship between these two otherwise quite distinct areas of UK policy (section 7). In this regard, Proposition H4c refers to the idea that the distinctive intensity of official UK commitments to nuclear power can credibly be seen to *depend upon* the ostensibly separate policy aim to sustain military nuclear submarine capabilities at some requisite level of scale and economic viability. This will be called the '*the UK nuclear submarine dependency proposition* (H4c)'. With the implicated direction of the causality constituting an especially strong challenge to analysis, this proposition was tested using additional evidence gathered from all the documents and interviews described in the preceding paragraphs. This was investigated using further more specifically-targeted and fine-grain forms of all the research methods reviewed above. Finally, for the fourth specific proposition constituting the general 'deep incumbency hypothesis' (H4), our attention again takes a historical turn, but this time in relation to a specific critical juncture. Emerging in the initial, broader historical analysis mentioned above, the focus here is on the radical turnaround in UK Government civil nuclear policy that occurred in a period running from the beginning of 2003 to the end of 2006. This marks the interval between authoritative UK Government policy statements that nuclear power was "unattractive" (DTI 2003), to assertions by the Prime Minister that "nuclear power is back with a vengeance" (BBC News 2007). If elite UK civil nuclear commitments are indeed dependent (in ways that are under-visible) on officially-perceived imperatives to maintain nuclear submarine capabilities, then this period should

constitute the critical juncture when these dependencies are *most* visible. This will be the pivotal proposition in this study, which we refer to as the '*the 2003-6 policy reversal proposition* (H4d)'.

To test this final proposition (discussed in section 8), we created a timeline for all major policy initiatives, reports, commercial developments and campaigning activities relating to UK civil nuclear energy, nuclear new-build, nuclear propulsion and nuclear submarines manufacture, from the mid-1950s until the inception of this paper at the beginning of 2015. Firstly, systematic Google searches were carried out by adding the word 'policy' to each of the search terms which had been used for testing propositions H4b and H4c. Government archives were then checked for any additional policy documents which the document search process may have missed. Next, the reference lists of all these documents were searched, as well as any 'supporting documents' mentioned. Google and Lexis Nexis were used to search for media coverage of commercial developments and campaigning activities, using the same search terms listed previously. Finally, this information was corroborated with further information from Hennessy and Jinks (2016), and from statements and recommendations by the interviewees (as well as the many other colleagues and wider contacts working in this field with whom we engaged as described above).

Section 5: How Intense are UK Policy Commitments to Civil and Military Nuclear Infrastructures?

5a: UK Policy Commitments to Civilian Nuclear Power

Evidence for strongly-felt policy imperatives to maintain nuclear electricity infrastructures in the UK can be traced back to the earliest days of this technology in the post-war period, a time of dynamic industrial renewal and technological optimism in the UK (Cockroft 2006). When the British Queen switched on the world's first nuclear power station at Calder Hall in 1956, she reflected on the prevailing crisis in energy supply to declare a "bright future" for nuclear power: *"Today we are in a sense seeing a solution of that crisis as this new power, which has proved itself to be such a terrifying weapon of destruction, is harnessed for the first time for the common good of our community."* (newsletter.co.uk). The Lord Privy Seal Richard Butler stated at the time that "*It may be that after 1965 every new power station being built will be an atomic power station*" (BBC 1956). In this same heady climate, the chairman of the US Atomic Energy Commission had said two years before that "*our children will enjoy in their homes, electrical energy too cheap to meter*" (New York Times, 17th September 1954) – a sentiment that subsequently became very widely quoted.

Although somewhat tarnished by the passage of time since the 1950s, the general tone of enthusiastic exceptionalism for civil nuclear power has – by and large and with only a few exceptions (the most important being analysis later in this study) – been consistently maintained over more than half a century. As we shall see, it is still recognisable in the intensity of present-day UK policy commitments. Yet right from the outset, there has been a consistent pattern of failure to deliver on ostentatiously ambitious plans. The 1955 *White Paper on Nuclear* outlined a construction programme for 5-6 GWe of nuclear power to be constructed by 1965 (HM Government, 1955), which was scaled back to 3 GWe in 1960 (Aldred & Starkey 2013). In 1964, the UK's 'second nuclear programme' was announced on the basis that at least 5 GWe of new nuclear capacity (increased to 8 GWe in 1965), would need to be built between 1970-1976. None of the new reactors came online until the mid 1980s, and the declared capacity requirements were not met by nuclear power (National Archives, 2016).

The third UK nuclear programme was announced in 1979 by Energy Secretary David Howell, referring to nuclear as "*a cheaper form of electricity generation than any known to man*" (Howell quoted in Aldred and Soddard, 2016). Again the 'need' for nuclear was very firmly asserted, with Howell stating in Parliament that: "*it will be difficult, if not impossible, to meet this country's long-term energy needs without a sizeable contribution from nuclear power*", going on to announce the "*need to order at least one new nuclear power station a year in the decade from 1982, or a programme of the order of 15,000 megawatts over 10 years*" (Howell quoted in Hansard 1979). Yet this programme of 15 GWe in the end amounted to just one new reactor, Sizewell B, with a size of around 1.2 GWe being constructed (IAEA 2016b). Then in the final stages of the Hinkley C public inquiry in the late 1980s Lord Silsoe from the CEGB again put forward the case that it would be "extremely challenging" to maintain UK electricity supply unless large amounts of new nuclear capacity was constructed by 2005 (Proceedings from the Hinkley C inquiry, 1990).Yet again, no additional capacity was initiated at all after this point – and no such difficulties ensued.

Despite the rocky recent history around the Hinkley Point C project (Thomas 2016), immediately current statements by senior members of the new post-BREXIT Conservative Government are redolent with similarly implacable faith that nuclear power – seemingly as a matter of principle – must hold a central place in UK energy strategies. In one of his first interviews as new Chancellor of the Exchequer on the BBC Today Programme Phil Hammond MP underscored that new nuclear "*must go ahead*" (Hammond quoted in Macalister 2016b). The new Secretary for the Environment and Rural Affairs, Andrea Leadsom, outlined that there were proposals to "*develop 18GW of new nuclear power at six sites across the UK*" (Leadsom 2016). Greg

Clark, new Secretary of State for Business, Energy and Industrial Strategy as one of his first major actions, undertook a 'nuclear energy mission' to Japan to drum up funds for nuclear investment in the UK from Hitachi and Toshiba (Collingridge 2016).

These are actions taken in the context of what can be considered as the fourth official UK nuclear power programme. The White Paper *Our Energy Future* (2008) made official the already-declared UK Government position that new nuclear power "*should have a role to play*". This latest form of UK nuclear commitment was originally based around a proposed 16 GWe of new generating capacity being constructed (DECC 2011b)This figure was set out in the *National Policy Statement EN-1* where the overarching energy plan included "*…proposals for 16 GW of new nuclear power generation capacity by the end of 2025*" (DECC 2011b:30). As reported by the World Nuclear Association, a main global nuclear industry body, "*Government ministers have consistently said that 16 GWe of new nuclear capacity should be built at five sites by 2025, though this target date has slipped to 2030*" (World Nuclear Association 2016a).

It had been outlined that there was an "*urgent need*" for nuclear power stations (DECC 2011a: 10) and this was not only based around climate change targets, but that nuclear was needed to 'keep the lights on'. In 2013, then Prime Minister David Cameron described nuclear as "*vital*" for Britain's "*long term economic plan*", (David Cameron quoted in Dominiczak 2013), and Energy Secretary Ed Davey stated: *"if people at home want to be able to keep watching the television, be able to turn the kettle on and benefit from electricity, we've got to make these investments. It's essential to keep the lights on and to power British business" (*Ed Davey quoted in Dominiczak 2013)

In 2015 nuclear's purportedly 'essential' role for 'keeping the lights on' was also restated by the then newly appointed Energy Secretary Amber Rudd in her maiden speech on the UK's energy trajectory (Rudd 2015). This followed on from some quite extraordinary high-level sentiment expressed with the voice of scientific authority by the Government's Chief Scientific Advisory, Sir David King in the build up to the confirmation of the present nuclear programme, in declaring repeatedly that commitments to nuclear power were not a simply a matter choice, but "essential" in order to "*combat global warming and still keep the lights on*" (Walker & King 2008). Rather than being one low-carbon energy choice amongst others, Sir David regularly asserted that nuclear was in fact "*a scientific necessity*" (King 2005) and that the UK had has "*no alternative to nuclear power*" (King 2006). With similar sentiments also expressed by King's successors in the role of Chief Scientist, what is notable is the lack of qualification. It will be discussed later in this study quite how accurate is this picture of 'no alternatives' in relation to currently extant government policy data. But the point for now, is that the intensity and uncompromising tone – as a claimed matter of science rather than merely policy – could hardly be more stark.

Of course, the difficulty in justifying such unqualified assertions would regularly take its toll, with various protagonists periodically acknowledging under pressure that the lights *would*, in fact, stay on even without nuclear deals going ahead (Carrington 2016). Perhaps most interesting, was the striking reversal of Sir David King's own personal position after he left office. Without elaborating on the remarkable change of emphasis, he did acknowledge publicly in 2014 that nuclear would in fact "*not be needed*" for a low carbon transition, which could be achieved solely through renewables and energy storage (Lean 2014). But, though the magnitudes of these rhetorics have ebbed and flowed with currents of debate and qualities of interrogation, what has remained constant over the past decade is the intensity of the underlying material policy commitments, under which official sources quite simply never question that nuclear power must necessarily remain part of future energy plans.

What can be very clearly seen throughout the history of nuclear power in the UK, then, is a consistent picture of implacably strong policy commitments to large nuclear capacity, typically based around rhetorics under which this is claimed to be "necessary" or "essential" in order to "keep the lights on" (or, also, more recently,

tackle climate change). Yet over a succession of four distinct very large announced programmes following this pattern, the envisaged level of new build has either not materialised at all, or remained very far short of what was initially declared to be “essential”. In no earlier case, have the firmly asserted adverse consequences actually eventuated. It is on these grounds, that it can confidently be concluded in relation to our first proposition that – albeit strongly contested in particular quarters – a perceived imperative to maintain civil nuclear infrastructures has played a continuously prominent (if not dominant) role in elite UK policy discourse over the past half century.

5b: UK Policy Commitments to Military Nuclear Capabilities

As is amply demonstrated by current high-profile policy controversies over the replacing of the existing UK Trident ballistic missile submarine fleet (Dorman 2016; Beale 2015; North West Evening Mail 2016; Edwards 2014; Mortimer 2015b), the retention of nuclear-propelled submarines has also long been seen by both major UK political parties as being crucial to British military power and wider 'national security' (Blair 2006) This is because a fleet of at least three or four nuclear-powered ballistic missile boats is widely regarded as the minimum credible platform for deployment of British strategic nuclear weapons, a position that has existed since the early 1960s (Hennessy and Jinks 2016). The renewal of this so-called 'deterrent' has according to government figures risen from £25 billion in 2014, to £31 billion (MoD, 2015), however other analysts have put life time costs at £205 billion (Burke, 2016). Although the MoD denies this figure, they also refuse to provide any lifetime cost, but regardless, it is clear from figures available that the financial commitment will be immense.

Not only do the capabilities embodied in nuclear propelled-ballistic missile submarines form a central pillar of military strategy (Ministry Of Defence 2005); they are also seen as constituting a key element in contemporary British national identities more generally (especially those at the highest political levels in Whitehall and the major parties) (Ritchie 2014). The imperative perceived by UK policy elites to possess nuclear weapons was eloquently expressed by Ernest Bevan, a leading figure in Attlee's Labour administration (1945-51): "*We've got to have this thing over here whatever it costs [and] we've got to have the bloody Union Jack on top of it*" (reported in Ian Jack, 'Trident: the British question', Guardian, 2016).

Indeed, over the period since the Second World War, few sentiments are more treasured in elite British strategic policy discourse than expressions of pride in the way that the UK "*punches above its weight*" (Cockburn 2011) on the international stage .This perceived national quality is repeatedly identified with what is variously referred to as the international "*status*" (Holden & Maclellan 2016) or "*standing*" (Coughlin 2015) conferred by national military nuclear capabilities (Ritchie 2012). It is also clear that the "top table" of permanent seats at the UN Security Council is entirely, de facto, occupied by formally-recognised nuclear weapons states (USA, Russia, UK, France and China) (see Figure 3 below). It is widely discussed that ambitions to sustain Britain's position at this 'top table' may be a driving factor in motivations to maintain a recognised militarily-credible nuclear weapons capability (Barckham & Norton-Taylor 2010). Such a view, for instance, has been emphasised by Britain's key ally the United States, with a rare intervention by US Defence Secretary Ash Carter holding that the UK needs to maintain its nuclear weapons capability in order to continue its "*outsized role in the world*" (quoted in Cowburn 2016).

To maintain the performance of such 'standing' on the world stage through nuclear weapons capability, the UK has since 1969 relied on a system of 'Continuous-At-Sea-Deterrence', based on 'round the clock' patrols (Royal Navy, 2016). Aims to develop this extraordinary capability go back to 1950, when the case was first made that mastering technological developments around nuclear submarine propulsion were essential to sustain the image of Britain's power at sea, with the Admiralty concluding that "*the atomic submarine will be a much more effective weapon…than any submarine so far produced*" (Hennessy and Jinks: 133). At Harwell in the 1950s research into nuclear propulsion intensified conducted by a "navy/civil team" tied into Harwell's other research on the main UK civil nuclear programme (Hennessy and Jinks 2016: 135). It was not until 1958 and the transfer of a nuclear reactor for submarine propulsion under the Mutual Defence Agreement with the USA, that the UK began construction of an operational submarine with a reactor developed by Rolls Royce, with the first British built nuclear submarine completed at Vickers Shipyard in Barrow-in-Furness in 1963.

By this time, of course, the UK had already developed nuclear weapons, with delivery of this capability initially forming a responsibility of the Royal Air Force. But with the development of nuclear submarine propulsion, and perceived increasing risks to land-based or air-based nuclear weapons systems, the British Nuclear Deterrent Study Group (BNDSG) concluded in 1962 that *"if we are to continue to deploy an independent strategic deterrent, the only sensible policy remaining would be a Polaris type submarine"* (quoted in Hennessy and Jinks, 2016: 209). As Hennessy and Jinks go on to illustrate, the submarine nuclear propulsion based nuclear weapons system "*combined the advantages of land-based ballistic missiles with the flexibility of air-launched missiles with the disadvantages of neither*" (ibid: 201). The policy for an at-sea "deterrent" system was confirmed through the Nassau Agreement between Harold Macmillan and President Kennedy signed in 1963 for the development of the *Polaris* SSBN submarine.

There was a period of potential instability in the 1964 election as Harold Wilson's Labour Party campaigned on a manifesto that included policies for nuclear disarmament. However this position was almost immediately reversed once the Labour party gained power. Hennessy and Jinks (2016) discuss this abrupt about-turn, noting that the previous Conservative Government had put immense pressure on the speedy development of Polaris submarine so that so much development and expenditure would have taken place once Labour had come to power that they would "*face quite a large bill should they decide to cancel it*" the logic being that "*if enough progress could be achieved and sufficient money firmly committed by the time of the election, the future would be more assured*" (Sir Hugh Mackenzie quoted in Hennessy and Jinks, 2016: 238). Similarly, the Conservative Party were said to have 'bombarded' the Barrow shipyard with campaign material around this issue: campaigning that "[Harold] Wilson's anti-Polaris means a defenceless Britain and a destitute Barrow". Labour MP Walter Monslow remarked that he had "*never known such scare tactics*" that had "*a tone of jingoism at its worst*" (Monslow quoted in Hennessy and Jinks, 2016: 239). Soon after coming to power, Harold Wilson had concluded that abandoning Polaris was not an option, and remarked that the deterrent "*had an emotional appeal to the man in the pub*" (Wilson quoted in Hennessy and Jinks, 2016: 243).

In 1968 the first *Polaris* submarine set sail, beginning the UK's strategic sea-based nuclear "deterrent" that has apparently been on patrol for every minute of every day since April 1969 (Royal Navy 2016), and apart from the earliest days of the Harold Wilson Government in 1964, successive UK Governments have committed to maintaining and renewing the continuous-based-deterrent without fail. This intense commitment is further demonstrated in the 1970s. While the Labour Manifesto had appeared again to be 'open minded' about Trident replacement, in actual fact a secret working group established in 1977, called the 'Restricted Group' had been working to establish how the replacement of Polaris would be achieved, and The *Duff Mason Report* exploring the pros and cons of continuing with an at-sea nuclear deterrent was produced, however was 'top secret' and not distributed outside of the carefully-selected 'Restricted Group' (Hennessy and Jinks, 2016).

In arguing for the continuation of Britain's sea-based nuclear deterrent the *Duff-Mason* report highlighted the national significance of the weapons system, pointing out that: "*To give up our status as a nuclear weapons state would be a momentous step in British history*" (Duff Mason report quoted in Hennessy and Jinks, 2016: 522). The Duff-Mason report is considered one of the most important documents in the political history of the UK "*…because on Callaghan's personal instructions in his last hours in office, it was given to Mrs Thatcher, thus breaking the normal convention that new governments do not see the papers of the previous administration*". (Hennessy and Jinks, 2016: 518). The Report demonstrates the uniquely protected nature of decision making around the nuclear weapons system where the power of decision making passed from a secretive select group within one political party (Labour), to a similarly secretive group within another (Conservative) in an unprecedented move (ibid.).

Throughout the 1980s, Thatcher would go on to strongly promote the development of Trident announcing in a speech at the Barrow Shipyard that "*we have to have nuclear submarines. We have to have the nuclear weapon*" (Thatcher, 1980). The importance for the nuclear submarine-based deterrent for Britain's standing in

the world was strongly emphasised when she stated: *"Britain is not just another country. It has never been just another country… We would not have grown into an empire if we were just another European country… It was Britain that stood when everyone else surrendered and if Britain pulls out of that [nuclear] commitment, it is as if one of the pillars of the temple has collapsed"* (Thatcher quoted in Jack, 2016).

Enthusiasm for Trident continued under Prime Minister John Major in the 1992. By this time any remaining Parliamentary debate around the topic was confined to whether to proceed with a fourth *Vanguard Class* Trident submarine or to only have three boats as some Labour members argued for. Major used this position to attack the Labour Party at a speech once again to workers at the Barrow Shipyard where he announced that the Conservative Party "*will order, build, deploy and arm that fourth Trident submarine…we will not take any risk with that crucial shield. But I tell you who would. Labour would.*" (Major quoted in Hennessy and Jinks, 2016: 515).

In 1997 the New Labour Government came to power. Yet the commitment to retaining nuclear weapons continued. The Strategic Defence Review confirmed the commitment of the then-new Labour government to continuing the UK's nuclear deterrent, at a time when the building programme for the Vanguard submarines was nearing completion: *"The world would be a better place if such weapons were not still necessary, but the conditions for complete nuclear disarmament do not yet exist… (SDR 1998).* [6] In the foreword to a 2006 Defence White Paper, Tony Blair stated *"For 50 years our independent nuclear deterrent has provided the ultimate assurance of our national security... We believe that an independent British nuclear deterrent is an essential part of our insurance against the uncertainties and risks of the future"* (Future of the Deterrent 2006: 5).

Occurring at a juncture that will be of particular interest in this analysis, this White Paper elaborated on the continuing nature of this commitment to nuclear weapons capability, arguing essentially that the high costs were worth it for this 'ultimate assurance of our national security'.[7] During discussions in the same period over Vanguard replacement, considerable attention was given to the perceived need to maintain UK nuclear defence capabilities.[8] The MOD stated in 2005 that "*"it is a high priority for the UK to retain the suite of capabilities required to design complex ships and submarines, from concept to point of build; and the complementary skills to manage the build, integration, assurance, test, acceptance, support and upgrade of maritime platforms through-life.*"(Ministry of Defence 2005: 7). It was emphasised that such capabilities must be maintained within the UK because of difficulties with overseas procurement (Defence Committee 2007). Funding was put in place to ensure that major UK suppliers such as BAE Systems and Rolls Royce could maintain key skills in nuclear propulsion (MOD report 2006).

Throughout this period of discussion, nuclear propulsion capabilities are consistently represented as a "strategic capability" of the first importance (Defence Industrial Strategy, 2005). Unsurprisingly for any infrastructure investment programme on this scale, benefits are loudly attributed not only in relation to military defence goals, but also in relation to for the creation of high-skilled jobs and a much-needed boost for British manufacturing industry (Blair 2006). As stated in the Defence Industrial Strategy:

> *Given all these considerations, maintaining a UK systems engineering capability in defence sectors has a broader political and strategic impact: it signifies the UK's status as a major defence nation; it allows the UK to bring to coalition operations unique or distinctive capabilities; and in some areas like nuclear submarines, it allows the UK to produce strategically significant, complex systems which are not available, or which we would not wish to source, from the international market*. (Ministry Of Defence 2005: 63):

Whether an attack ballistic missile boat, a nuclear propelled submarine is a formidable feat of engineering. Sustaining a sufficiently exclusive national base for producing the skills, expertise and equipment required in

order to construct, operate and maintain this infrastructure, is a very demanding undertaking – especially for a country that is in other respects increasingly losing its manufacturing base (Meek, 2014) or seeing this become tangled in the capabilities of other countries (ibid.) So, with these capabilities so central to the credibility of one of the most treasured aspects of British political identity, anxieties are growing.

Accordingly, rhetorics have intensified surrounding the continuation of the UK's at-sea deterrent, and its relation to British identity on the world stage. For instance, politicians expressing criticisms of this technology are labelled as a 'national security threat' by members of the Government (Mortimer 2015b). Prominent members of the British military declare that such politicians may have to be removed by a "*mutiny*" should they come to power (Mortimer 2015a). Politicians who question the tactical logic of Trident are accused of "*siding with the enemy*" (Mason & Asthana 2016). Despite the nuclear weapons issue continuing to be contested in various forms over recent years, it is now considered "*electoral suicide*" to contemplate opposition towards Trident (Peter Mandelson and Neil Kinnock quoted in BBC News, 2016). The opposition of the current leadership to Trident renewal is one of the most frequently cited issues in the rebellion of the Parliamentary party, that is currently held to threaten the entire future of the British Labour Party (Walker & Stewart 2016) That the recent vote in Parliament on constructing a new fleet of nuclear submarines for the delivery of the UK's "deterrent" was carried with a majority of 355 (Mason & Asthana 2016), show how entrenched these commitments are – spanning British Party divides.

Another point to make with regard to the sustaining of Trident and the associated British nuclear engineering skills base, is that in recent years, developments in non-nuclear options for submarine propulsion have raised the question as to whether conventional submarines could be used as an alternative to the very expensive and complex nuclear propulsion systems. Indeed, in recent years there have been important breakthroughs in different forms of diesel-electric and fuel cell submarines (O'Callaghan 2014). However it was concluded by the MoD in the Defence White Paper 2006 that: "*a conventionally-powered submarine was rejected because of the impracticality of developing a non-nuclear propulsion system that could generate the necessary power and endurance*." (HM Government 2006: 38). Similar to the conclusions reached by the Royal Navy in 1950, nuclear propulsion is still widely regarded in expert circles as being a superior technology in its own right because of the characteristics whereby "[t]*he main advantages of nuclear–powered submarines are that they act as a deterrent by having the capability of being anywhere in the region; they can remain submerged almost indefinitely and their high speed (compared to conventional diesel-electric boats) enables fast deployment*" (UCL IEPL Australian submarine options report 2013: 12). It is for these kinds of reason that, as Ian Jack (2016) observes "*Britain's submarine-launched nuclear weapon…seems immune to obsolescence".*

The superiority of nuclear propulsion over conventional submarines designs is also recognised internationally. For example, Singh (2016) outlines that "*nuclear submarines confer an edge to a fighting force that diesel electrics find difficult to match. The fact that SSNs are bigger, tougher, more heavily armed and longer-ranged than conventional subs makes them indispensable assets. They can also perform functions that diesel-electric subs generally cannot – like cross an ocean underwater and at high speed or remain submerged for weeks.*" (Singh 2016). The militarily superior status of nuclear submarine propulsion is recognized by other countries including India where the technology is considered to be "*vital*" to the country's regional power (IDR, 2012). Brazil, a country currently constructing a nuclear submarine refers to the technology as having *"enviable deterrent capability…* where *the nuclear submarine is simply the "Lord of the seas"* (Moura Neto 2009).

Interesting, it is in Brazil that the significance of developing a national nuclear submarine force is also particularly strongly and directly related to the aim of joining what is held to be an internationally elite group of countries with this capability. In opening a shipyard in 2014 for construction of the first Brazilian nuclear propelled submarine, President Dilma Rousseff stated: *"the Brazilian naval force…have contributed decisively to our nation, for our country integrating into the select group of five member countries of the Council of the United Nations Security dominating the submarine construction technology with nuclear propulsion"* (quoted in

Planalto 2014). Especially significant in this statement, is that what is referred to in relation to the acquisition of this coveted international status, is not capabilities specifically in nuclear weapons, but in nuclear propelled submarines.

This last point is interestingly reflective of the UK debates reviewed above. It is clear that there exists a widespread view in the world that – in addition to their role as a strategic nuclear weapons platform – nuclear submarine capabilities are also a crucial aspect of international status in and of themselves. For a country whose relative economic decline in the world places its cherished seat at the 'top table' of international affairs under increasing pressure, (Barckham & Norton-Taylor 2010), the imperatives are especially acutely felt. And in addition to this, of course, the skills and capabilities associated with this advanced manufacturing chain (embodied for instance in Rolls Royce and BAE Systems facilities at Barrow shipyards) are held to be of inherent value in themselves (Hartley 2012). This appears especially important where support appears to be wanting in the sustaining or development of similarly valuable skills and capabilities in other areas of advanced technology, like, for instance, renewable energy (Cameron 2015). Here, though, of course, important questions are raised over whether the particular privileged position of nuclear manufacturing supply chains are a symptom or a cause of wider industrial decline (Mort 2002).

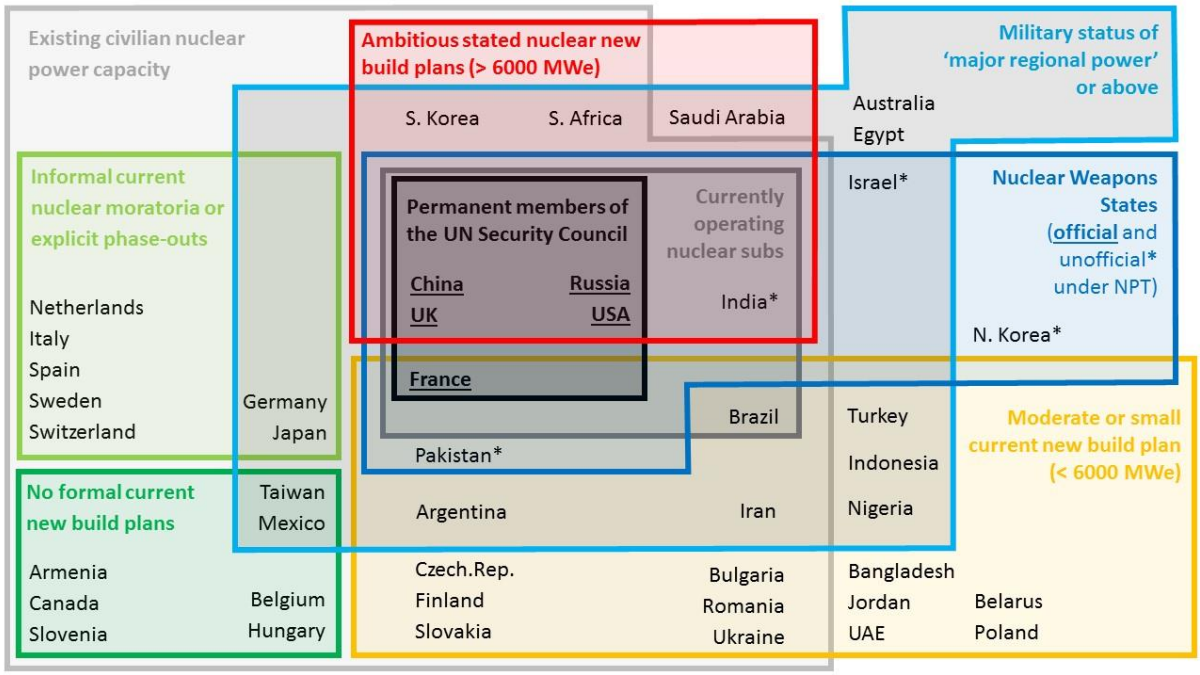
Either way, it is clear that there persist a variety of political, security-based, and industry-focused reasons for the maintenance of intense high-level policy commitments to the sustaining of British nuclear submarine capabilities – augmented by the strong symbolic value to a particular elite British identity on the world stage, As Dorman (House of Commons Defence Committee 2007: 182) argues "*Could any British Prime Minister consider abandoning this prestige item?*", "*would any prime minister want to be remembered as the one that abandoned the nuclear deterrent?*" For Dorman the answer is "a resounding no". It is on grounds like this, that it can confidently be concluded in relation to our first proposition that – albeit also strongly contested in particular quarters – a perceived imperative to maintain military nuclear infrastructures has played a continuously prominent (if not dominant) role in elite UK policy discourse over the past half century.

6: Are There Under-Visible Linkages Between UK Military and Civil Nuclear Policy Priorities?

6a: The International Comparative Background

Having established that UK policy commitments to civil and military nuclear infrastructures are each very strong, it remains to explore whether and to what extent these imperatives might be linked. One first perspective on this picture, is to consider the international context. Here it has already been noted how – in terms of the proportional scale of new build programmes for civil nuclear power plants – the UK is anomalous not only in Europe (Baker & Stoker 2012), but in liberalised energy markets more generally (Kee 2015). No other European country is attempting anything on the scale of the nuclear new build repeatedly and prominently referred to in UK policy making (Elliott 2015; World Nuclear Association 2016d). Indeed, several countries in Europe with larger existing nuclear power and construction industries are currently phasing out nuclear (Lawrence et al. 2016). On a wider international scale, it can be seen from Figure 3 that the UK is part of a relatively small group of countries maintaining ambitions for new nuclear power at overall scales of programmes above 6 GWe (IAEA 2016b; World Nuclear Association 2016g). The question thus arises as to how this comparative international picture can be analysed on a more systematic basis, in relation to a series of different relevant criteria concerning contrasting conditions and levels of both military as well as civil nuclear commitments.

Figure 3: Circumstantial relationships between different categories of international military, civil nuclear and geopolitical status



Organised in the form of intersecting domains in a Venn diagram, Figure 3 shows schematically the basic patterns in which all countries in the world with any significant association with either civilian or military nuclear commitments, variously fall into a series of contrasting relevant categories. These include: countries with existing civil nuclear capacity of some kind; those which have large-scale projected civil nuclear programmes (above 6 GWe); states with smaller scale current civil nuclear plans (below 6 GWe); countries with

existing capacity but no nuclear build plans; states which presently pursue explicit moratoria or which are deliberately phasing out civil nuclear power. On the military side, Figure 3 also shows all countries in the world that can be categorised as holding the status of a 'major regional power' or above; or which have been recognised officially or unofficially as being a 'nuclear weapons state'; or which have acquired national capabilities in nuclear-propelled submarines (Nolte 2010). Finally in the centre (picking up on an important feature of the discussion in the last section), Figure 3 shows countries that enjoy the geopolitical status of being permanent members of the United Nations Security Council.

Despite the many complexities and ambiguities, the evidence summarised schematically in Figure 3 does suggest a number of possible general patterns in international military and civil nuclear commitments. Before discussing these, several particular caveats are necessary. First, there is the somewhat arbitrary figure of 6 GWe for the precise level of firmly planned new nuclear build at which to draw a distinction between 'large' or 'moderate or small' civil nuclear programmes. Not least, this pays no attention to the scale of energy or finance markets in the country in question. Nor does it attend to the ambiguities and conditionalities in which scales of plans are often expressed. But this figure does nonetheless offer a valid broad illustration of a basic difference between plans amounting to a scale not far different from a single modern large scale power station (with twin reactors rated at 3.2 GWe) and markedly large programmes representing some multiple of this scale. Likewise, the distinction drawn by the German Institute of Global and Area Studies (GIGA) between 'major regional' and other levels of military power (Nolte 2010), is also a function of many different variables. Yet it nonetheless serves usefully to identify those countries around the world that find themselves most motivated and able to invest most heavily in military capabilities of all kinds. And, of course, all the categories employed in this picture are subject to change over time. So attention is required to retrospective circumstances and prospective possibilities.

All this said – and despite the summarised evidence being only circumstantial – features of this picture may prompt avenues worthy of further interrogation. For example, there is a clear broad correlation between general military and civil nuclear status. Of the 23 countries (among a total of 195] states in the world) ranked in military terms at the level of 'major regional power' or above, all but two (Australia and Egypt) have historically developed at least some form of civil nuclear commitment. And these 21 states include all but one (North Korea) of the only 10 countries in the world that have thus far developed military nuclear technology of some kind.

Of course, this holds no necessary implications for any definite links (let alone directions) of causality. It is possible, for instance, that the extraordinary expense of both civil and military nuclear capabilities simply makes each a reflection of national economic capacities. But here it must be recalled that some of the strongest economies in the world are either not presently pursuing civil nuclear power at all, or actively phasing it out (albeit for contrasting reasons, like Germany and Japan). So it is not the case that economic power is on its own a simple driver of nuclear commitment. Other factors are evidently also at work.

Likewise, there exist a host of other factors in world politics that serve to complicate any simple interpretation of the relationships encompassed in Figure 3. It makes a difference, for instance, how vulnerable a country may feel to immediate military threats. And global superpowers have explicitly offered protection implicating their own nuclear weapons capabilities to other states in return for renouncing their own nuclear weapons aspirations. These and many other such geopolitical complexities confound – and caution against – any simple interpretation of apparent patterns.

Nonetheless, it would be remiss not to note that Figure 3 does suggest at least *prima facie* grounds for considering some highly specific (if only circumstantial) relationships between the high-level geopolitical standing of permanent membership of United Nations Security Council and the status of being an officially-recognised 'nuclear weapons state' under the Non-Proliferation Treaty (Green 1997). Although not a formally

acknowledged criterion, the correlation between these two categories is perfect (UNSC 2016; Ross 2016) (comprising China, France, Russia, the UK and USA). And the significance of this is underscored in the discussion in the last section of strong policy statements in Brazil, explicitly linking these issues.

Perhaps reflecting strong military perceptions of the uniquely credible status of nuclear-propelled submarines as a platform for nuclear weapons (discussed in the last section), there is also a strong conjunction between permanent membership of the UN Security Council and pursuit of nuclear-propelled submarine capabilities. India and Brazil are the only countries with nuclear submarines who are not permanent UN Security Council members. Yet both are major regional powers – the former as an unofficial nuclear weapons state (Thomas 2002) and the latter with a history of interest in developing nuclear weapons capabilities and explicit political aspirations linking military nuclear capabilities with permanent membership of the UN Security Council (Stalcup 2012; de Sá 2015; Velazquez 2014; Stuenkel 2015; Krasno 1994). Thus it again seems difficult not to entertain a linkage between pursuit of military nuclear technology and this highest form of geopolitical status.

Also potentially relevant as a broader circumstantial context for the present specific analysis of the UK, are a series of apparent associations between the scales of envisaged civilian nuclear power programmes and the intensity of commitments to military power. Only eight countries (of 190 around the world) are actively pursuing large-scale civil nuclear programmes (above 6 GWe): South Korea, Saudi Arabia, South Africa, China, Russia, India, UK and USA. Half of these are official nuclear weapons states and permanent members of the UN Security Council (China, Russia, UK and USA). Only one permanent member and official nuclear weapons state (France) is not pursuing a large-scale civil nuclear programme – and this is anyhow precluded in this case, because national civilian nuclear capacity in France is already saturated.

Aside from this, Brazil is the only country in the world in possession of nuclear submarine capability that is not also pursuing a large-scale civil nuclear programme. And even in this one exception, Brazil is still among the small minority of the world's nations declaring moderate or small prospective civil nuclear plans. The particular position of Brazil with regard to linkages between nuclear weapons and international status has already been mentioned. Only three countries of the eight pursuing major civil nuclear programmes are not among those also actively sustaining military nuclear technologies: South Korea, Saudi Arabia and South Africa. But these are still all major regional powers, all of which are repeatedly associated in wider policy discussions with covert policy aspirations to develop nuclear weapons (Kim 2001; Purkitt & Burgess 2005; Bahgat 2008).

So, although the picture is complex and far from definitive, it is clear that there does exist a *prima facie* case for at least examining potential linkages between civil nuclear commitments on the one hand and military nuclear aspirations on the other – equally in respect of nuclear weapons and submarine propulsion capabilities. This circumstantial international comparative picture certainly does not imply on its own that there is any such link in the UK case. But it does show that such a linkage in the UK would not necessarily be at odds with the wider global patterns. And it does further suggest that the hitherto serious neglect of analysis concerning possible links between commitments to nuclear submarine capabilities and attachments to civilian nuclear power, is – in the UK and beyond – an anomaly worth addressing

6b: Linkages Between Civil and Military Nuclear Capabilities

The discussion in previous sections has established that there are strong *prima facie* grounds for asking about linkages between clearly-established UK policy commitments to civil nuclear power on the one hand and military nuclear capabilities on the other. This in turn forms a basis for posing particular questions about extant patterns of economic overlap and organisational involvement spanning both sectors. Before examining this evidence, however, it is important to note that this raises some quite unique sensitivities. A notional separation between civil and military nuclear activities is arguably one of the most intensively-performed regulatory functions in the world (IAEA 2016a).

The task of affirming this separation is undertaken, for instance, by some of the world's longest-standing and highest-profile intergovernmental technology-regulatory bodies (World Nuclear Association 2016f): the International Atomic Energy Agency (IAEA 2015a) and Euratom (European Commission 2014). The focus of this attention is especially on fissile and other specialised nuclear materials (IAEA 2016a). But specialist technologies and skills do not escape attention. So, there are strong pressures (equally for industrial practices themselves and for publicly available data about them) to downplay the degree to which military and civilian nuclear activities are interlinked. It is in the light of this general suppressive pressure on documentation, that this section will discuss evidence for civilian/military nuclear industry linkages in the UK.

Using the methodology discussed in section 4, 46 companies were found to be involved simultaneously in both civilian and defence nuclear sectors in the UK. These are listed in Table 1, below and on the following page.

Table 1: Table of companies involved in both civilian and military nuclear sector in the UK

	Company	HQ location	What they do
1	Alstom	France	Engineering, turbines, turbogenerators
2	Altran UK	UK	Consultancy
3	Amec Foster Wheeler	UK	Technical assessment, advice, consultancy
4	Ansaldo NES	UK	Design, manufacture, full life-cycle
5	Arc Energy Resources	UK	Welding, Cladding, tubular components
6	AREVA	France	Reactors
7	Assystem	France	Engineering, consultancy, EPRs, propulsion systems
8	Atkins	UK	Engineering, building
9	Atos	France	IT and control room equipment
10	Balfour Beatty	UK	Civil engineering
11	Babcock	London	Engineering; waste; weapons-handling; launch systems; life-cycle support
12	BNM / Tachart	UK	Bolts and nuts
13	Bradken	Australia	Cast metals, machined components
14	Cammell Laird	UK	Shipbuilding
15	Capula	UK	Automation, IT
16	Carillion	UK	Construction
17	Centronic	UK	Radiation detectors
18	Costain Group	UK	Engineering, building, consultancy
19	Darchem	UK	Fabrications, pool liners, piping systems, waste containers
20	Frazer-Nash	UK	Consultancy
21	Independent F&A	UK	Forgings and alloys
22	Jacobs	United States	Design, consultancy, engineering support, life-cycle

23	L3 communications	United States	Security systems
24	Mitsubishi Heavy	Japan	Reactors, submarines
25	Morgan Sindall	UK	Construction
26	Mott MacDonald	UK	Consultancy
27	Newburgh Precision	UK	Precision machined & fabricated components; hull sections
28	NIS ltd	UK	Nuclear transport flasks, glove boxes
29	NSG Environmental Ltd	UK	Decommissioning and waste
30	NSV	Dubai	Ventilation
31	Nuvia	UK	Nuclear engineering and project management; also decommissioning
32	Oxand	France	Asset and risk management
33	Poyry	Finland	Consultancy
34	PwC	United States	Consultancy
35	Redhall Nuclear	UK	Engineering, project management
36	Rolls Royce Nuclear	UK	Reactor cores, engineering
37	Safety Critical	UK	Safety assessment
38	Schneider Electric	France	Engineering; weapon launch control systems
39	Sheffield Forgemasters	UK	Steel
40	Sir Robert McAlpine	UK	Building, civil engineering
41	Tata Steel	India	Steel
42	Thales	France	Security; computerised support systems; communications; sonar
43	Thomas Consulting	UK	Civil engineering
44	Truflo Marine Ltd	UK	Valves
45	Ultra Electronics	UK	Instrumentation; communications; reactor control systems; sonar
46	Weir Group	UK	Engineering

Here, it is worth noting that the majority of these companies do not see nuclear as their core business; for example, a large high quality steel-maker will manufacture components for numerous sectors, of which nuclear is just one. However, the nuclear sector brings certain challenges which distinguish it from many other sectors – including rather particular performance criteria, stringent safety requirements and rigorous quality, predictability and reliability standards (Cogent 2015). This means that the number of companies with the capabilities to supply to the nuclear sector is relatively limited. Unfortunately, information is not readily available as to the magnitude of the streams of revenue concerned – either in each respect or in aggregate.

Two of the biggest players are worthy of note. First, there are the Rolls Royce nuclear operations, based in Derby, whose central role in manufacturing the nuclear steam raising plant for British submarines has for many decades made them synonymous with this important military nuclear supply chain. With longstanding side interests in associated supply roles for civilian nuclear business, Roll Royce announced in 2008 an intention to explore larger scale opportunities in the civilian nuclear sector more proactively (World Nuclear News 2008). The logic of this decision is shown in an illuminating slide from a presentation of 2012 by a senior directly-responsible Rolls Royce executive, marked as “strictly private” (but publicly available on the internet), shown in Figure 4.[9] This graphic summarises a projected ramping up from that date of ‘inorganic’ growth in the civil nuclear business of Rolls Royce (in other words, achieved through corporate acquisitions (Nanndakumar et al. 2014)), envisaged to rise from effectively zero in 2011 to around £0.8 billion in 2018. It is the anticipated growth in global civil nuclear business acquired by this means (shown in the lower left hand side of Figure 4), that is held to combine with the inconveniently intermittent ‘drum beat’ of nuclear submarine orders (shown on the lower right hand side), to allow for a more satisfactory overall smoothing of orders and an associated projection of a remarkable rate of growth in combined revenues of factor three over seven years.

This chimes with other sporadic remarks from Rolls Royce to the effect that civilian nuclear supply chains form a key part not only of their extant order books, but – even more so – of their anticipated strategic orientation (Rolls Royce, 2015). For example, connected to George Osborne's trade deal with China in 2015, Rolls Royce have formed key memoranda of understanding with Chinese nuclear firms for future contracts (World Nuclear News, 2016). There can be little doubt that this key national UK engineering asset identifies its future to depend quite centrally on perceived synergies between civilian and military nuclear engineering supply.

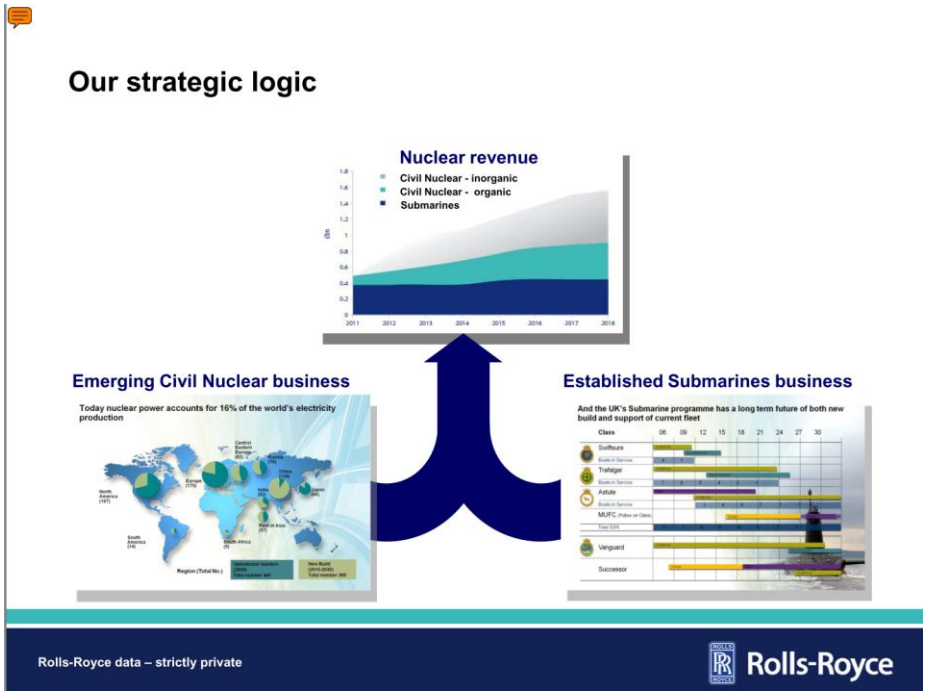


Figure 4: Rolls Royce Graphic Showing Strategic Rationale for Combining Civilian and Military Nuclear Business

Source: Nuclear New Build Industrial Challenges – A Rolls-Royce Perspective: presentation by John Molyneux, Rolls Royce, February 2012

A second illustrative example of these synergies can be found around London-based Babcock International. With major operations based at the most important Royal Navy nuclear submarine servicing facilities at Devonport in Plymouth and on the Clyde near Glasgow, Babcock and Wilcox has long been a major player in both civilian and military sectors. Among many other interests, Babcock provide weapons-handling and launch systems for the UK's nuclear submarines, and are also the sole provider of deep maintenance and infrastructure support for the submarines. On the civilian side, their declared nuclear activities are focused on waste handling operations. However, Babcock also hold a wholly-owned subsidiary, Cavendish Nuclear, which is currently licensed to operate 13 nuclear sites in the UK including 7 operational power plants (Cavendish Nuclear 2016) and which has been awarded mechanical pipework contracts for the Hinkley C power station. Babcock are also the sole owners of Frazer-Nash, which provides project management and consultancy services to both civil and defence nuclear programmes in the UK.

A number of other officially accredited sources in the public domain explicitly highlight the linkages between developments in the fields of UK civil nuclear power and submarine nuclear propulsion.[10] For example, evidence to the 'Engineering: turning ideas into reality' enquiry (HoC 2009) from the Royal Academy of Engineering emphasises that there are "untapped synergies" between the two sectors [HoC 2009: 456]. In their own evidence, construction engineering firm AMEC Foster Wheeler noted "strong technical overlap of engineering skills and technologies" [HoC 2009: 427]. Two trade organisations, the Institution of Engineers (INucE) and the British Nuclear Energy Society stated "*There is significant scope for interchange… as the power*

plant of a nuclear submarine is in general, similar to that of a modern power station… The Royal Navy can be seen as a training ground for supporting the future UK nuclear power sector." [11]

This same Parliamentary inquiry also pointed out the opportunities for transfer of capabilities between the two sectors (HoC 2009).[12] A report by the British American Security Information Council (2012) into nuclear skills and technology capabilities also noted the opportunities which could arise from exploiting these linkages more fully, for instance through technology transfers and spin-offs.[13] Furthermore, leading industry figures participating in interviews for the present project also clearly noted the linkages they see to exist. One stated that "[Our company] has operations in both civil and defence. There is considerable movement of people between both" (code 01, 2015). Another said: "The logic in moving [our business] into civil was based on the synergies which exist and which could be exploited. There are lots of places where that's not yet being optimised, sometimes for technical reasons, but more often than not for reasons of behaviour, inertia etc." (code 02, 2015).

What seems clear, then, is that despite international regulatory pressures to perform a separation between civilian and military nuclear activities, there are in fact many synergies. Notwithstanding their sensitivity, these are not only explicitly documented in the public domain, but are also authoritatively documented to form a key part of corporate strategies in this field – including plans for quite radical levels of growth. Indeed, in policy debates on the military side, there is a repeated refrain that synergies between military and civil nuclear activities are underexploited (HoC 2009).

6c: The Under-Visibility of Civil-Military Nuclear Linkages

Having established that substantive economic and wider strategic business linkages do indeed exist between UK interests in military and civil nuclear engineering, it remains to explore the extent to which these are visible in high-level energy policy documentation bearing on official UK commitments to civil nuclear power. Given the sensitive nature of the issues (for instance, in relation to international nuclear safeguards regimes discussed earlier), it should not necessarily be expected that any lobbying activities driven by these motivations would be similarly visible. This is indeed, what is found.

The overall picture, both in formal energy policy documentation and in the vast bulk of wider independent and critical literatures around UK civil nuclear strategies, is a complete absence of any acknowledgment of formative links between commitments to military nuclear submarine capabilities and attachments to civil nuclear power. None of the key policy documents discussing in detail the stated rationales for the civilian new build programme mention any key words related to wider issues of military nuclear capabilities (DECC 2011a; DECC 2009; BIS 2013; BERR 2008; EDF Energy 2005; DTI 2003; DTI 2006) (see endnote 4 for full search terms). DECC press releases and web pages related to the civil nuclear new build programme also do not reveal any acknowledgement of these linkages (DECC 2015).

In a brief (extremely rare) discussion of exactly this point in the public domain, a major consultancy firm with a number of important government contracts in the energy sector, Oxford Economics (2013: 31), recently note that:

> *The naval and civil reactor industries are often viewed as separate and to some extent unrelated from a government policy perspective. However, the timeline of the UK nuclear industry has clear interactions between the two, particularly from a supply chain development point of view.*

In evidence to the UK Parliamentary Select Committee on Innovation Universities Science and Skills, a key academic nuclear research organisation, the Dalton Institute, casts further rare light on the reasons for official obscuring of civil and military linkages. Consistent with identification of the international sensitivities discussed earlier, the Dalton Institute seems to offer here an illuminating glimpse of policy discussions that must necessarily (of their own logic) remain private, concerning a need for 'perception management':

> *The UK is not now in the position of having financial or personnel resources to develop both programmes in isolation. For example, reactor physicists on the military programme can develop their skills and knowledge by researching civil systems, and then only when necessary divert to classified work to follow a specialist career path. This link does however need to be* ***carefully managed to avoid the perception*** *that civil and military nuclear programmes are one and the same* (Innovation Universities Science and Skills Committee 2008: 61-2; emphasis added).[14]

A further possible factor that might help explain the absence of official acknowledgement of what in other respects seem evidently strong linkages between civil and military nuclear commitments, involves a wider phenomenon in the military supply industry, referred to by protagonists as the pressures for the concealment of costs of military behind civilian programmes. A potentially useful snapshot of these pressures is offered by a senior executive from the leading UK (and international) defence (and submarine) manufacturing firm BAE Systems. Whilst serving on secondment to the Royal United Services Institute (RUSI), Gavin Ireland noted somewhat regretfully of the submarine business that "*through-life costs cannot be absorbed or masked by other programmes as can be the case with fast jets …*" (Ireland 2007: 25).

What seems to be referred to here, are the obstacles presented by the relatively small current scale of UK civil nuclear business and the impediments to openly realising synergies with the military activities that this author is more focally interested in. One key means to the ''masking' of important cost streams would be to merge

research and development and skills and training provision across military and civilian-related areas. As will be reviewed in section 7, it is exactly this kind of measure that has characterised the past decade of UK nuclear industrial policy.

Unsurprisingly, there exists no record in formal public domain policy documentation (at least, that we have been able to find) acknowledging that a part might be played in these initiatives by the intention of 'masking' military costs. But it would be naïve to expect this. So, although the lack of official confirmation certainly does not constitute evidence for any kind of concealment of these kinds of drivers in the shaping of civil by military nuclear imperatives, it would be equally irrational to take this as evidence for the absence of such dynamic. What is significant, is that there does exist in obscure backwaters of policy literatures on the military side, a range of quite substantive documentary evidence that important linkages not only exist between UK civil and military commitments, but that these are subject to a number of pressures for 'masking' from public attention. That the sources of this evidence should be policy actors with a strong inside knowledge of – and interests in – these dynamics, further enhances the credibility of this evidence.

This leads to a final broader point concerning the visibility of these linkages in academic and wider critical literatures on UK civil nuclear policy. Other commentators have noted that academic research on broader aspects of nuclear power policy (beyond looking at overtly declared factors like climate change and energy security) has been limited during the period of the 'nuclear renaissance' (Valentine & Sovacool 2010). Albeit systematically under-attended to in even in the specialist quarters of the national media, a quite extraordinarily high quality body of critical analysis exists in the UK, concerning the questionable basis for existing UK declared policy rationales for the intensity of official commitments to civil nuclear power (Mackerron 2008; Dorfman 2011; Blowers 2013; Porritt 2013; Burke 2013; Tickell 2014; Toke 2012; Lowry 2015; Thomas 2016) .

Mention is made in a number of specific instances of particular kinds of possible linkage between civilian and military sectors (Wynne 2010; Sovacool & Valentine 2012; S Thomas 2010; Scrase & MacKerron 2009). Specific issues discussed in this regard include supply chains for the crucial nuclear weapons material tritium (Bergeron 2002; Squassoni 2013); of governance and management provision for both civilian and military nuclear wastes (Walker 2000); and of differences in regulatory frameworks for safeguarding flows of high-enriched uranium involving both civilian and military applications (Ritchie 2014). However, our own extensive literature review has been unable to find any earlier discussion of military-civil nuclear specifically relating to the major industrial systems around nuclear submarine reactor manufacture – including vital provision of capabilities, technologies, components, skills and education. What therefore forms a key part of the focus of the present study, thus remains largely under-researched – and even unacknowledged. It seems that pressures for 'masking' documented above to apply in formal policy circles, may have repercussions far beyond.

Section 7: Is UK Civil Nuclear Policy Partly Driven By Commitments to Nuclear Submarine Capabilities?

What has been established so far is that there is strong circumstantial evidence for the existence of linkages between UK civil and military nuclear commitments and that these are at the very least broadly consistent with wider complex international patterns. It has been shown that the absence of formal policy acknowledgements (or even wider critical discussion) does not of itself necessarily undermine this evidence, because strong incentives can also be documented for 'masking' these linkages. But simply to show that such linkages exist and are at least privately familiar in elite private policy making discussions, does not of itself necessarily mean that there are important formative drivers going one way or another. In the complex and opaque world of high-level policy making, apparent correlations may be due to a variety of different reasons.

So, attention must now turn to the more difficult task of illuminating the ways and degrees in which UK civil nuclear policy may – or may not – have been actually partly driven by commitments to nuclear submarine capabilities. Here, it is important to recall that simply to investigate such a question does not imply any side-lining of the importance of other potential policy drivers – or their inevitably complex interdependencies. Lacking the same incentives for 'masking' in official literatures, these more openly-documented factors will be scrutinised in more detail later in this paper. In this section, we explore the strength of evidence suggesting that the particular factor of commitments to nuclear submarine capabilities may at least have played some formative role in conditioning the intensity of official UK attachments to civil nuclear power. This is all the more important because, as has been documented, this potentially significant factor in UK energy policy has been virtually entirely neglected in official, academic and critical literatures alike.

Whilst these kinds of formative influences are (for obvious reasons) difficult to illuminate in official documentation, especially on the civilian side of UK nuclear debates, commentary is more forthcoming on the military side. Here the apparent significance of a military driver can be seen from the reverse side, in terms of explicit acknowledgements of the importance of maintaining a viable UK civil nuclear programme to military objectives. In Parliamentary select committee evidence, Dr Jeremy Stocker of the International Institute for Strategic Studies pointed out in 2006, that the British submarine force may barely be large enough to sustain a viable nuclear submarine building capacity, and suggested that "this will especially be so if, despite renewed calls for them, a new generation of civil nuclear power stations is not constructed." (HoC 2006, p.EV103 [written evidence from Dr Jeremy Stocker]).[15]

Likewise, the security Think Tank the Foreign Policy Centre asked rather starkly in the same context: "how can the British government be serious about being a nuclear weapons power if it is not going to have a modern nuclear industry?" (Foreign Policy Centre 2006: 9). In somewhat more nuanced terms, the academic security analyst, Dan Plesch of SOAS, stated in his evidence to the Defence Select Committee that:

> *…when it comes to the United States looking at renewing support for Britain, Britain is required to show that it is a serious nuclear power and the question will I think arise immediately in the mind of John Bolton and his colleagues as to how can Britain be an independent nuclear state of any description if it has decided to phase out its civil nuclear industry.* (HoC 2006 Strategic Context, p. EV18 (oral evidence from Mr Dan Plesch, Research Associate at SOAS)[16]

It is for all these reasons that the report by Oxford Economics cited earlier offers a very rare acknowledgement from the civilian side of these debates, that military supply chain considerations might exercise a formative effect on the unfolding of developments on the civilian factors, stating of the synergies between military and civil UK engineering capacity that: "[w]ithout this synergy the UK supply chain would not have been

sustainable." (Oxford Economics 2013: 31).[17] In private discussions, informed individuals are also not reticent about noting the formative effects of these linkages. One senior figure in the civil nuclear sector told this study: ""They are synergistic; the military base has always leant heavily on the fact that there are civil people around." (code 03, interview 2015).

However, it is important to note that these kinds of linkage can also present challenges. For instance, the MoD and parts of the military supply industry have expressed concerns that a vibrant civil new build program could attract skilled individuals ***away*** from the defence sector, thus acting as a drain on key skills and capabilities[18]. Such risks are amplified by general concerns regarding the poor state of the nuclear skills base in the UK (BIS 2013; Cogent 2011; DECC 2015).[19] From this perspective, a civilian new-build program might actually act *against* the interests of the defence sector. For example, a report by Cogent states that "*The civil nuclear sector also competes for skills with the defence sector,that is the submarine and deterrent maintenance and build programmes"* (Cogent et al 2008: 74). A recent DECC report notes that this is especially problematic in the nuclear sector because of the frequent recruitment restrictions to UK nationals due to security considerations (DECC 2015: 4). A NESA workforce assessment states:

"MOD operates in an increasingly competitive market place for individuals with deep specialist nuclear skills. The developing UK civil nuclear programme is forecast to increase its recruitment activity… The potential to lose Defence personnel with essential nuclear skills to the civil sector remains a significant threat". (NESA 2014 workforce assessment, p.20)

However, these kinds of concern tend to be raised even by their protagonists more as subordinate issues to be looked out for, than as major policy imperatives in their own right. On balance, overlaps between supply chains are actually seen by many defence experts as a further *opportunity* for the military sector, because the logical response to skills shortages (on the part of the government or private sector) would be to provide the resources for more skilled individuals, especially UK nationals, which the civil nuclear programme is well-placed to do.[20] For example, RAEng say that "Ultimately, a strong civil industry is very much in the interests of the military" (HoC 2006 p. EV107, RAEng evidence). And one senior civil industry representative told us:

> *The more vibrant the civil nuclear sector, the more they hope that'll attract talented STEM-trained workers out of schools and into the nuclear industry, which would help the subs skills base by supplying UK nationals… This cross-over is good for the Navy. The Navy don't always see this; they think that there will be skills leakage. One barrier that Rolls face is in building that trust, to make the Navy see that skills and capabilities will be additive, rather than taking away from the Navy*. (Code 4, 2015).

For their part, BAE Systems is the main current engineering contractor for UK nuclear submarines – from one of whose former executives the quote was cited earlier concerning the importance of 'masking' strategies. It is especially significant then, that parliamentary evidence from BAE points out that pressures on skills create a need, rather than a disincentive, for further integration between the civilian and military nuclear supply chains:

> *The UK nuclear engineering manufacturing base needs to work co-operatively to maximise the value it delivers… The timescales before the new power stations are required do not allow free competition and market forces alone to generate this capacity. There is a need for an integrated UK approach to development of facilities and people to establish a world class UK nuclear engineering supply chain.* (HoC 2009 Engineering the Future, p.122, written evidence from BAE).

Part of the reason that linkages between the two sectors should be additive in the way described by BAE is the need for a good 'drumbeat' of business in order to keep the complex supply chains for both nuclear submarines and power stations viable in the context of such long lead times.[21] A report by the NAO (2008)

pointed out that, in the context of the strategic decision in the 2005 Defence Industrial Strategy to retain all the capabilities unique to submarines and their nuclear reactors, the sector remains dependent on a continuous flow of MoD business to maintain capabilities and preserve skills (NAO 2008).[22] Here, one senior figure in the civil sector told us:

> *Both [civilian and military] rely on a good drumbeat; both are stop-start industries; if the drumbeat slows, the supply chain drains away… If companies get too many requests to keep their equipment or supply chain on standby, or the business is not frequent enough, they will move away from supplying nuclear components to other less challenging parts of their business*. (Code 3, 2015)[23]

From the discussions above (and the extended quotes in the endnotes), then, it is clear at least on the military side that there are strong formative pressures acting to reinforce UK government commitments to maintaining a civil nuclear power industry. In short, without a healthy industrial base of nuclear engineering companies and skills and training organisations to fulfil at least second tier roles in new nuclear power programmes, the UK could not realistically hope to maintain its cherished status as a militarily-credible nuclear weapons state. As reviewed earlier in this study, the manifest importance of this characteristic in elite (and many wider) UK political identities, of itself indicates the intensity of formative pressure that this implies.

Despite the dearth of formal acknowledgement in official energy policy literatures, then, it is difficult not to conclude in answer to the question forming the title of this section that the evidence on balance is indeed that UK civil nuclear policy is at least partly conditioned by commitments to maintaining nuclear submarine capabilities.

Section 8: What Conditioned the Radical Reversal of UK Nuclear Policy in the Critical Juncture, 2003-2006?

One crucial way to interrogate the emerging findings that there do exist general formative pressures by which military commitments are influencing UK civil nuclear policy, is to examine in detail a particular historical period during which such pressures might be expected to have been most pronounced. Choosing a specific interval allows documents and historical processes to be scrutinised in much greater detail than would otherwise be the case. Despite the evident pressures for 'masking' any such formative effects of kinds that we have noted above, a failure of such detailed scrutiny to identify any evidence for the operation of such factors, might nonetheless be taken as grounds to reject the hypothesis. When positing concealed factors in policy, there are particular responsibilities to undertake self-critical analysis of this kind. So, insofar as rendered possible by the available evidence, we will now turn to this task of falsification and validation.

There is no ambiguity about the period in which to best test the hypothesis of formative influence operating from the military to the civil side of UK nuclear policy. It is this period between 2003 and 2006 that is widely acknowledged to have seen what the House of Commons Public Administration Select Committee described as a "remarkable about-face" on nuclear power (2009: 13). Yet as stated by the Environmental Audit Committee regarding the government's commissioning of a second energy review that would revisit the nuclear question only 2 years after the Energy Review of 2002 was "why it occurred at all" (Environmental Audit Committee 2006: 60). It was in this period that official UK policy on nuclear power changed from one of being largely critical (for instance, in finding nuclear power to be "unattractive"), towards a view that this technology is so essential for climate change mitigation and energy security that it justified burgeoning calls for a "nuclear renaissance" and Prime Ministerial statements that "nuclear power is back with a vengeance" (BBC News 2007). Rarely has UK policy making in any sector turned about quite so abruptly and comprehensively. Even more rare, is that this should occur without any obvious conditioning development in the wider world.

The Energy Review undertaken in 2002 by the Performance and Innovation Unit (PIU) of the Prime Minister's Strategy Unit was arguably the most extensive UK energy review ever undertaken (House of Commons Trade and Industry Select Committee 2006). Informants have described to the present research team, how the inception of this review differed in several respects from the norm – and this is also publicly documented (Mitchell 2010). First, the PIU Energy Review is significant in that it was commissioned outside the established institutional infrastructure of energy policy, in the then Department of Energy. Second, it began with a remit to appraise UK renewable resources, thus initially convening even further beyond the normal scope (thus 'below the radar') even of energy policy, let alone nuclear strategy in particular.

With the logic of this remit then leading inexorably through renewable energy resources, to energy in general (including nuclear power), what also evidently played a factor in the distinctiveness of the PIU Review was the recruitment process. In a break with the usual practice in which such important energy policy documents are written by insiders, with only relatively little (carefully-selected) external involvement, the PIU study used an approach, innovative in Whitehall, under which the review team as a whole were drawn largely from outside government. Recruitment criteria further bolstered independence from established interests, in using a snowballing process simply to seek individuals on the basis for multiple attestations only of expertise, without serious counter-considerations around alignment. It is likely that these unusual features of this Review, (apparently not repeated for long), are not unrelated to the equally unusual t**. In short, the PIU recommended explicitly against constructing new nuclear power because of unfavourable economics and concerns over the disposal of nuclear waste. Instead, it unequivocally substantiated a shift towards an energy system dominated by decentralised renewables and energy efficiency policies.

Despite reported arguments behind the scenes between Patricia Hewitt as Secretary of State for Trade and Industry (DTI), and Margaret Beckett as Secretary of State for Environment, Food, and Rural Affairs (DEFRA), and others over the nuclear implications of this PIU analysis (Taylor 2016), a more conventionally-produced White Paper, *Our Energy Future*, followed swiftly on its heels in January 2003 and shared many of its key features. This included the observation that nuclear power was "unattractive" (DTI 2003a: 12), with the crucial statement that – due to issues surrounding economics and waste – the Government "would not be pursuing specific proposals for nuclear new build" (DTI, 2003: 64). Although following a period of general de facto scepticism over nuclear power since the collapse of privatisation plans and the bailout of British Energy at the end of the 1980s (see Section 5a – Taylor, 2007), this did represent the single most clearly and explicitly negative appraisal of future prospects for nuclear power in the history of UK energy White Papers since 1955.

However, in September2005, Tony Blair announced in a speech to the Labour Party conference that nuclear was being reconsidered – without invoking specific substantive new developments in the world precipitating this need for such a rapid re-assessment of UK energy policy. Although the findings of the PIU Review and subsequent Energy White Paper remained apparently unrefuted, Blair emphasised that all options were now back on the table "including civilian nuclear power"(Blair, 2006 in a speech to Labour Party conference). Accordingly, after an unprecedentedly short period (Environmental Audit Committee 2006) , a new energy review was launched in November 2005. This time, the work was led and implemented in-house by the DTI.

Many observers (including the House of Commons Public Administration Committee) commented critically on this remarkably short timeframe and on the relatively poor quality and greater secretiveness of the second energy review when compared with the first (Taylor, 2016; House of Commons Public Administration Committee, 2009). It emerged in subsequent commentary that Tony Blair's own personal strategy team exercised particular influence. In 2005, a small group of hand-picked political advisors were commissioned directly by Number Ten within the Cabinet Office to work on a range of topics including energy. As documented by Taylor (2016), this group was led by Tony Blair's long-term personal associate John Birt, a former Director General of the BBC, with no particular energy experience. Even nuclear advocates have described the resulting report as "a more secret piece of work", about which many civil servants (even in the Cabinet Office) "…were not involved or even told" (Taylor, 2005: 61). It was this small, secretive working group that came to the (eventually highly formative) conclusion that nuclear power was after all required. To this day, there exists no documentation in the public domain as to the means by which their conclusions were reached, or the arguments on which it rested, nor why the public findings of the earlier PIU study were deemed to be superseded in this regard.

Initiated by these developments, the 2005 energy review was also very different from the PIU-led review in 2002-3. Instead of being led by an independent panel of energy policy experts, this second review was led by Malcom Wicks, the Secretary of State for Energy. The organisation that was in charge of handling submissions for the review was AEA Technology, staffed largely by former members of the Atomic Energy Authority (The Observer, 2005). With no obvious explanatory factor in the outside world, this rapid revisiting of the energy issue (and in particular nuclear power) was also a puzzle to many politicians at the time (The Observer, 2005). The resulting consultation document was very short (DTI 2006), and comments were required in less than 3 months. So this second energy review was only took about half the time that the PIU review did, a few years before. Important changes were also occurring at this stage in the composition of the Blair Cabinet, with removal of some more critical figures involved in 2003 and their replacement by individuals with more favourable views of nuclear power. A typical tone in the reporting of this is exemplified by the BBC, for whom this was "widely seen as clearing one obstacle to building more nuclear plants" (BBC News, 2006) – as if the rationale for the clearing of obstacles were self-evident, without need for discussion as to why. With the review thus completed, the subsequent final report *Our Energy Challenge* concluded that nuclear had a "role to play" (DTI, 2006) paving the way for a White paper by the end of 2006.

Of course, this did not occur without serious concerns being raised. The House of Commons Trade and Industry Select Committee published a report (House of Commons Trade and Industry Select Committee 2006) which, while not critical of nuclear power itself, nevertheless pointed towards the problematic nature of the inquiry, in that it "risks being seen as little more than a rubber-stamping exercise for a decision the prime minister took some time ago" (MP Peter Luff, Chair of House of Commons Trade and Industry Select Committee , quoted in The Guardian, 2006). Greenpeace launched and won a legal challenge against the Government, which found that the consultation was "deeply flawed" and "unlawful" because it had fallen well short of the promise of "the fullest consultation" that was the proviso for the reconsideration of nuclear promised in 2003 (The Royal courts of Justice, 2007).

It was in answer to this remarkable finding, however, that Tony Blair famously announced that this serious legal rejection of the quality of the policy process would nonetheless "not affect policy at all" (BBC News, 2007). Forced by this legal intervention, a second consultation on nuclear was quickly conducted and again criticised by NGOs as being seriously flawed. Nevertheless, a yet further nuclear white paper was released in 2008, which stated unequivocal support for new nuclear power:

> *The Government believes it is in the public interest that new nuclear power stations should have a role to play in this country's future energy mix alongside other low-carbon sources; that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the Government should take active steps to open up the way to the construction of new nuclear power stations. (BERR 2008: 10)*

The question therefore arises, as to what drove this dramatic turnaround in policy? As discussed elsewhere in section 9, there are no suggestions that any substantive flaws were found in the earlier analysis, or that new developments occurred in the short intervening period to materially overturn what was legally recognised to have been deeper and more comprehensive analysis three years before. Nor are there any particularly visible signs of abrupt new developments in or around the UK civil nuclear industry itself, indicating innovative arguments or intensified mobilisations on a scale that might warrant the advent of the 'nuclear renaissance'. The French utility, EDF, had become more prominent in policy debates during this time. But there are no documented suggestions in the literature that EDF on their own somehow managed to turn UK policy around. So the question therefore remains especially in this period, as posed by the longstanding international nuclear expert, Professor Stephen Thomas, as to exactly "*what is the UK nuclear lobby?*"(Thomas, 2016). What is clear, is that whatever it was that conditioned this remarkable and abrupt change in policy in the period 2003-2006, it was (as pointed out by nuclear commentator and proponent Stephen Taylor) undertaken by a "secretive group" and "behind the scenes" (Taylor, 2016) at the highest levels of Government.

Another striking feature of this period is also the increased interest surrounding the "nuclear renaissance" that kicked in after 2003 in British publications, as shown by figure 5 below indicates the number of articles mentioning the term "nuclear renaissance" between 1990-2015.

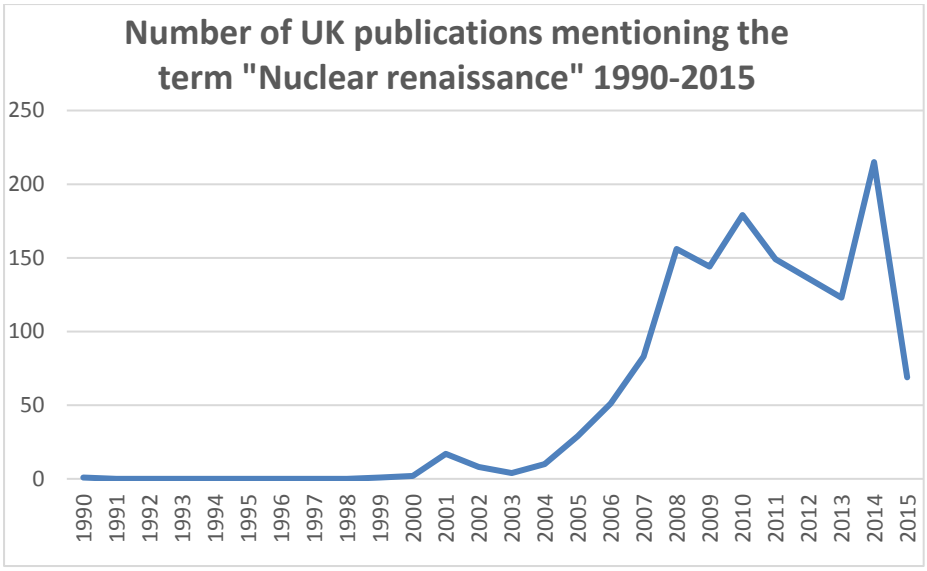


Figure 5: Number of articles mentioning the term "nuclear renaissance" in UK publications LexisNexis© (2016)

This by no means stands for concrete evidence, however it nonetheless emphasises the significant increase in activities surrounding nuclear power in the crucial period of study. Such processes are notoriously difficult to investigate, especially in any rigorously critical fashion. To illuminate the background to this policy turnaround, we therefore conducted a timeline analysis of major policy and commercial developments, policy documents, official reports and lobbying initiatives relating broadly to the UK military nuclear sector from 1955 to 2014 (see section 4 for methodological details). The results are summarised in Figure 6. Even allowing for possible growth in policy documentation more generally, or an over-visibility of more recent initiatives, Figure 6 clearly shows a marked intensification of policy activity in this sector, during exactly the period of the otherwise unexplained turnaround in civil nuclear policy. Indeed, the evident intensity of this activity seems unparalleled in the history of UK military nuclear policy, exceeding by some margin earlier peaks in activity associated with major policy developments such as the inception of the Polaris programme in 1962, or its successor the Trident programme in 1980.

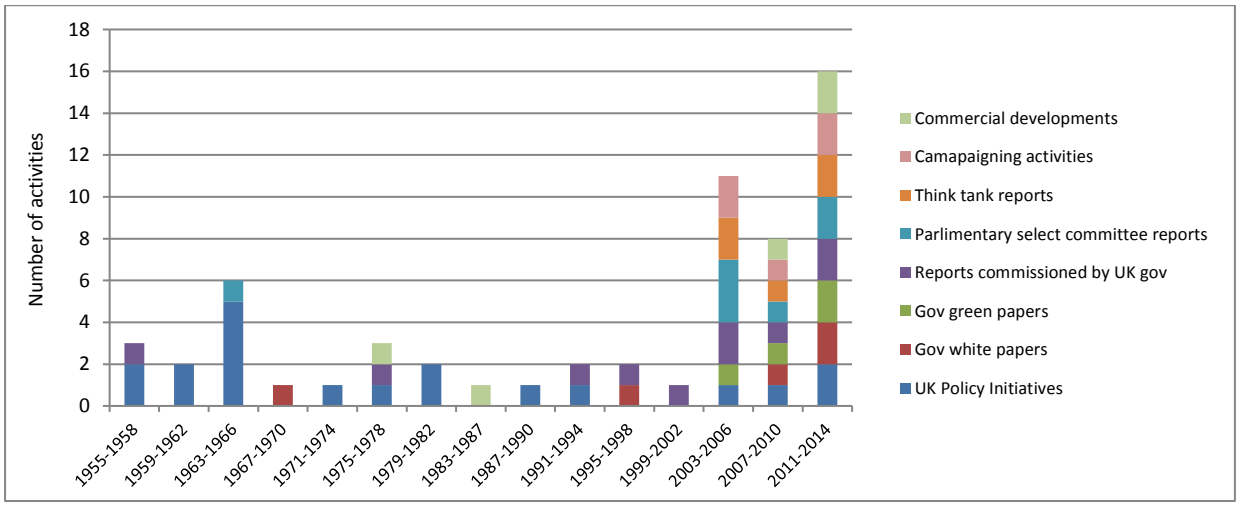


***Figure 6: histogram showing intensity of activity in UK military nuclear policy, in 4-year increments**: 1955-2014,*

The picture is therefore again very clear. The otherwise unexplained and unprecedented reversal in UK civil nuclear policy occurred in precisely the same short time interval as an equally unprecedented – and well-documented – crisis in UK military nuclear policy. Indeed, just this kind of unique reversal in civil nuclear policy is repeatedly and openly acknowledged in the military policy literature to present a significant part of a solution to the perceived crisis in key military capabilities occurring at that time. Observed even by proponents of civil nuclear power to have been due to a "secretive process" operating "behind the scenes" at the highest political levels, then, the 2003-6 reversal in UK energy strategy is thus very strongly circumstantially associated with evidently massive concurrent pressures asserted by military nuclear interests.

Given the clarity of the policy documentation on the military side in this period, it is quite remarkable that the significance of these pressures is virtually entirely unacknowledged the civil nuclear policy debates – either at the time or subsequently. Whatever the formative influences may have been, the acknowledged secrecy of Tony Blair's nuclear decision process in 2005 means that evidence as to causes must necessarily (in absence of first hand testimony) remain little more than circumstantial. Yet there are a few further specific ways in which the evident importance of military policy drivers in this period can be resolved to a further level of detail that offers to clarify the picture somewhat beyond this. These emerge when attention is given to quite how much of the literature reviewed earlier in this study in establishing general influences of military on civil nuclear policy, actually fall into the exactly the period of 2003-6 in focus here.

Elsewhere we have documented the variety of activities that occurred in this crucial period with regards to nuclear activities related to nuclear activities related to the construction of submarines and the "about turn" (Public Accounts Committee. 2009), regarding enthusiasm for civilian nuclear energy (Johnstone & Stirling 2016; Johnstone & Stirling 2015b)**.** Following the Defence Review published in May 2003 (House of Commons Defence Committee, 2003) a few months after the Energy White Paper published in January of the same year, significant levels of activity related to military-related nuclear policy took place. This involved various White Papers, Green Papers, Commissioned Reports, think tank reports, and key campaigning activities related that related to defence related nuclear issues. A defence Review report was published in May 2003 (House of Commons Defence Select Committee, 2003), outlining the need to maintain the nuclear deterrent pointing out that although the decision was being taken in the next parliament, the Trident was likely to be replaced. An additional chapter on Future Capabilities was published in 2004 (MoD, 2004).

In April 2004 the Keep our Future Afloat Campaign (KOFAC) was formed which is constituted by Trade Unions including UNITE, GMB, local political interests including Barrow Borough Council, Cumbria County Council and industry representatives to encourage "*new investment in the [submarine construction] industry and its skills base to influence industry and government leaders, shadow Ministers, the wider public, local authorities and media" as an "influential champion of the UK submarine industrial base"* (KOFAC, 2016). Since April 2004, KOFAC has led an intense lobbying campaign targeting all political party conferences and providing input to *"Select Committee Inquiries, Defence policy reviews, on supply chain issues, potential mergers and other forms of industrial base change"* (ibid.). The power of KOFAC's lobbying campaign is widely noted, for example then Secretary of State for Defence Geoff Hoon commenting that KOFAC was "*one of the most effective defence lobbies I have come across*." (ibid.)

KOFAC consistently drew attention to the 'skills gap' outlining that "Suppliers who can service both military and civil requirements will be better placed to survive the variations in the nuclear market place" (KOFAC, 2005). Ties between civil and military with regards to the supply chain is also highlighted in KOFAC's response to the 2006 review on the Industrial base for retention of the nuclear deterrent pointing out that: "there is a need to sustain and grow skills development for the civil and defence nuclear industry", "Reduce indecision about future investment in new civil nuclear industry and in the nuclear submarine industry" and "Underpin essential learning pathways to develop the skills needs of the civil and defence nuclear industry" (KOFAC, 2006). KOFAC's responses have not been confined to defence related reviews however. In It also engaged in energy

policy consultations, highlighting the importance of a shared skills pool for the military and civilian nuclear sectors (KOFAC submission to the Energy Review, 2006) and made the positive case for nuclear power in the second nuclear consultation in 2007 pointing out that "Affordability in the civil and defence sectors can be enhanced through their interaction and by harnessing the total nuclear supply chain in the north west" (KOFAC, 2007).

At a similar time to the founding of KOFAC, the Ministry of Defence commissioned a three-volume report conducted by the RAND corporation on the *United Kingdom's Nuclear Submarine Industrial Base* (Rand, 2005a; 2005b; 2005c), which examined in detail the skills issue surrounding the construction of nuclear submarines and the need for planning around investment to maintain skills & expertise related to specialised skills surrounding nuclear submarine propulsion. In 2005 *The Defence Industrial Strategy White Paper* (MoD 2005) was released recognising the *"high priority for the UK to sustain the suite of capabilities required to design complex ships and submarines"* where the UK *"…will retain all of those capabilities unique to submarines and their Nuclear Steam Raising Plant, to enable their design, development, build, support, operation and decommissioning"* (MoD 2005: 70). In the second half of 2005 the DTI undertook a UK nuclear skills supply gap analysis. In early 2006, BAE Systems, the company that constructs nuclear submarines formed the *"key supplier forum"* in 2006 to bring together and coordinate for the purposes of cost reductions and future planning among the key stakeholders in nuclear submarine construction, including BAE Systems, Rolls Royce and Alstom among others (BAE Systems Key Supplier Forum, 2006).

The White paper on *The Future of the UK's nuclear deterrent* was published in 2006 recommending the renewal of the Trident-based weapons system, and alongside this, the House of Commons Defence Committee under took a substantive review into *The Manufacturing and Skills Base* for the renewal of the strategic deterrent (House of Commons Defence Committee, 2006). Key evidence was given by stakeholders for example Rolls Royce, who pointed out that the depletion of skills in the civilian sector had "reduced the support network available to the military programmes" (Rolls Royce quoted in House of Commons Select Committee, 2006: 110). In 2006 as well, The DTI unveiled plans to preserve nuclear skills and R&D capabilities as part of a National Nuclear Laboratory (NNL) and formal announcements of the formation of the National Nuclear Laboratory was announced in October 2006 (Fairhall, 2007), as well as plans for a National nuclear Skills Academy (House of Commons Select Committee, 2006). The NNL operates to train and develop skills in nuclear working with partners across the civil and defence nuclear sectors (NNL, 2016). Therefore it is clear from the brief overview above, that considerable activity was taking place in the policy sphere related to the issues of nuclear submarine capabilities and the retention of key nuclear skills to support this industry, during the critical period of 2003-2006.

Section 9: Comparing Alternative Hypotheses – Rationality? Regimes? Individuals and Networks?

As highlighted from the outset, the main purpose of this paper has been to explore systematically a hitherto virtually unaddressed possible reason for the otherwise unexplained intensity of official UK policy attachments to nuclear power – and especially the unprecedented reversal of a brief interruption to these commitments in the period 2003-6. This possible contribution to understanding these events is, that it is perceived imperatives to maintain national UK capabilities to design, build and operate nuclear-propelled submarines, that have exercised a crucially formative influence on the intensity of parallel policy commitments to civil nuclear infrastructures. The potential importance of this particular factor is all the greater, because it remains so undiscussed in debates over UK energy policy.

It is not the purpose of this study (nor does length permit us) to offer a similarly detailed exploration of all the alternative contrasting hypotheses discussed in Section 2 as addressing potentially converging contributory factors in explaining the intensity of UK policy attachments to civil nuclear power. These were: *(i) the 'face value' UK civil nuclear policy hypothesis* (H1); *(ii) the UK nuclear power entrenchment hypothesis* (H2); *the elite policy actor and networks hypothesis* (H3); as well as *the UK deep incumbency hypothesis* (H4). Nor is it necessary for the substantiation of the present argument to explore each of these in equal length. The point here is not that perceived imperatives in elite UK policy cultures to maintain nuclear submarine capabilities, form a sufficient basis for understanding the distinctively pro-nuclear character of UK energy strategies. The argument has rather been, that this perceived military nuclear imperative is clearly salient in principle – and arguably evidently quite highly empirically relevant to understanding particular pivotal 'critical junctures', like that occurring between 2003 and 2006.

So the relevant test at this point for the alternative hypotheses (H1; H2; H3) returned to now is somewhat less demanding. Here, the crucial question for the present analysis is not about the relative salience of the different hypotheses, but about whether any of them might be judged to be so clearly sufficient in its own right – or whether they are collectively so compelling – such as to so fully explain the pattern of events that the relevance of parallel military drivers is rendered effectively redundant. In seeking to address this final task, it is very helpful that there exists a quite voluminous policy literature on some of these alternative hypotheses. What needs to be asked of this evidence, is simply whether these alternative hypotheses offer – individually or collectively – such a clearly sufficient basis for understanding, that resort to the present (acknowledgedly less explicitly documented) military nuclear imperatives is rendered unnecessary.

This section will therefore quickly review the evidence in relation to this criterion for each possible alternative kind of explanation in turn. Then – by reference to the theoretical discussion in Section 3 – the following (penultimate) section will focus in detail on the fourth hypothesis concerning the extent to which the policy dynamics discussed here warrant consideration as a possible instance of a 'deep incumbency complex'.

First, there is the 'default' hypotheses is to take UK energy policy literatures at face value and accept that declared criteria around economic efficiency, energy security and environmental performance all act together to explain the observed level of commitment to nuclear power. This is the '*face value civil nuclear policy hypothesis*' *(H1)*. Arguably the single most important feature of this concerns the increasing UK policy imperative to address climate change. It is especially on these grounds that key figures in this story like UK Chief Scientist Sir David King declared repeatedly over the course of the history reviewed here, that there is "no alternative" (King 2006) to a nuclear strategy for the UK, and that nuclear power is a 'necessity' (David King, 2005).

The remarkable uncompromising and unqualified rhetorical intensity of such assertions are in themselves both a clue as to their political nature and an indication as to their underlying substantive weakness. Without taking a position one way or another on the relative pros and cons of nuclear power as compared with other low carbon energy options, it is abundantly clear from longstanding official UK government appraisals and analysis by leading energy policy consultancies on which these often depend, that there emphatically does exist a wide variety of viable low carbon 'alternatives' to nuclear power in the UK. Whilst it remains legitimate to interpret this evidence in ways that prefer nuclear power over these other alternatives, it is quite simply untenable to interpret this official policy literature as a basis for any claim that nuclear power is an unqualified 'necessity'.

Going back several decades (Stirling 1994), a succession of authoritative assessments – including those officially undertaken for successive energy reviews discussed in this study, show very clearly – within the bounds of the significant ever-present uncertainties and conditionalities – that renewable energy and energy efficiency measures do offer possible means to secure climate change mitigation in ways that are at the same time requisite in their scale, expedient in their timeliness and manifestly competitive in cost with nuclear power (Liebreich 2016; National Audit Office 2016; DECC 2016a; Mott MacDonald 2011; Davies & Lloyd 2013; DTI 2006; Environmental Audit Committee 2006; PIU 2002). The challenge is therefore not one of desperation as suggested by the strident language of 'no alternatives', but rather a matter for precisely the kinds reasoned and measured social choice that this polarising language makes more difficult.

To pick just one among many official UK sources confirming that this picture was clearly visible in high-level policy making circles during crucially formative periods reviewed in this study, there is the example of the report by the UK Parliament's Environmental Audit Committee, which confirmed nuclear power to perform poorly on international comparisons on almost all counts[24] (Environmental Audit Committee 2006). Similar arguments apply to the relative performance of alternative energy strategies in relation to possible arguments concerns security of supply – especially in relation to tensions over Russian gas supply to Eastern Europe (Cherp and Jewell 2011; Kuzemko 2014; Umbach 2010; Winstone *et al* 2007). This was indeed, the basis for the finding in the 2003 Energy Review discussed in detail in Section 8, that new nuclear build in the UK was in that crucial period on balance "unattractive" (DTI, DFT 2003, p.12; 44; 61)

Nor is this a reflection of specific conditions relating restrictedly to this time period alone. It has been acknowledged since the early 1970s that the UK enjoys the best renewable energy resource in Europe (Wilson, 2012). Indeed, official government data has shown since the 1980s that renewables are comparable or cheaper in cost to nuclear (Stirling, 1994) – a picture that has continued to become progressively clearer and more pronounced in successive detailed cost-curve analyses as the economic performance of technologies like wind power continues to improve (Resch 2006). That such findings can readily be found in the documentation underlying the PIU Energy review (2002) and the subsequent White Paper of 2003, makes it especially difficult to understand the events of that period documented in the last section.

Another dimension to the overall energy security narrative that is sometimes referred to as being crucial in driving renewed commitments to nuclear is that nuclear is necessary in order to sustain 'baseload' electricity supply. As stated in the 2007 White Paper on Energy following the energy review, nuclear was needed because "[it is] the only low-carbon form of baseload Generation" (DTI 2007: 187) . However, it is unclear why this line of argumentation should lead to the intense level of support for nuclear in the UK. For a start, the PIU review had outlined the potential to move away from such a baseload model of electricity provision in the original energy review in 2002-2003 (PIU 2002; DTI 2003). Also, key reports and future modelling of energy systems highlight that non-baseload based energy systems are possible. These outline that flexible systems based around high levels of penetration of renewables in the electricity mix are technically feasible, as well as economically competitive and potentially cheaper ways to design systems of electricity supply (Abbott 2012; Infield & Watson 2007; Sovacool 2009; Diesendorf 2016). The idea that future energy systems may well be moving away from a baseload model is well established with the head of the National Grid in the UK recently

acknowledging such a position (Beckman 2015). So, the baseload argument does not seem to adequately account for the particular levels of intense support for nuclear experienced in the UK.

In short, the evidence is clear that – whilst nuclear power may be judged under the most favourably-disposed perspectives to offer a potential option – it is simply not possible reasonably to conclude on the basis of the available authoritative evidence, that nuclear power is as distinctively attractive as implied in UK policy outcomes response – let alone that it is (as claimed in high level policy rhetorics 'a necessity' brooking 'no alternatives'. The existence of numerous viable – if not manifestly preferable – alternatives again underscores that this hypothesis simply cannot on its own satisfactorily explain the unique intensity of UK policy commitments to nuclear power over either policy strategies for achieving secure, low carbon energy services.

The second hypothesis that was especially substantiated in the theoretical section of this study, is the *entrenched UK nuclear power regime hypothesis (H2).* This posits that the reason why the UK remains so distinctively committed to nuclear power, is due to 'regime resistance' exercised by assertively successful interests in this particular sector. Examples of this kind of explanation can be found in various versions of sociotechnical regime theory – for example where Geels (2014) explains the ways in which an energy 'regime' constituted by the coal and nuclear industries acts very actively to resist the transition to renewables, for instance through the lobbying of state institutions. Here, there can be little doubt as to the validity and utility of recognising the political forces that can be asserted by successful incumbent industries on encompassing governance institutions – effectively 'capturing regulation' (Kern & Smith 2008) and operating to 'entrap' (Walker 2000) wider state structures. This issue has been addressed by a different study under the auspices of the same research project as this paper (Johnstone & Stirling 2015a). The question in the present case is, however, over how persuasive it is, that it should have been the British nuclear industry more than that of other more likely countries, that enacted such powerful pressures with sufficient force to compel the currently-observed intensity of UK Government attachments to nuclear power. And in this event, why would the UK Government be so reliant in delivering on this, on civil nuclear engineering supply chains that are actually predominantly French and Chinese – or, under other scenarios, Japanese, Korean or American?

By contrast with the findings surveyed in this paper for the manifest activity around military nuclear interests in the period of the crucial juncture reviewed here (2003-2006), there exists no similar evidence for a comparable scale of activity by UK civil nuclear interests. There was in this period no British commercial nuclear reactor vendor, the national nuclear utility British Energy had gone bankrupt, and even EDF (who were later to take over this business) were not yet visibly 'lobbying' until the Energy Review began. In the words already noted by the expert analyst, Professor Steve Thomas – it is even in this manifestly formative period, difficult to know what actually constituted the 'UK civil nuclear lobby'(Thomas 2016).

If 'sociotechnical regime' explanations are taken seriously, then the particular intensity of UK civil nuclear commitments would be seen to reflect an especially bullish and assertive civil nuclear industry (Geels, 2014), operating under conditions of especially weak 'niche' developments around challenger technologies like renewable energy. Yet what must be acknowledged here, is that the UK nuclear engineering industry has long been among the weakest of those ever established internationally (Thomas 1988). With (as discussed above) the cost-effectively available 'niche' renewable resources actually being the most favourable in Europe, the UK might be expected also to accrue stronger and earlier industrial interests (and associated lobby pressures) in these sectors, than many other countries. In short, as other research under the auspices of this same project shows [SWP], sociotechnical regime theory would more readily predict that it would be Germany, rather than the UK, that would become most entrenched in civil nuclear power. The fact that the reality is manifestly the reverse of this, suggests that – whatever its incremental or supporting value might be – an '*entrenched UK nuclear power regime hypothesis*' cannot of itself satisfactorily explain the observed pattern of events.

The final hypothesis to be considered in this section is the *elite policy actors and networks hypothesis (H3).* Highlighting the relevance of individual agency and interpersonal networks, this kind of explanation focuses on the detailed ways in which the decision for new nuclear build was made 'behind closed doors', involving powerful elite actors around civilian nuclear power interests both in government and industry. As we have discussed above, evidence for this can be found in accounts like that of Stephen Taylor, who points out the 'secret' nature of Tony Blair's strategy team that reviewed nuclear during 2005, and the 'behind the scenes' nature of the conflicts between Margaret Beckett, Patricia Hewitt and others (Taylor 2007). Other indicators of this more individualistic and networked understanding of political processes might also refer to media concerning, for example, the 'wining and dining' of DECC officials by nuclear power companies as revealed by Freedom of Information requests by Rob Edwards published in *The Guardian* (Edwards, 2014).

A further indicator of the relevance of network interactions between elite individual policy actors is the manifest role played by 'revolving doors' in nuclear policy, in which senior politicians often take key roles in nuclear lobby groups and then later return to politics, a practice that is considered to be particularly endemic in the nuclear industry[25]. Negotiations around the 'Strike price' for Hinkley C as part of the Contracts for Difference (CfD) framework, for example, were reported to have involved 'behind closed doors' processes of this kind (Vidal, 2014). Implicating many prominent individuals, displaying curious reversals of positioning on nuclear power – and including the role of the brother of Prime Minister Gordon Brown as a nuclear lobbyist (Wheeler 2007)– there can be little doubt as to the importance of these kinds of dynamics. Indeed, some key experts go as far as invoking them in postulating that the French nuclear utility EDF effectively managed completely to outmanoeuvre the UK Government by this kinds of means, enabling them to secure UK nuclear assets as a means to channel revenues from British electricity consumers into payment for French nuclear decommissioning costs [26].

Further particular versions of this elite actor-network hypothesis variously invoke a range of supposedly decisive roles played by different purportedly key individuals, including Tony Blair himself (Taylor 2016). Brian Wilson (Wilson quoted on BBC Newsnight, 2008), David King (King quoted in Leake 2008) and Sue Ion (Ion quoted in Taylor, 2016) are all variously quoted as asserting their own personal importance in the policy turnaround in the period 2003-2006. An emphasis on the role of elite actors was also encountered in this study during interviews and conversations with several key experts. An example of this kind of argument, is that it was the interactions between elite individuals like those named above during the critical juncture 2003-2006 that persuaded Tony Blair of the need to (rather ignominiously) reverse his then recently and carefully-established new nuclear policy. In more recent times, different individuals become identified in similarly supposedly formative personal roles, including an increasingly current view that adherence to plans for the Hinkley Point C reactor simply reflect the personal dispositions of former Chancellor George Osborne.

With respect to this hypothesis, then, the short answer is that it is impossible to refute the manifest relevance to the course of events, of actions by elite individuals and their networks of relations. In governance processes entirely mediated by such individuals, how could it possibly be otherwise? The real question in this case, is not whether there are suggestions as to less visible formative roles for such individuals, but the extent to which such individual agency is in itself decisive – or itself conditioned by more distributed formative pressures? Without diminishing the importance of this factor, it is difficult fully to explain the course of events in the UK reviewed solely in these terms, because the identities of the particular elite individuals and networks variously implicated have all changed so radically over periods during which the intensities of the commitments have manifestly remained the same. None of the individuals – or even networks – mentioned in relation to events in the period 2003-2006, for instance, are still implicated in the present continuing anomalously intensive commitment to nuclear power.

Likewise, those accounts that do emphasise ostensibly formative roles for individual agency, variously focus even in the same period, on completely different supposedly focal individuals. As with any conspiracy theory,

the necessarily opaque nature of interpersonal communications and relations make it difficult to be sure either way. Whatever formative roles they may play, then, individual actors and networks are clearly subject to wider conditioning pressures that confer greater continuity in the observed pattern events, than is evident in their own individual careers. It is for this reason, then – as well as healthy general scepticism about the sufficiency of under-corroborated 'conspiracy theories' in a complex and intractable world (Clarke 2015)(Sunstein 2014) – that it seems that this final alternative hypothesis (while salient) also cannot be considered sufficient in itself.

This brings us to the final question of this study, whether the evident influence on UK civil nuclear policy of elite policy commitments to military nuclear capabilities can be considered to reflect a phenomenon that might be termed a 'deep incumbency complex'? Before turning to this question, it is important to emphasise again what has, and has not, been argued in this present section. In a field as complex, dynamic, uncertain and secretive as civil and military nuclear policy, it would be unwise in the extreme to seek to assert definitive conclusions, or unitary understandings. All of the hypotheses reviewed here are likely to hold some value in helping to understand particular aspects in the observed course of events.

To take each in turn, the determinants of UK civil nuclear policy criteria that are declared in official documentation are all evidently important and valid in principle – it would be difficult to claim that policy processes are so disingenuous that they exercise no influence at all (H1). Likewise, it would be naïve to argue that there do not exist significant pressures from entrenched interests in UK civil nuclear sector – even though this may be relatively small and weak. And – as has just been explored - elite policy actors and their networks are undoubtedly deeply implicated in the forming of policy commitments of all kinds. The analysis summarised here, is simply that none of these well-recognised factors can reasonably be considered to be sufficient in itself. Nor – for the reasons discussed – is it persuasive to assume that all these taken together are fully sufficient on their own. It does appear some other factor is involved.

Section 10: Is There a 'Deep Incumbency Complex' Around UK Civil and Military Nuclear Power?

It now falls to this final concluding section of this study, to review carefully the series of systematic stages in the hypothesis testing process that has framed the reasoning throughout this paper. The first step in the argument was to establish a *prima facie* case for identifying the unusual intensity and persistence of official UK policy commitments to civil nuclear power and for raising questions over what might be driving this. This case was established in **Section 2**, which showed that the UK is not only noticeably internationally distinct in this regard, but that it might even be thought on the basis of other resource and political-economic considerations to be a setting in which a shift of emphasis *away* from nuclear power might be more strongly expected than in some other countries (like Germany), where this is – in striking contrast to the UK – actually taking place. It certainly does seem reasonable to want to try to understand such an apparent anomaly.

After then introducing in **Sections 3** and **4** the theoretical and methodological groundings for an enquiry into such an anomaly, the next step in the argument was to characterise some of the most plausible possible reasons why this unusual intensity of nuclear commitment is observable in the UK. Four hypotheses were introduced to this effect:

(1) The first was *the 'face value' UK nuclear policy hypothesis (H1),* in which formal policy rationales for UK attachments to nuclear power are accepted as sufficient explanation in themselves – to do with the declared cost-effectiveness of nuclear power when compared with alternative means to deliver secure, low carbon energy strategies.
(2) The second was the *UK nuclear power entrenchment hypothesis (H2),* in which the intensity of commitment is taken to reflect powerful political pressures and lobbying on the part of a particular sectoral 'sociotechnical regime' around UK nuclear power.
(3) The third was *the elite policy actor and networks hypothesis (H3)*, in which the course of events is held entirely to have been driven not by sector-based structural forces, but by more specific – and perhaps generally privileged – webs of agency involving elite individuals and communities.
(4) The fourth was *the UK deep incumbency hypothesis (H4)*, under which the intensity of UK nuclear commitments is held to reflect pressures that extend beyond the civil nuclear industry alone or any specific elite interpersonal networks, to implicate ostensibly diverse and separated interests and deeper forms of social agency. In particular, this was held to be centre around perceived imperatives to maintain the national military and geopolitical status that is widely held to be associated with possession of strategically-credible nuclear weapons platforms: nuclear powered submarines.

The first three of these hypotheses (H1; H2; H3) are based on quite familiar ideas, explored in large extant literatures, so they are more readily evaluated than the final one on the deep incumbency hypothesis. It was for this reason, that the pictures in relation to these first three hypotheses were summarised here in a relatively briefer way, than the attention given to the more entirely novel deep incumbency hypothesis (H4). Accordingly, **Section 9** explored the different patterns of relevance and sufficiency associated with each of these hypothetical ways to understand the observed dynamics. In short, it was concluded there that each of these first three hypotheses (H1-3) clearly has some role to play in informing understandings of these obscure, complex and diverse processes. Stated policy rationales are clearly advanced in good faith and exercise some influence (H1). The UK nuclear industry obviously enjoys particular forms of influence and seeks to exercise this (H2). Individual actors and elite networks have evidently been highly active and can be shown to have been relevant at particular points (H3).

But the findings in Section 9 of this paper are nonetheless also quite clear in another respect. No matter how they are viewed – and without even necessarily implying any prohibitive criticism of nuclear power – available official UK cost and performance data manifestly *do not support* the observed intensity of policy attachments to nuclear power, as compared with other low carbon energy strategies, or the manifest possibility (if so chosen), of entirely non-nuclear UK low carbon energy trajectories. So while relevant, *the face value nuclear policy hypothesis (H1)* is thus shown to be insufficient in itself. Likewise, the UK nuclear sector is actually among the weakest of any of those national nuclear industries that have been developed – for instance when compared with Germany. So whatever its other merits may be, a *UK nuclear power entrenchment hypothesis (H2)* does not fully explain the observed distinctive pattern of developments in the UK. Similarly, there are of course many signs of significant roles played by individual elite actors in UK nuclear policy. But reports of these roles are so diverse and diffuse – and contradictory in their specific implications – that they are also not enough to explain the particular abrupt turn of events in 2003-2006. So, *the elite policy actor and networks hypothesis (H3)* is also evidently insufficient on its own satisfactorily to understand the intensity and persistence of UK policy attachments to nuclear power. Nor do these hypotheses together (H1-3) offer any persuasive basis for understanding the especially striking pattern of events during the particularly formative critical juncture of policy reversal documented in this study over the brief period 2003-2006.

It is on this basis, then, that attention can be judged to be warranted to the fourth hypothesis, concerning the *UK deep incumbency complex (H4)* – even though this idea is much less well documented in extant literatures and virtually entirely unmentioned in relation to these policy developments in the UK. Indeed, it is with regard to the under-visibility of this kind of hypothetical process, that a number of earlier responses to the present research project prompt a further particular point (Jewell 2015; Stirling & Johnstone 2016). Both in critical comments from other academics, and in sceptical reactions by journalists to the current line of analysis, it does seem that there exist strong aversions to anything that can be caricatured as a 'conspiracy' theory. Indeed, it may be that it is these kinds of inhibitions that have some role to play in the notable dearth of attention to this kind of explanatory factor. As was noted in the discussion of theories about power in Section 3, the effects of incumbency can be as pronounced in efforts to understand the world, as they are in attempts to act in it.

Yet simply to posit in this way the possible influence of a phenomenon as potentially opaque and influential as the kind of 'deep incumbency' hypothesised here, should not of itself be taken to imply the propounding of some simple kind of 'conspiracy theory'. Indeed (as explained most recently above), the deep incumbency hypothesis explored here is directly contrasted in this study with a distinctively different hypothesis – on the dynamics of elite policy actors and networks (H3). If anything, it is this latter contrasting understanding that might more readily be taken to resemble conventional ideas about elite conspiracies. In fact, then (in explicitly concluding in the last section that these kinds of elite network dynamics, while relevant, are not sufficient explanation in themselves), the present exploration of a more distributed and structural deep incumbency complex, is quite explicitly *repudiating* of a conventional conspiracy theory. Far from ideas of 'deep incumbency' being subject to this kind of criticism, the detailed discussion in Section 3 of underlying dynamics of power shows how it is actually accusations of 'conspiracy theory' themselves that can be seen as simplistic.

Indeed, it is not without relevance to the nature of the processes envisaged in the deep incumbency hypothesis, that this rather obvious point on conspiracy theories seems regrettably necessary to clarify so repeatedly. With this point addressed here, however, the more substantive business of testing the deep incumbency hypothesis can proceed in a number of clear and systematic further steps. The first of these was to investigate more stringently whether impressions are reliable, that otherwise disparate UK Governments have maintained strong persistent commitments both to civil and military nuclear technologies. **Section 5** explored this issue in detail. The result was to establish with some confidence that the protracted conjunction of these two ostensibly contrasting commitments is indeed a demonstrable political reality in the UK. Crucially, it was shown that these dual attachments have each been maintained over many decades in the face of considerable

adversity. So neither can be seen merely as an artefact of selection on the part of the present research project, nor of background noise in a volatile policy discourse. The deep incumbency hypothesis might therefore on these grounds, be judged at least to be *applicable in principle*.

The next step was to test the proposition (beyond a mere conjunction in intense UK military and civil nuclear commitments), that more generally manifest and substantive linkages are actually observable between these UK Government attachments to renewing civil nuclear power and maintaining national capabilities to sustain nuclear propulsion infrastructures for military submarines. **Section 6** explored various dimensions of this issue. For instance, on one obvious aspect: the general international context was found to display (as summarised in Figure 3) broadly recognisable patterns of association between commitments to civil nuclear power and military nuclear status – including nuclear submarine capabilities. When considered in light of the number of economically developed nations around the world, the extent of the overlap between the very small number of countries with declared plans for large civil nuclear programmes and those seeking to maintain nuclear weapons capabilities – is quite striking. Whilst far from conclusive and not (as might be expected in such a complex world) without anomalies, this picture is at least *broadly consistent* with a deep incumbency hypothesis. It seems that reasons for investigating this dynamic may not be uniquely relevant to the UK.

Beyond this, an array of general linkages were established in Section 6 between civil and military nuclear activities in the UK, including a large number of British companies with significant levels of involvement in both fields. On closer scrutiny, some of these companies – like the lead contractor in the nuclear submarine reactor programme, Rolls Royce – were found to be very explicit (albeit in ways that were evidently intended to be quite private) in emphasising the commercial strategic importance to their own business of building on what they highlighted to be, for them, crucial civil-military linkages (see Figure 4). Such strategic commercial pressures in this sector were also found to be quite strongly and clearly documented in policy literatures around military nuclear capabilities. The possible operation of a nuclear incumbency complex broader than nuclear power alone, may thus on these grounds at least be held to be suggested by *circumstantial evidence*.

Yet the almost total lack of any mention of such pressures anywhere in the voluminous literatures concerned with UK energy strategies – especially in any officially declared rationales for policy commitments to civil nuclear power – requires a higher burden of evidence and analysis. This striking level of silence in UK energy policy debate on even the potential relevance of this factor was confirmed in **Section 6.** But this detailed review of extant policy documentation did also illuminate some possible reasons for the evident under-visibility of these kinds of links. Here, it is telling that a former senior executive for the leading UK nuclear submarine contractor BAE Systems, made reference in one public policy document to the relevance of strategies to 'mask' such links. It is in light of this documented – and obvious – motivation for secrecy, that it would be naïve to interpret the relative dearth of published acknowledgements of a 'deep incumbency complex' as decisive evidence in itself for the absence of such a phenomenon. Yet the gravity of the issues addressed here does nonetheless impose on the present argument, a need for more tangible levels of support.

So, informed by understanding that the operations of a deep incumbency complex (were it to exist), should be expected to be under-visible, **Section 7** went on to investigate whether the broadly observable circumstantial linkages already documented, do also suggest particular concrete kinds of formative relationship between civil and military areas of UK policy making. Here, a number of further salient findings emerged – especially on the military side of UK policy debates, where perceptions are evidently most intense concerning the threats to UK nuclear submarine capabilities and the need to support these. Taken together, UK policy documents from a wide variety of sources at the highest levels in this military strategy arena – including dedicated Parliamentary Select Committee Inquiries – are very clear and unequivocal that the sustaining of a national civil nuclear power programme is of great relevance to the maintaining of national nuclear submarine capabilities. *Outside the energy sector, then, evidence for this particular kind of civil-military link is far more than circumstantial*.

Remarkably (for an issue on which there is such silence on the energy side), the substantive evidence is actually very strong on the military side, for intense policy pressures to sustain a civil nuclear programme in which UK military nuclear contractors can participate (if necessary at lower tiers in civil supply chains), in order to maintain their viability as part of a national submarine nuclear capability. And it is significant here that direct evidence has been found for the action of pressures to keep secret this kind of 'masking' of one policy commitment behind another. So, striking levels of silence on such pressures on the energy side can hardly be thought to be surprising. Yet to suggest such covert policy imperatives acting with such significant repercussions, does nonetheless still warrant a more stringent level of testing. Given the momentous implications, if the functioning of a deep incumbency complex is confidently to be held to be relevant to UK energy policy, it is necessary to identify more substantive evidence on the energy policy side as well.

It was for this reason that attention then finally turned in **Section 8**, to a detailed examination of the particular remarkable turnaround in UK nuclear strategy occurring in the period between 2003 and 2006. This critical juncture in UK energy policy is variously widely acknowledged to be very difficult to explain. The policy reversal under Prime Minister Blair from a view of nuclear power as 'unattractive' to a perceived need for a 'nuclear renaissance' took place very abruptly in this period, without any manifestly major changes in the strategic energy environment, nor any particular new declared lines of reasoning. There was no obviously formative change in leading individuals. And the associated policy process was heavily criticised at the time both by Parliament and Judicial Review as being much too cursory and secretive. So, finding a way to understand the formative dynamics in this particular crucial period, seems to offer an especially compelling opportunity to comprehend the more general patterns with which this study is concerned.

What is striking then, is that this evidently crucial formative period in UK civil nuclear policy coincides exactly with an unprecedentedly intense peak in policy activity mobilising acute concerns around nuclear submarine capabilities (Figure 6). Political initiatives simultaneously addressing both civil and military nuclear commitments are actually readily visible (when looked for) in this period, both in Parliament and on the part of a multitude of lobbying organisations. Indeed, some of this background lobbying in this episode is attested to have been among the most effective ever encountered in UK politics. It was also in this period that the origins can be found for a range of important policy initiatives that still continue to this day – involving major institutional provision spanning civil and military nuclear sectors, for integrated skills and training infrastructures, a co-ordinated engineering supply chain and linked research and regulatory activities. The existence of these joint civil-military nuclear agencies is in itself quite compelling. That they should have arisen around a period of such striking policy reversal on civil nuclear power, further accentuates their salience.

Of course, though it is explicit in their remits that these initiatives span both civil and military sectors, it remains the case that none of the programmes or agencies referred to here in themselves explicitly attest to any more general or powerful policy pressures that might actually be formative on civil nuclear policy as a whole. And it must be clearly acknowledged, that we have found no official UK energy policy document that openly declares such a determining link. Yet it is in the nature of any hypothesis in social and political science – especially in an area like this – that no single specific causal factor can in any case ever simply be regarded as proven. So again, a relative absence of evidence, would not necessarily constitute evidence of absence of the phenomenon. And where there is direct documentary evidence for incentives to 'mask' such a dynamic, an absence of evidence is even less surprising. So, there can of course be no certainty in this. Perhaps further research may shine more light. This would certainly seem to be justified. *But in the light of the evidence presented in this paper, it does seem difficult to avoid a strong impression that the persistence and intensity of UK policy attachments to civil nuclear power reflect at least some kinds and degrees of formative influence from deep parallel commitments to the maintaining of nuclear submarine capabilities*.

Taking the analysis together and as a whole, then, it seems quite compelling that a phenomenon akin to the kind of 'deep incumbency complex' introduced here, does hold some relevance for the understanding of key

features in UK energy policy. At the very least, the case does seem sufficiently strong, that the onus of any further argument – or aims for further research – should lie as much in refutation as additional substantiation.

Of course (and once again), none of this should be taken to imply that the evidence presented here for the operation of a deep incumbency complex can be considered in itself to offer a sufficient basis for understanding the focal phenomenon: the distinctive intensity of UK policy attachments to nuclear power. To show this phenomenon to be salient to UK energy policy *does not entail* that the other hypotheses considered here (or others) should thereby somehow be rejected. Far from it. As repeatedly emphasised throughout this paper, multiple interlinked factors must necessarily be expected to remain in play in any complex, high-profile, large-stakes political process like this. Each possible source of understanding displays contrasting merits and shortcomings in addressing specific aspects of the complex and ambiguous political dynamics around nuclear policy making in the UK. A range of different formative factors clearly remains salient in principle, variously applying to greater or lesser extents in contrasting specific historic or political settings, or under divergent analytical perspectives. *But what makes the deep incumbency hypothesis distinctive and of particular interest to understanding UK energy policy, is that it has hitherto remained so virtually entirely undiscussed*.

And it is here that we come to a final implication of the present analysis. This is perhaps the most significant of all in its wider repercussions, but can be relatively briefly expressed. It springs precisely from the issue repeatedly documented here, of the levels of secrecy associated with apparent pressures to 'mask' the evident influence of military imperatives on civil energy policy. If it is as true as suggested in this analysis, that military pressures to maintain UK nuclear submarine capabilities have exercised some formative effect on the persistent intensity of official commitments to civil nuclear power, then the manifest levels of secrecy about such an evidently important conditioning factor in UK energy policy, would actually arguably be the most momentous finding of all.

There is, after all, an enormous policy literature around the purported rationales for strategic priorities and associated choices in the UK energy sector. In this field as in others, it is fundamental equally to the quality of expert policy discourse, of legally-enforced levels of transparency and accountability and of democratic political debate in general, that the stated rationales for major policy commitments may be taken in good faith as being effectively complete and sufficient. Of course, it is only to be expected that contrasting interests will be expressed with varying kinds of emphasis and candour. But it would be remarkable indeed, if a policy commitment as important, expensive and with such long run implications as the present UK Government attachment to nuclear power, were to be revealed to rest to some formative extent, on a completely separate perceived policy imperative that remains entirely officially unacknowledged.

For that matter (though beyond the scope of this particular study), a similar point applies to the rationale for the presently much-discussed issues around the proposed renewal of the UK Trident nuclear submarine programme. If some aspect of the deep incumbency hypothesis explored here is even only partly true, then some part of the costs of maintaining the UK nuclear submarine capability are actually falling on an increased 'nuclear premium' that the Government is evidently willing to see paid for electricity under the terms of relevant nuclear contracts. If the UK civil nuclear renaissance were to proceed as envisaged, then some part of these elevated costs (when compared with alternative low carbon energy strategies) would, under this hypothesis, effectively represent an additional concealed increment in the cost of the military capability. And if this civil nuclear programme were not to eventuate as currently planned, then questions would need to be asked about whether the costs of the Trident renewal would in that event be correspondingly underestimated.

But the most important possible implication raised by this study is even broader and deeper. If it really is the case that a persistent policy commitment as costly, controversial and politically momentous as the current UK Government attachment to nuclear power, is actually partly driven by factors that remain entirely undeclared, then the implications would be very grave and disturbing not only concerning the quality of associated policy

processes and transparency of Government in the UK, but also for the health of British democracy as a whole. To explore these issues further lies beyond the scope of the present study. But it is on these grounds – as much as the repercussions for energy policy alone – that the potential onward significance of this research lies.

Acknowledgements

The authors would like to pay thankful tribute to the many individuals whose work – and often generously-given expertise and experience – have contributed so much to making this research possible. The value is as great where these inputs have been sceptical and critical, as where they have been supportive or contributory. We are extremely grateful to Josh Hutton, Jenny Lieu, and Tim Foxon for very useful comments during the review process. A particular debt is owed to the anonymous interviewees and informants variously cited in this study. Beyond this, others whose comments are especially appreciated on aspects of the argument in many conversations, meetings and presentations are as follows: Paul Brown, Tom Burke, Ana-Paula Camelo, Paul Dorfman, Rob Edwards, Ian Fairlie, Jessica Jewell, Gordon MacKerron, David Lowry, Catherine Mitchell, Craig Morris, Jonathan Porritt, Tim Radford, Benjamin Sovacool, Eva Stegen, Johan Schot, Steve Thomas, Oliver Tickell and Dave Toke. Josie Coburn did a fantastic job formatting the references. We are especially thankful to Pete Roche and the nuclear news service. Much valued also, have been conversations with colleagues in the ESRC-funded DiscGo Project, as part of which this work was undertaken – including on these issues especially Pierre-Benoit Joly, Stefan Kuhlmann and Peter Stegmaier. Beyond this, the great debt owed to so many researchers in this wider field, is evident from the bibliography.

References

Abbink, J. & Salverda, T. eds., 2013. *The Anthropology of Elites: power, culture and the complexities of distinction*, New York: Palgrave Macmillan.

Abensour, M.R., 2011. *Democracy Against the State: Marx and the Machiavellian Moment*, Cambridge: Polity Press.

Agora Energiewende, 2015. *The Energiewende in the Power Sector : State of Affairs 2014*, Berlin: Agora Energiewende.

Aldred, J. & Starkey, N., 2013. Nuclear power in the UK - A history. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2013/oct/21/nuclear-power-in-the-uk-a-history [Accessed August 26, 2016].

Allen, M.T. & Hecht, G. eds., 2001. *Technologies of Power: essays in honor of Thomas Parke Hughes and Agatha Chipley Hughes*, Cambridge: MIT Press.

Archer, M.S., 2010. Morphogenesis versus structuration: on combining structure and action. *The British journal of sociology*, 61 Suppl 1(Dawe 1970), pp.225–52.

Archer, M.S., 1995. *Realist social theory: the morphogenetic approach*, Cambridge: Cambridge Univ Press.

Arendt, H., 1970. *On Violence*, New York: Harcourt Brace Jovanovich.

Arthur, W.B., 1989. "Competing Technologies, Increasing Returns, and Lock-in by Historical Events." *The Economic Journal*, 99(394), pp.116–131.

Arthur, W.B., 1990. Positive Feedbacks in the Economy. *Scientific American*, 262, pp.92–99.

Atherton, P., 2014. Why has Britain signed up for the world's most expensive power station? *The Spectator*.

Aubrey, C., 1991. *Meltdown: the collapse of the nuclear dream*, London: Colllins & Brown.

Babbie, E., 2013. *The Practice of Social Research*, Canada: Wadsworth, Cengage Learning.

Bachrach, P. & Baratz, M.S., 1962. Two Faces of Power. *The Americun Political Science Review*, 56(4), pp.947–952.

Bahgat, G., 2008. *Proliferation of nuclear weapons in the Middle East*, Florida: University Press of Florida.

Baigorri, A., Caballero, M. & Chaves, M., 2012. States and the nuclear power . An international perspective. *International Review of Sociology*, 22(January 2015), pp.446–470.

Baker, K. & Stoker, G., 2012. Metagovernance and nuclear power in Europe. *Journal of European Public Policy*, 19(7), pp.1026–1051.

Baker, L., Newell, P. & Phillips, J., 2014. The Political Economy of Energy Transitions: The Case of South Africa. *New Political Economy*, 19(6), pp.791–818.

Barckham, P. & Norton-Taylor, R., 2010. Trident: Deadly – and very, very expensive. *The Guardian*

Online. Available at: https://www.theguardian.com/uk/2010/may/20/trident-submarine-coalition-government-scrap [Accessed August 26, 2016].

Barnett, A., 2010. Is there a UK "deep state"? *Open Democracy*, July, pp.2–4.

Barnett, M. & Duvall, R. eds., 2005. *Power in Global Governance*, Cambridge: Cambridge University Press.

BBC News, 2007. Blair defiant over nuclear plans. *BBC News Online*. Available at: http://news.bbc.co.uk/1/hi/uk_politics/6366725.stm [Accessed August 26, 2016].

BBC News, 2011. Hinkley Point protest: Blockade at nuclear power station. *BBC News Online*. Available at: http://www.bbc.co.uk/news/uk-england-somerset-15146781 [Accessed August 26, 2016].

BBC News, 2015. Security fears over China nuclear power deal. *BBC News Online*. Available at: http://www.bbc.co.uk/news/uk-politics-34549478 [Accessed August 26, 2016].

Beale, J., 2015. Ex-military chiefs: Scrapping Trident nuclear subs "irresponsible folly." *BBC News Online*. Available at: http://www.bbc.co.uk/news/election-2015-32507890 [Accessed August 26, 2016].

Beckman, K., 2015. Head of UK's National Grid says "idea of large power stations for baseload is outdated." *Renewable Economy*.

Bendor, J., 2010. *Bounded Rationality and Politics*, Berkeley and Los Angeles: University of California Press.

Berenskoetter, F. & Williams, M.J. eds., 2007. *Power in World Politics*, Abingdon: Routledge.

Berg, B.L., 2001. *Qualitative Research Methods For the Social Sciences*, Needham Heights, MA: Allyn & Bacon.

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.

BERR, 2008. MEETING THE ENERGY CHALLENGE A White Paper on Nuclear Power. , (January).

Berthélemy, M., 2012. *What drives innovation in nuclear reactors technologies? An empirical study based on patent counts.*, Paris: Cerna, Centre d'economie industrielle, Mines ParisTech.

Bessant, J. et al., 2005. Managing innovation beyond the steady state. *Technovation*, 25(12), pp.1366–1376.

Biermann, F. et al., 2009. The Fragmentation of Global Governance Architectures : A Framework for Analysis. *Global Environmental Politics*, 9(4), pp.14–41.

Birmingham Policy Comission, 2012. *The Future of Nuclear Technology in the UK*, Birmingham: University of Birmingham.

BIS, 2013. *Nuclear Industrial Strategy - The UK's Nuclear Future*, London: Department for Business, Innovation and Skills.

Blair, T., 2006. Prime Minister, Rt Hon Tony Blair's Parliamentary Statement on Trident. *KOFAC*

Website. Available at: http://www.navalshipbuilding.co.uk/navalship_newsdetails.asp?newsID=729&newsCatID=8 [Accessed August 26, 2016].

Blowers, A., 2013. Nuclear Power – A Flawed Case. Part 1: Why we don't need nuclear now. *Town & Country Planning*, January 20, pp.37–40.

Boffey, D., 2016. Theresa May "raised objections to project as home secretary." *The Guardian Online*. Available at: https://www.theguardian.com/uk-news/2016/jul/30/theresa-may-delayed-hinkley-point-chinese-beijing-vince-cable [Accessed August 26, 2016].

Bogner, A., Littig, B. & Menz, W. eds., 2009. *Interviewing Experts*, Basingstoke: Palgrave Macmillan.

Bohman, J., 2016. Democratising the global order: from communicative freedom to communicative power. *Review of International Studies*, 36(2), pp.431–447. Available at: http://www.bbc.co.uk/news/uk-politics-30778427 [Accessed August 26, 2016].

Bradford, P., 2013. Nuclear renaissance was just a fairy tale. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2013/jul/11/nuclear-renaissance-power-myth-us [Accessed August 26, 2016].

Broomby, R., 2015. Questions about UK scrutiny of Chinese nuclear tie-up. *BBC News Online*.

Brown, P., 2008. *VOODOO ECONOMICS AND THE DOOMED NUCLEAR RENAISSANCE*, London: Friends of the Earth.

Burke, T., 2013. Behind the nuclear smoke and mirrors. *The Ecologist*, Oct 2013.

Callon, M., 1991. Techno-economic networks and irreversibility. *A sociology of monsters: Essays on power, technology and domination*, 38, pp.132–161.

Cameron, A., 2015. Government U-turn on renewables shows gas, oil and nuclear are still favourites. *The Guardian*. Available at: https://www.theguardian.com/sustainable-business/2015/dec/20/government-u-turn-renewables-gas-oil-nuclear-favourites.

Carcelli, S. et al., 2014. The Nuclear Regime Complex: a new dataset. In *Proceedings of the International Studies Association Annual Convention, 26th March 2014*. Toronto, Canada.

Carrington, D., 2016. Minister admits lights would stay on even if Hinkley nuclear plant is delayed. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2016/apr/19/minister-admits-lights-would-stay-on-even-if-hinkley-nuclear-plant-is-delayed [Accessed August 26, 2016].

Cavendish Nuclear, 2016. About Us. *Cavendish Nuclear Website*. Available at: http://www.cavendishnuclear.com/about-us/ [Accessed August 26, 2016].

Cerbaro, R.H., 2011. Competition-trapping the Concept of Power. *European Journal of Social Sciences*, 21(1), pp.148–153.

Certomà, C. & Tornaghi, C., 2015. Political gardening . Transforming cities and political agency. *Local Environment: The International Journal of Justice and Sustainability*, 20(10), pp.1123– 1131.

Chabot, B., 2016. Wind power and nuclear electricity production in China , India , Brazil and South Africa (BICS) up to 2015. , pp.1–7. Available at: http://cf01.erneuerbareenergien.schluetersche.de/files/smfiledata/5/5/8/4/6/2/141WindNucB

ICS2015.pdf [Accessed August 26, 2016].

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

Charmaz, K., 2006. *Constructing Grounded Theory: a practical guide through qualitative analysis*, London: Sage Publications.

Clarke, S., 2015. Conspiracy Theories and Conspiracy Theorizing. , 32(2), pp.131–150.

Clegg, S.R., Courpasson, D. & Philips, N., 2006. *Power and Organisations*, London: Sage Publications.

Clegg, S.R. & Hardy, C. eds., 1999. *Studying Organization: theory and method*, London: Sage Publications.

Cochran, T.B. et al., 2010. *Fast Breeder Reactor Programs: History and Status*, Princeton, NJ: International Panel on Fissile Materials and Program on Science and Global Security, Princeton University.

Cockburn, P., 2011. Patrick Cockburn: Why must Britain always try to "punch above her weight"? *The Independent*. Available at: http://www.independent.co.uk/voices/commentators/patrick-cockburn-why-must-britain-always-try-to-punch-above-her-weight-2314908.html [Accessed August 26, 2016].

Collingridge, D., 1984. Lessons of nuclear power US and UK history. *Energy Policy*, March, pp.46–67.

Collingridge, D., 1983. *Technology in the Policy Process: controlling nuclear power*, London: Frances Pinter.

Collingridge, D., 1979. The entrenchment of technology - the case of lead petrol additives. *Science and Public Policy*, 6(5), pp.332–8.

Collingridge, J., 2016. Minister heads to Tokyo on nuclear energy mission. *The Times Online*. Available at: http://www.thetimes.co.uk/article/minister-heads-to-tokyo-on-nuclear-energy-mission-rkcw82gwx [Accessed August 26, 2016].

Collins, N., 2010. Tories plan new nuclear power plant every 18 months. *The Daily Telegraph*. Available at: http://www.telegraph.co.uk/news/earth/energy/7476680/Tories-plan-new-nuclear-power-plant-every-18-months.html [Accessed August 26, 2016].

Collins, R., 2004. *Interaction Ritual Chains*, Princeton, NJ: Princeton University Press.

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

Coughlin, C., 2015. Cameron must save Britain's world-power status. *Gulf News*. Available at: http://gulfnews.com/opinion/thinkers/cameron-must-save-britain-s-world-power-status-1.1511443 [Accessed August 26, 2016].

Cowburn, A., 2016. US Defence Secretary Ash Carter says Britain must renew Trident to maintain "outsized" role in world. *The Independent*.

Dahl, R.A., 1957. The Concept of Power. *Behavioral Science*, 2(3), pp.201–215.

Davies, G. & Lloyd, A., 2013. *Technology Supply Curves for Low- Carbon Power Generation; A report to the Committee on Climate Change*, London: Poyry.

DECC, 2016a. *DECC Contracts for Difference auction*, London: Department of Energy & Climate Change.

DECC, 2016b. *DECC Government Major Projects Portfolio data 2016*, London: Department of Energy & Climate Change.

DECC, 2013a. *Leading the way; the UK's new nuclear renaissance*, London: Department of Energy & Climate Change.

DECC, 2011a. *National Policy Statement for Nuclear Power Generation (EN-6) Volume I of II*, London: The Stationary Office.

DECC, 2011b. *Overarching National Policy Statement for Energy (EN-1)*, London: The Stationary Office.

DECC, 2011c. *Overarching National Policy Statement for Energy (EN-1) Overarching National Policy Statement for Energy (EN-1)*, London.

DECC, 2013b. *UK Renewable Energy Roadmap Update 2013*, London: Department of Energy and Climate Change.

Deleuze, G. & Guattari, F., 1987. *A Thousand Plateaus: capitalism and schizophrenia*, Minneapolis: University of Minnesota Press.

Depelteau, F. & Powell, C. eds., 2013. *Applying Relational Sociology: relations, networks and society*, London: Palgrave MacMillan.

Deutsche Welle, 2011. Tens of thousands of Germans take to the streets in anti-nuclear protest. *DW Online*.

Diesendorf, M., 2016. Dispelling the nuclear "baseload" myth: nothing renewables can't do better! *The Ecologist*, pp.2–3. Available at: http://www.theecologist.org/News/news_analysis/2987376/dispelling_the_nuclear_baseload_myth_nothing_renewables_cant_do_better.html.

Dominiczak, P., 2013. New nuclear plant "needed to keep the lights on." *The Daily Telegraph Online*. Available at: http://www.telegraph.co.uk/news/earth/energy/nuclearpower/10393043/New-nuclear-plant-needed-to-keep-the-lights-on.html [Accessed August 26, 2016].

Dorfman, P., 2011. Who to Trust on Nuclear? *The Guardian Online*. Available at: https://www.theguardian.com/commentisfree/2011/apr/13/nuclear-power-sustainable-energy [Accessed August 26, 2016].

Dorman, A., 2016. Debating Trident now is a nakedly political act. *The New Statesman*.

DTI, 2003. *Our Energy Future: Creating a Low Carbon Economy*, London: DTI Publications.

DTI, 2006a. *The Energy Challenge* Dept. of Trade and Industry, ed., London: H.M.S.O.

DTI, 2006b. *The Energy Challenge - Energy Review Report 2006*, London: The Stationary Office.

DTI, DFT, D., 2003. *Energy White Paper - Our energy future: creating a low carbon economy*, London: Stationery Office.

Ecotricity, 2016. Ecotricity and Greenpeace primed for Hinkley Point legal challenge. *Ecotrocity*

Website. Available at: https://www.ecotricity.co.uk/news/news-archive/2016/ecotricity-and-greenpeace-primed-for-hinkley-point-legal-challenge [Accessed August 26, 2016].

Edgerton, D., 2006. *Warfare State: Britain, 1920-1970*, Cambridge: Cambridge Univ Press.

Edquist, C. ed., 1997. *Systems of Innovation: technologies, instituions and organizations*, London: Routledge.

Edwards, R., 2014. Revealed: MoD's new multi-million pound Trident deal with America. *The Herald Scotland online*. Available at: http://www.heraldscotland.com/news/13190790.Revealed__MoD_s_new_multi_million_pound_Trident_deal_with_America/ [Accessed August 26, 2016].

Edwards, T. ed., 2007. *Cultural Theory: classical and contemporary positions*, Los Angeles: Sage Publications.

Elliott, D., 2015. *Green Energy Futures: A Big Change for the Good*, London: Palgrave Macmillan.

Elster, J. ed., 1986. *Rational Choice*, New York: New York University Press.

Environmental Audit Committee, 2006. *Keeping the lights on: Nuclear, Renewables and Climate Change*, London: The Stationary Office.

Ernst & Young, 2016. *Renewable Energy Country Attractiveness Index: What happens when grid parity hits?*, London: Ernst & Young Limited.

Ernstson, H., 2008. *In Rhizomia: actors, networks and resilience in urban landscapes*, Stockholm: Department of Systems Ecology, University of Stockholm.

European Commission, 2014. *Report on the Implementation of Euratom Safeguards in 2014*, Brussels: European Commission.

European Environmental Agency, 2016. *Renewable energy in Europe — approximated recent growth and knock-on effects*, Luxembourg: European Environmental Agency.

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.

Federal Ministry of Economics and Technology, 2011. *Germany's new energy policy: Heading towards 2050 with secure, affordable, and environmentally friendly energy*, Berlin: Federal Ministry of Economics and Technology.

Feenberg, A., 1999. *Questioning Technology*, London: Routledge.

Feenberg, A., 1992. Subversive rationalization: Technology, power, and democracy. *Inquiry*, 35(3-4), pp.301–322.

Felt, U. et al., 2007. *Taking European Knowledge Society Seriously : Report of the Expert Group on Science and Governance to the Science, Economy and Society Directorate, Directorate-General for Research, European Commission*, Brussels: European Commission.

Fine, B., 2007. The Mineral-Energy Complex is Dead: long live the MEC? In *Proceedings of the Amandla Colloquium: Continuity and Discontinuity of Capitalism in the Post-Apartheid South Africa, 4-6 April*. Cape Town.

Finon, D. & Midttum, A. eds., 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. *Sustainability*, 8(476).

Fligstein, N. & McAdam, D., 2012. *A Theory of Fields*, Oxford: Oxford Univ Press.

Forsythe, D.E., 1980. Ethics and Politics of Studying Up in Technoscience. *Anthropology of Work Review*, XX(1), pp.6–11.

Foucault, M., 1977. *Security, Territory, Population*, London: Palgrave Macmillan.

Foxon, T., 2007. Bounded rationality and hierarchical complexity : Two paths from Simon to ecological and evolutionary economics. *Ecological Complexity*, 3(2006), pp.361–368.

Fraenkel, E., 2010. *The Dual State: A Contribution to the Theory of Dictatorship*, London: The Lawbook Exchange.

Frankfurt School-UNEP, 2016. *Global Trends in Renewable Energy Investment 2016*, Frankfurt: Frankfurt School of Finance and Management gGmbH 2016.

Fredheim, R., 2016. *Are Conspiracy Theories a Threat to Democracy?*, London: Leverhulme Trust.

Galbraith, J.K., 1993. *American Capitalism: The Concept of Countervailing Power*, Piscataway, NJ: Transaction Publishers.

Galbraith, J.K., 1996. *The Anatomy of Power*, Boston, MA: Houghton Mifflin.

Galloway, A.R. & Thacker, E., 2007. *The Exploit: a theory of networks*, Minneapolis: University of Minnesota Press.

Garg, P., 2012. Energy Scenario and Vision 2020 in India. *Journal of Sustainable Energy & Environment*, 3(August 2002), pp.7–17.

Garud, R. & Karnøe, P., 2003. Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. *Research Policy*, 32(2), pp.277–300.

Geels, F., 2005. *Technological Transitions and System Innovations: a co-evolutionary and socio-technical analysis*, Cheltenham, UK; Northampton, MA: Edward Elgar.

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., 2004. From sectoral systems of innovation to socio-technical systems. *Research Policy*, 33(6-7), pp.897–920.

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., 2014. Reconceptualising the co-evolution of firms-in-industries and their environments: Developing an inter-disciplinary Triple Embeddedness Framework. *Research Policy*, 43(2), pp.261–277.

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.

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(August 2003), pp.399–417.

Giddens, A., 1984. *The Constitution of Society: outline of the theory of structuration*, Cambridge: Polity Press.

Gigerenzer, G. & Selten, R. eds., 2002. *Bounded Rationality: The Adaptive Toolbox*, Cambridge, MA: MIT Press.

Gilbert, N. & Conte, R. eds., 1995. *Artifical Societies: the computer simulation of social life*, London: UCL Press.

Gillham, B., 2000. *Case Study Research Methods*, London: Continuum.

Glennon, M.J., 2014. National Security and Double Government. *The Federalist*, 5, pp.1–114.

Gosden., E., 2016. New Hinkley Point nuclear plant in doubt as Government delays decision despite EDF approval for £18bn project. *The Telegraph Online*. Available at: http://www.telegraph.co.uk/business/2016/07/28/green-light-for-hinkley-point-as-new-18bn-nuclear-plant-approved/ [Accessed August 31, 2016].

Gosden, E., 2016. EDF board member resigns, attacking Hinkley Point nuclear project as financially "risky." *The Telegraph Online*. Available at: http://www.telegraph.co.uk/business/2016/07/28/edf-board-member-resigns-attacking-hinkley-point-nuclear-project/ [Accessed August 31, 2016].

Green, R., 1997. Nuclear Weapons , the Military and the Law : Reflections on the World Court Decision. *Medicine & Global Survival*, 4, pp.5–8.

Greener, I., 2005. The Potential of Path Dependence in Political Studies. *Politics*, 25(1), pp.62–72.

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*, London: Palgrave MacMillan.

Guo, X. & Guo, X., 2016. Nuclear power development in China after the restart of new nuclear construction and approval: A system dynamics analysis. *Renewable and Sustainable Energy Reviews*, 57(December 2014), pp.999–1007.

Guyer, B.L. & Golay, M.W., 2015. Requirements for the Success of Civilian Nuclear Power in the United States. *The Bridge*, 45(2), pp.48–54.

Guzzini, S., 2009. *On the measure of power and the power of measure in International Relations*, Copenhagen: Danish Institute for International Studies.

Guzzini, S., 2005. The Concept of Power: a Constructivist Analysis. *Journal of International Studies*, 33(3), pp.495–521.

Habermas, J., 1976. *Legitimation Crisis*, Cambridge: Polity Press.

Hall, T., 1986. *Nuclear politics*, Harmondsworth: Penguin.

Halperin, S. & Heath, O., 2012. *Political Research: Methods and Practical Skills*, Oxford: Oxford Univ. Press.

Hargreaves, T. et al., 2011. *Sustainability Transitions from the bottom-up: civil society, the multi-level perspective and practice theory*, Norwich: Centre for Social and Economic Research on the Global Environment.

Harrison, L., Little, A. & Lock, E., 2015 *Politics: the key concepts*, Abingdon, Oxon ; New York, NY: Routledge.

Hartley, K., 2012. *Defence-Industrial Issues : Employment , Skills , Technology and Regional Impacts*, London; Washington: British American Security Information Council.

Hartung, W.D., 2011. *Prophets of War: Lockheed Martin and the making of the military industrial complex*, New York: Nation Books.

Harvey, F., 2015. 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 August 31, 2016].

Hasenclever, A., Mayer, P. & Rittberger, V., 1997. *Theories of International Regimes*, Cambridge, UK: Cambridge University Press and the British International Studies Association.

Hecht, G., 2010. The Power of Nuclear Things. *Technology and Culture*, 51(1), pp.1–30.

Hekkert, M.P. & Negro, S.O., 2009. Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change*, 76(4), pp.584–594.

Held, A., 2010. *Modelling the future development of renewable energy technologies in the European electricity sector using agent-based simulation*. Karlsruhe, Germany: Karlsruhe Instituts für Technologie (KIT).

Hess, D.J., 2013. Industrial fields and countervailing power : The transformation of distributed solar energy in the United States. *Global Environmental Change*, 23(5), pp.847–855.

Heyman, J.M., 2004. The Anthropology of Power-Wielding Bureaucracies. *Human Organization*, 63(4), pp.487–500.

Hill, C.., 2013. *An Atomic Empire: A Technical History of the Rise and Fall of the British Atomic Energy Programme*, London: Imperial College Press.

HM Government, 2016a. Civil nuclear power in the UK: investment opportunities. *UK Trade and Investment Webpages*. Available at: https://www.gov.uk/government/publications/civil-nuclear-power-in-the-uk-investment-opportunities/civil-nuclear-power-in-the-uk-investment-opportunities [Accessed August 31, 2016].

HM Government, 2015. *National Security Strategy and Strategic Defence and Security Review 2015*, London: Crown Copyright.

HM Government, 2016b. Small Modular Reactors Competition Phase One. *HM Government*

Webpages. Available at: https://www.gov.uk/government/publications/small-modular-reactors-competition-phase-one [Accessed August 31, 2016].

HM Government, 2006. *The Future of the United Kingdom 's Nuclear Deterrent*, London: Crown Copyright.

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.

Holden, M. & Maclellan, K., 2016. British lawmakers back renewal of Trident nuclear deterrent. *Reuters*. Available at: http://www.reuters.com/article/us-britain-defence-renewal-idUSKCN0ZY2M8 [Accessed August 31, 2016].

Hollis, M. & Smith, S., 1991. *Explaining and Understanding International Relations*, Oxford: Clarendon Press.

Hommels, a., 2005. Studying Obduracy in the City: Toward a Productive Fusion between Technology Studies and Urban Studies. *Science, Technology & Human Values*, 30(3), pp.323–351.

House of Commons Defence Committee, 2007. *The Future of the UK's Strategic Nuclear Deterrent: The White Paper Oral and Written Evidence Volume 2*, London: Crown Copyright.

House of Commons Defense Committee, 2007. *The Future of the UK's Strategic Nuclear Deterrent : the White Paper*, London: The Stationary Office.

House of Commons Trade and Industry Select Committee, 2006. *New nuclear? Examining the issues*, London: The Stationary Office.

Howell, D., 1979. *Nuclear Power Hansard: vol 976 cc287-304*,

Hughes, T., 1983. *Networks of Power: electrification in western society 1880-1930*, Baltimore: Johns Hopkins University Press.

Hutton, J., 2016. Nuclear power has an essential role in Britain's energy system. *Financial Times*.

IAEA, 2016a. IAEA Safeguards in Practice. *International Atomic Energy Agency Webpages*. Available at: https://www.iaea.org/safeguards/safeguards-in-practice [Accessed August 31, 2016].

IAEA, 2015a. *IAEA Safeguards Serving Nuclear Non-Proliferation*, Vienna: International Atomic Energy Agency.

IAEA, 2015b. *Nuclear Technology Review 2015*, Vienna: International Atomic Energy Agency.

IAEA, 2016b. PRIS Reactor Database. *IAEA Reactor Database*. Available at: https://www.iaea.org/pris/ [Accessed August 31, 2016].

IEA, 2015a. Germany: Statistics. *IEA Country Profiles*. Available at: https://www.iea.org/countries/membercountries/germany/statistics/ [Accessed August 31, 2016].

IEA, 2015b. UK: Statistics. *IEA Country Profiles*. Available at: https://www.iea.org/countries/membercountries/unitedkingdom/statistics/ [Accessed August 31, 2016].

IEA, 2015c. *World Energy Outlook*, Paris: International Energy Agency.

Infield, D. & Watson, S., 2007. Planning for Variability in the Longer Term: The Challenge of a Truly Sustainable Energy System. In G. Boyle, ed. *Renewable Electricity and the Grid*. London: Earthscan, pp. 201–2011.

Ireland, G., 2012. *The Challenges Facing the UK Submarine Base*, London.

IRENA, 2014. *Renewable Energy Technology Innovation Policy: a process development guide*, Bonn: International Renewable Energy Agency.

IRENA, 2016. *Roadmap for a Renewable Energy Future*, Bonn: Irena Innovation and Technology Centre.

Jasanoff, S., 2005. *Designs on Nature: science and democracy in Europe and the United States*, Princeton: Princeton University Press.

Jasanoff, S. & Kim, S., 2009. Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. *Minerva*, 47(2), pp.119–146.

Jewell, J., 2015. Proving the Deep State Requires Deeper Reasoning. *POLET Blog*, pp.5–8. Available at: http://polet.network/blog/2015/9/24/shallow-reasoning-on-the-deep-state [Accessed August 31, 2016].

Johnstone, P. & Stirling, A., 2015a. All at sea: making sense of the UK's muddled nuclear policy. *The Conversation*. Available at: http://theconversation.com/all-at-sea-making-sense-of-the-uks-muddled-nuclear-policy-48553 [Accessed August 31, 2016].

Johnstone, P. & Stirling, A., 2015a. *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.

Johnstone, P. & Stirling, A., 2015b. Shining a light on Britain's nuclear state. *The Guardian Online*. Available at: https://www.theguardian.com/science/political-science/2015/aug/07/shining-a-light-on-britains-nuclear-state [Accessed August 31, 2016].

Johnstone, P. & Stirling, A., 2016. Submerged politics of UK nuclear power. *The Spokesman*, 132, pp.75–86.

Johnstone, P. & Stirling, A., 2015b. Why Germany is dumping nuclear power – and Britain isn't. *The Conversation*. Available at: http://theconversation.com/why-germany-is-dumping-nuclear-power-and-britain-isnt-46359 [Accessed August 31, 2016].

Jordan, G., 1990. Sub-Governments, Policy Communities and Networks: refilling the old bottles. *Journal of Theoretical Politics*, 2(3), pp.319–338.

Joseph, J. & Roberts, J.M. eds., 2004. *Realism Discourse and Deconstruction*, London ; New York: Routledge.

Kee, E., 2015. Can nuclear succeed in liberalised energy markets? *World Nuclear News Website*. Available at: http://www.world-nuclear-news.org/v-can-nuclear-succeed-in-liberalized-power-markets-0420152.html [Accessed August 31, 2016].

Keohane, R.O. & Victor, D.G., 2011. The Regime Complex for Climate Change. *Perspectives on Politics*, 9(1), pp.7–23.

Kern, F. et al., 2014. From laggard to leader: Explaining offshore wind developments in the UK.

Energy Policy, 69(June 2014), pp.635–646.

Kern, F. & Smith, A., 2008. Restructuring energy systems for sustainability? Energy transition policy in the Netherlands. *Energy Policy*, 36(11), pp.4093–4103.

Kim, S.S., 2001. Security, nationalism and the pursuit of nuclear weapons and missiles: The South Korean case, 1970–82. *Diplomacy & Statecraft*, 12(4), pp.53–80.

King, D., 2006. David King: Why we have no alternative to nuclear power: if there were other sources of low carbon energy I would be in favour, but there aren't. *The Independent Online*. Available at: http://www.independent.co.uk/voices/commentators/david-king-why-we-have-no-alternative-to-nuclear-power-5329750.html [Accessed August 31, 2016].

King, D., 2005. The nuclear option isn't political expediency but scientific necessity. *The Guardian Online*. Available at: http://www.theguardian.com/politics/2005/dec/16/greenpolitics.environment [Accessed August 31, 2016].

Knappett, C. & Malafouris, L. eds., 2008. *Material Agency: towards a non-anthropocentric approach*, Berlin: Springer.

KOFAC, 2006. Memorandum of 14 April 2006 from the trade union led "Keep Our Future Afloat Campaign" to the dti Consultation.

Koopmans, R. & Duyvendak, J.W., 1995. The Political Construction of the Nuclear Energy Issue and Its Impact on the Mobilization of Anti-Nuclear Movements in Western Europe. *Social Problems*, 42(2), pp.235–251.

Krasno, J., 1994. Brazil's secret nuclear program. *Orbis*, 38(3), pp.425–437.

de la Durantaye, L., 2009. *Giorgio Agamben: a critical intrduction*, Standford, CA: Stanford University Press.

Latour, B., 2005. *Reassembling the Social An Introduction to Actor-Network-Theory*, Oxford: Oxford University Press.

Law, J., 1991. *A Sociology of Monsters: Essays on Power Technology and Domination* J. Law, ed., London: Routledge.

Law, J., 2004. *After Method: Mess in Social Science Research*, Abingdon: Routledge.

Lawrence, A., Sovacool, B. & Stirling, A., 2016. Nuclear energy and path dependence in Europe's "Energy union": coherence or continued divergence? *Climate Policy*, 16(5), pp.622–641.

Leach, M., Scoones, I. & Stirling, A., 2010. *Dynamic Sustainabilities: Technology, Environment, Social Justice*, Abingdon: Earthscan.

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 August 31, 2016].

Leake, J., 2008. I pushed Blair's nuclear button. *The Times Online*. Available at: http://www.thesundaytimes.co.uk/sto/news/uk_news/article78444.ece [Accessed August 31, 2016].

Lean, G., 2014. Nuclear power may not be needed, says top atomic advocate. *The Daily Telegraph Online*. Available at: http://www.telegraph.co.uk/news/earth/energy/nuclearpower/11244499/Nuclear-power-may-not-be-needed-says-top-atomic-advocate.html.

Lévêque, F., 2010. Innovation trends in nuclear power generation. *EU Energy Policy Blog*. Available at: http://www.energypolicyblog.com/2010/05/09/innovation-trends-in-nuclear-power-generation/ [Accessed August 31, 2016].

Lévêque, F., 2015. *The economics and uncertainties of nuclear power*, Cambridge: Cambridge University Press.

Liberal Democrats, 2015. *Liberal Democrats Manifesto 2015: Stronger Economy. Fairer Society. Opportunity for Everyone*, London: Liberal Democrats.

Lichfield, J., 2015. UK nuclear strategy faces meltdown as faults are found in identical French project. *The Independent Online*. Available at: http://www.independent.co.uk/news/uk/home-news/uk-nuclear-strategy-faces-meltdown-as-faults-are-found-in-identical-french-project-10186163.html [Accessed August 31, 2016].

Liebreich, M., 2016. *BLOOMBERG new energy finance summit: In search of the miraculous*, New York: Bloomberg New Energy Finance.

Lindblom, C., 1959. The Science of "Muddling Through." *Public Administration Review*, 19(2), pp.79–88.

Lockwood, M. et al., 2016. Historical institutionalism and the politics of sustainable energy transitions : A research agenda. *Environment and Planning C: Government and Policy*, Forthcomin.

Loeb, P., 1986. *Nuclear culture: Living and working in the world's largest atomic complex*, Philadelphia: New Society Publishers.

Loorbach, D., 2014. *To Transition! Governance panarchy in the new transformation*, Rotterdam: Erasmus University.

Lowry, D., 2015. No way nukes! Challenging the mainstream "concensus" for nuclear power. *The Ecologist*.

Lukes, S., 1977. *Essays in Social Theory*, London: Macmillan.

Lukes, S., 2002. Power and agency. *British Journal of Sociology*, 53(3), pp.491–496.

Lukes, S., 2005. *Power: a radical view*, Basingstoke: Palgrave MacMillan.

Lütkenhorst, W. & Pegels, A., 2014. *Stable Policies – Turbulent Markets : The costs and benefits of promoting Solar PV and Wind Energy*, Geneva: International Institute for Sustainable Development.

Macalister, T., 2016a. Hinkley Point C nuclear project in crisis as EDF finance director resigns. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2016/mar/07/hinkley-point-c-nuclear-project-in-crisis-as-edf-finance-director-resigns [Accessed August 31, 2016].

Macalister, T., 2016b. 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 [Accessed August 31, 2016].

Macalister, T., 2016c. UK government needs a nuclear plan B, says Tim Yeo. *The Guardian Online*. Available at: https://www.theguardian.com/uk-news/2016/jun/19/uk-government-should-have-a-nuclear-plan-b-tim-yeo-hinkley-point-bradwell-scheme [Accessed August 31, 2016].

Mackerron, G., 2008. Gordon MacKerron: This way is more likely to leave us in the dark. *The Independent Online*. Available at: http://www.independent.co.uk/voices/commentators/gordon-mackerron-this-way-is-more-likely-to-leave-us-in-the-dark-770005.html [Accessed August 31, 2016].

Mackerron, G., 1996. Nuclear power under review. In J. Surrey, ed. *The British Electricity Privatisation Experiment: The Record, the Issues, the Lessons*. London: Earthscan, pp. 138–163.

Malerba, F. ed., 2004. *Sectoral Systems of Innovation: concepts, issues and analysis of six major sectors in Europe*, Cambridge: Cambridge University Press.

Mallard, G., 2014. Crafting the Nuclear Regime Complex (1950–1975): Dynamics of Harmonization of Opaque Treaty Rules. *European Journal of International Law*, 25(2), pp.445–472.

Mansbridge, J., 2001. The Making of Oppositional Consciousness. In J. J. Mansbridge & A. Morris, eds. *Oppositional Consciousness: The Subjective Roots of Social Protest*. Chicago: Univ Chicago Press.

Martin, J.L., 2011. *The Explanation of Social Action*, Oxford: Oxford University Press.

Martin, R., 1971. The Concept of Power : A Critical Defence. *British Journal of Sociology*, 22(3), pp.240–256.

Mason, R. & Asthana, R., 2016. Commons votes for Trident renewal by majority of 355. *The Guardian Online*. Available at: https://www.theguardian.com/uk-news/2016/jul/18/mps-vote-in-favour-of-trident-renewal-nuclear-deterrent [Accessed August 31, 2016].

Massumi, B., 2009. National Enterprise Emergency: Steps Toward an Ecology of Powers. *Theory, Culture & Society*, 26(6), pp.153–185.

Massumi, B., 2015. *Politics of Affect*, Cambridge: Polity Press.

Meadowcroft, J., 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Sciences*, 42(4), pp.323–340.

Meek, J., 2014. *Private Island: Why Britain now belongs to someone else*, London: Verso.

Ministry Of Defence, 2005. *Defence Industrial Strategy: Defence White Paper*, London: The Stationary Office.

Mitchell, C., 2016. Momentum is increasing towards a flexible electricity system based on renewables. *Nature Energy*, 1(2), pp.517–518.

Mitchell, C., 2010. *The Political Economy of Sustainable Energy*, London: Palgrave MacMillan.

MoD, 2006. Government response to Select committee response to Select Committee 9th Report. *Select Committee 9th report appendix*.

Moore, M. & Westley, F., 2011. Surmountable Chasms: Networks and Social Innovation for Resilient Systems. *Ecology and Society*, 16(1).

Morris, C. & Pehnt, M., 2012. *The Energy Transition: The German Energiewende*, Berlin: Heinrich Böll Stiftung.

Mort, M., 2002. *Building the Trident Network: a study of enrollment of people, knowledge and machines*, Cambridge, MA; London, UK: MIT Press.

Mortimer, C., 2015a. British Army "could stage mutiny under Corbyn", says senior serving general. *The Independent*. Available at: http://www.independent.co.uk/news/uk/politics/british-army-could-stage-mutiny-under-corbyn-says-senior-serving-general-10509742.html [Accessed August 31, 2016].

Mortimer, C., 2015b. Jeremy Corbyn is a threat to our national security, says George Osborne. *The Independent*. Available at: http://www.independent.co.uk/news/uk/politics/jeremy-corbyn-is-a-threat-to-our-national-security-says-george-osborne-10479327.html [Accessed August 31, 2016].

Mott MacDonald, 2011. *Costs of low-carbon generation technologies*, Bristol: Mott MacDonald.

Moura Neto, J.S. de, 2009. "A importância da construção do submarino de propulsão nuclear brasileiro." *Defesa Naval*. Available at: http://www.defesaaereanaval.com.br/a-importancia-da-construcao-do-submarino-de-propulsao-nuclear-brasileiro/?print=pdf [Accessed August 31, 2016].

Nanndakumar, M.K., Jharkharia, S. & Nair, A.S. eds., 2014. *Organisational Flexibility and Competitiveness*, New Delhi, India: Springer.

National Audit Office, 2016. *Nuclear power in the UK*, London: National Audit Office.

Needham, R., 1975. Polythetic Classification: convergence and consequences. *Man*, 10(3), pp.349–369.

Neslen, A., 2015. UK threatens to hit back at Austria over Hinkley Point legal challenge. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2015/feb/11/uk-threatens-to-hit-back-at-austria-over-hinkley-point-court-action [Accessed August 31, 2016].

Nolte, D., 2010. How to compare regional powers: analytical concepts and research topics. *Review of International Studies*, 36(4), pp.881–901.

Norris, R., 2016. Energy is the UK's big infrastructure opportunity - and must be at forefront of new Department. *RenewableUK Webpages*. Available at: http://www.renewableuk.com/news/news.asp?id=298536 [Accessed September 1, 2016].

North West Evening Mail, 2016. Barrow shipyard campaigners set for showdown with Labour Party bosses over Trident. *North West Evening Mail Online*. Available at: http://www.nwemail.co.uk/news/barrow/Barrow-shipyard-campaigners-set-for-showdown-with-Labour-Party-bosses-over-Trident-1cf696e7-2212-4dc9-a428-22a5e08918ad-ds [Accessed August 31, 2016].

North, D.C., 2006a. *Institutions, Instituional Change and Economic Performance*, Cambridge: Cambridge Univ. Press.

North, D.C., 2006b. *Institutions, Institutional Change and Economic Performance*, Cambridge:

Cambridge Univ. Press.

Nuclear Consulting Group, 2016. Nuclear Consulting Group. *Nuclear Consulting Group webpages*. Available at: http://www.nuclearconsult.com/ [Accessed August 31, 2016].

Nye, J.S., 2004. *Soft Power: the means of success in world politics*, New York: Public Affairs.

O'Callaghan, J., 2014. Death of the nuclear submarine? Huge diesel-electric vessel could replace other subs thanks to its stealth and efficiency. *The Daily Mail Online*. Available at: http://www.dailymail.co.uk/sciencetech/article-2820348/The-death-nuclear-submarines-Huge-diesel-electric-vessel-used-replace-subs-stealthy.html [Accessed August 31, 2016].

OECD-Orbis, 2016. OECD-ORBIS Database. *OECD-Orbis database*.

ONR, 2016a. Advanced Passive 1000 - AP1000®. *Office for Nuclear Regulation webpages*. Available at: http://www.onr.org.uk/new-reactors/ap1000/ [Accessed August 31, 2016].

ONR, 2016b. UK Advanced Boiling Water Reactor (UK ABWR). *Office for Nuclear Regulation webpages*. Available at: http://www.onr.org.uk/new-reactors/UK-ABWR/index.htm [Accessed August 31, 2016].

ONR, 2012. UK regulators confirm acceptance of new nuclear reactor design. *Office for Nuclear Regulation webpages*. Available at: http://news.onr.org.uk/2012/12/uk-regulators-confirm-acceptance-of-new-nuclear-reactor-design/ [Accessed August 31, 2016].

Oxford Economics, 2013. *The economic benefit of improving the UK's nuclear supply chain capabilities*, Oxford: Oxford Economics Institute.

Parker, J., 2010. Structuration Theories. In C. Crothers, ed. *Historical Developments and Theoretical Approaches in Sociology - Volume II*. Paris: UNESCO-EOLSS.

Parsons, T., 1954. *Essays in Sociological Theory*, Glencoe, Illinois: The Free Press.

Patterson, W., 1979. Environmental involvement in British civil nuclear policy. *Journal of the Institute of Nuclear Engineering*, 20(5), pp.1–6.

Patterson, W., 2007. Fifty years of hopes and fears. *Nature*, 449, p.664.

Patterson, W., 1977. *The Fissile Society*, London: Earth Resources Research.

Pavelec, S.M. ed., 2010. *The Military-Industrial Complex and American Society*, Santa Barbara: ABC-Clio.

Pemberton, B., 2016. Control, Historic Pitfalls, and the UK Nuclear Renaissance. *International Journal of Public Administration*, May.

Pesch, U., 2014. Tracing discursive space : Agency and change in sustainability transitions. *Technological Forecasting & Social Change*, 90, pp.15–19.

Pestre, D., 2007. *Historical Perspectives on Science, Society and the Political - report to the science, economy and science directorate, European Commission*, Brussels: European Commission.

Pickard, W.F. & Abbott, D., 2012. Addressing the intermittency challenge: Massive energy storage in a sustainable future [Scanning the Issue]. *Proceedings of the IEEE*, 100(2), pp.317–321.

Pierson, P., 2000. Increasing Returns, Path Dependence, and the Study of Politics. *American Political*

Science Review, 94(2), pp.251–267.

Pinch, T. & Richard Swedberg eds., 2008. *Living in a Material World: economic sociology meets scienceand tchnology studies*, Cambridge, MA; London, UK: MIT Press.

PIU, 2002. *The Energy Review*, London: UK Cabinet Office Performance and Innovation Unit.

Porritt, J., 2013. A nuclear renaissance in the UK? *Jonathon Porritt Blog*. Available at: http://www.jonathonporritt.com/blog/nuclear-renaissance-uk [Accessed August 31, 2016].

Powell, C. & Depelteau, F. eds., 2013. *Conceptualizing Relational Sociology: ontological and theoretical issues*, London: Palgrave MacMillan.

Pung, H. et al., 2005. *Sustaining Key Skills in the UK Naval Industry*,

Purdue, M., Kemp, R. & O'Riordan, T., 1984. The context and conduct of the Sizewell B Inquiry. *Energy Policy*, 12(3), pp.276–282.

Purkitt, H. & Burgess, S., 2005. *South Africa's Weapons of Mass Destruction*, Indiana: Indiana University Press.

Raman, R. et al., 2005. *The United Kingdom's Nuclear Submarine Industrial Base Volume 3: Options for Initial Fuelling*, Arlington: RAND Corporation.

Rambukkana, N. ed., 2015. *Hashtag Publics: the power and politics of discursive networks*, New York: Peter Lang.

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.

Raustiala, K. & Victor, D.G., 2004. The Regime Complex for Plant Genetic Resources. *International Organization*, May 2004.

Renewable Energy Association, 2015. *Renewable Energy Review 2014*, London: Renewable Energy Association.

RenewableUK, 2015. Supply Chain Map. *RenewableUK Webpages*. Available at: http://www.renewableuk.com/page/SupplyChainMap [Accessed September 1, 2016].

Reuters, 2015. Greenpeace and utilities launch suit against Hinkley nuclear plant. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2015/jul/02/greenpeace-utilities-launch-suit-against-hinkley-nuclear-plant [Accessed September 1, 2016].

Richards, D., 1996. Elite Interviewing: Approaches and Pitfalls. *Politics*, 16(3), pp.199–204.

Ritchie, N., 2012. *A nuclear weapons free world? Britain, Trident, and the challenges ahead.*, London: Palgrave Macmillan.

Ritchie, N., 2014. *Nuclear risk: the British case*, York: Article 36.

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.

Roe, E., 1994. *Narrative Policy Analysis: theory and practice*, Durham: Duke University Press.

Ross, E., 2016. The nine countries that have nuclear weapons. *The Independent Online*. Available at:

http://www.independent.co.uk/news/world/politics/the-nine-countries-that-have-nuclear-weapons-a6798756.html [Accessed September 1, 2016].

Royal Navy, 2016. Continuous at sea deterrent. *Royal Navy Website*. Available at: http://www.royalnavy.mod.uk/news-and-latest-activity/operations/global/continuous-at-sea-deterrent [Accessed September 1, 2016].

Rudd, A., 2015. Amber Rudd's speech on a new direction for UK energy policy. *Department of Energy and CLimate Change Webpages*. Available at: https://www.gov.uk/government/speeches/amber-rudds-speech-on-a-new-direction-for-uk-energy-policy [Accessed September 1, 2016].

Ruddick, G. & Grierson, J., 2016. Hinkley Point C in doubt after British government delays approval. *The Guardian Online*. Available at: https://www.theguardian.com/business/2016/jul/28/hinkley-point-c-to-go-ahead-after-edf-board-approves-project [Accessed September 1, 2016].

Runciman, D., 2016. *Are Conspiracy Theories Bad for Democracy? Ralph Miliband Lecture, 10th February 2016*, London: London School of Economics.

Ruz, C., 2015. Why do we need China to build our nuclear power plants? *BBC News Online*.

de Sá, A., 2015. Brazil's Nuclear Submarine Program: A Historical Perspective. *The Nonproliferation Review*, 22(1), pp.1746–1766.

Sabatier, P. a. & Weible, C.M., 2007. The Advocacy Coalition Framework: Innovations and Clarifications. In P. A. Sabatier, ed. *Theories of the Policy Process*. Boulder, Colorado: Westview Press, pp. 189–220.

Schank, J.F. et al., 2007. *Sustaining US Nuclear Submarine Design Capabilities*, Santa Monica, CA: RAND Corporation.

Schank, J.F. et al., 2005. *THe United Kingdom's Submarine Industrial Base Volume 1: Sustaining Design and Production Resources*, Pittsburgh: RAND Corporation.

Schiavone, F., 2014. *Communities of Practice and Vintage Innovation: a strategic reaction to technological change*, Heidelberg: Springer.

Schneider, C.J., 2012. *Research Amongst Elites: Challenges and Opportunities in Studying Up*, London: Routledge.

Schneider, M. & Froggatt, A., 2016. *The World Nuclear Industry Status Report*, Paris; London; Tokyo: Mycle Schneider Consulting Project.

Schreyögg, G., 2011. Organizational Path Dependence: A Process View. *Organization Studies*, 32(3), pp.321–335.

Schubert, C., Sydow, J. & Windeler, A., 2013. The means of managing momentum: Bridging technological paths and organisational fields. *Research Policy*, 42(8), pp.1389–1405.

Scott, J., 2008. Modes of power and the re-conceptualization of elites. *The Sociological Review*, 56(s1), pp.25–43.

Shove, E., 2003. *Comfort, Cleanliness and Convenience: the social organisation of normality*, Oxford: Berg.

Simon, H.A., 1983. *Reason in Human Affairs*, Stanford: Stanford University Press.

Singh, A., 2016. Why India Needs Both Nuclear and Conventional Submarines. *The Diplomat*. Available at: http://thediplomat.com/2016/05/why-india-needs-both-nuclear-and-conventional-submarines/ [Accessed September 1, 2016].

Skogstad, G., 2008. Policy Networks and Policy Communities: Conceptualizing State-Societal Relationships in the Policy Process. In L. A. White et al., eds. *The Comparative Turn in Canadian Political Science*. Vancouver; Toronto: UBC Press, pp. 205–220.

Smeed, J. et al., 2009. Power over, with and through: Another look at micropolitics. *Leading & Managing*, 15(1), pp.26–41.

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., 2008. *Social-ecological resilience and socio-technical transitions: critical issues for sustainability governance*, Brighton: STEPS Centre.

Söderbaum, F., 2004. Modes of Regional Governance in Africa: neoliberalism, sovereignty boosting and shadow networks. *Global Governance*, 10(2004), pp.419–436.

Somekh, B. & Lewin, C. eds., 2005. *Research Methods in the Social Sciences*, London: Sage.

Sovacool, B.K., 2009. The intermittency of wind, solar, and renewable electricity generators: Technical barrier or rhetorical excuse? *Utilities Policy*, 17(3–4), pp.288–296.

Späth, P. & Rohracher, H., 2010. "Energy regions": The transformative power of regional discourses on socio-technical futures. *Research Policy*, 39(4), pp.449–458.

Spencer-Wood, S., 2004. What Difference Does Feminist Theory Make in Researching Households? A Commentary. In K. S. B. and J. C. Brandon, ed. *Household Chores and Household Choices: theorizing the domestic sphere in historical archaeology*. Tuscaloosa, Alabama: The University of Alabama Press.

Stalcup, T., 2012. What is Brazil up to with its Nuclear Policy? *Georgetown Journal of International Affairs*. Available at: http://journal.georgetown.edu/what-is-brazil-up-to-with-its-nuclear-policy-by-travis-stalcup/ [Accessed September 1, 2016].

Stegmaier, P., Kuhlmann, S. & Visser, V., 2014. The discontinuation of socio-technical systems as a governance problem. In S. Borras & J. Edler, eds. *The Governance of Socio-technical Systems: Explaining Change*. Cheltenham: Edward Elgar, pp. 111–131.

Stegmaier, P., Kuhlmann, S. & Visser, V.R., 2012. Governance of the Discontinuation of Socio-Technical Systems. In *Proceedings of the International Jean Monnet Conference on the Governance of Innovation and Sociortechnical Systems in Europe*. Denmark: Copenhagen Business School.

Steinberg, A., 2008. Rhizomic Network Analysis: Towards a better understanding of knowledge dynamics of innovation in business networks. In F. Zhao, ed. *Information Technology Entrepreneurship and Innovation*. London: IGI Global, pp. 224–249.

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

Stirling, A., 2010. *Direction, Distribution and Diversity! Pluralising Progress in Innovation, Sustainability and Development*, Brighton: STEPS Centre, University of Sussex.

Stirling, A., 2014. *Emancipationg Transformations: from the controlling "the transition" to culturing plural radical progress*, Brighton: STEPS Centre, University of Sussex.

Stirling, A., 2016. Knowing Doing Governing: realising heterodyne democracies. In J.-P. Voß & R. Freeman, eds. *Knowing Governance: The Epistemic Construction of Political Order*. London: Palgrave MacMillan.

Stirling, A., 2005. Opening Up or Closing Down? Analysis, participation and power in the social appraisal of technology. In F. Berkhout, M. Leach, & I. Scoones, eds. *Science, Citizenship and Globalisation*. London: Zed.

Stirling, A., 2011. Pluralising progress: From integrative transitions to transformative diversity. *Environmental Innovation and Societal Transitions*, 1(1), pp.82–88.

Stirling, A., 1994. *Power Technology Choice: putting the money where the mouth is?*, Brighton: SPRU, University of Sussex.

Stirling, A., 2015. Power, Truth and Progress: towards knowledge democracies in Europe. In J. Wilsdon & R. Doubleday, eds. *Future Directions for Scientific Advice in Europe*. Cambridge: University of Cambridge, pp. 133–151.

Stirling, A., 2014. Transforming power: Social science and the politics of energy choices. *Energy Research & Social Science*, 1, pp.83–95.

Stirling, A. & Johnstone, P., 2016. On the "Deep State" Hypothesis. *Polet.network Webpages*. Available at: http://polet.network/blog//deep-state-uk-response [Accessed September 1, 2016].

Stirling, A. & Saurabh Arora, 2015. From Multiple Levels to Entangled Streams of Practice: dynamics of structuration in sociotechnical transformations. In *Proceedings of the International Sustainability Transitions Conference*. Brighton: SPRU, University of Sussex.

Stone, D., 2002. Introduction : global knowledge and advocacy networks. *Global Networks*, 2(1), pp.1–11.

Stothard, M., 2016. Trade unions press EDF to delay Hinkley Point C decision. *The Financial Times Online*. Available at: http://www.ft.com/cms/s/0/18e1c7f6-3eda-11e6-9f2c-36b487ebd80a.html#axzz4J0818D00 [Accessed September 1, 2016].

Strunz, S., 2014. The German energy transition as a regime shift. *Ecological Economics*, 100, pp.150–158.

Stuenkel, O., 2015. *The BRICS and the future of global order*, London: Lexington Books.

Sunstein, C.R., 2014. *Conspiracy Theories and Other Dangerous Ideas*, New York: Simon & Schuster.

Swyngedouw, E., 2004. *Social Power and the Urbanization of Water: flows of power*, Oxford: Oxford Univ Press.

Sydow, J., Schreyogg, G. & Koch, J., 2009. Organizational Path Dependence: opening the black box. *Academy of Management Review*, 34(4), pp.689–709.

Taylor, S., 2007. *Privatisation and collapse in the nuclear industry: The origins and causes of the British Energy crisis of 2002*, Abingdon: Taylor & Francis.

Taylor, S., 2016. *The fall and rise of nuclear power in Britain*, Cambridge: UIT Cambridge.

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

The Labour Party, 2015. *Britain can be better - The Labour Party Manifesto 2015*, London: The Labour Party.

Thomas, R., 2002. India's energy policy and nuclear weapons program. In D. R. SarDesai & G. C. Thomas, eds. *Nuclear India in the Twenty-First Century*. New York: Palgrave Macmillan, pp. 277–298.

Thomas, S., 2010. Competitive energy markets and nuclear power: Can we have both, do we want either? *Energy Policy*, 38(9), pp.4903–4908.

Thomas, S., 2016. The Hinkley Point decision: An analysis of the policy process. *Energy Policy*, 96, pp.421–431.

Thomas, S., 1988. *The realities of nuclear power : international economic and regulatory experience*, Cambridge: Cambridge University Press.

Tickell, O., 2014. Bombs Ahoy! Why the UK is desperate for nuclear power. *The Ecologist*. Available at: http://www.theecologist.org/blogs_and_comments/commentators/2530828/bombs_ahoy_why_the_uk_is_desperate_for_nuclear_power.html [Accessed September 1, 2016].

Toke, D., 2013. Climate change and the nuclear securitisation of UK energy policy. *Environmental Politics*, 22(4), pp.553–570.

Toke, D., 2011. The UK offshore wind power programme: A sea-change in UK energy policy? *Energy Policy*, 39(2), pp.526–534.

Toke, D., 2012. Will the Government Write a Blank Cheque for Nuclear Construction? *Huffington Post*. Available at: http://www.huffingtonpost.co.uk/david-toke/will-government-write-a-blank-cheque-for-nuclear-construction_b_1979027.html [Accessed September 1, 2016].

Tran, M., 2014. Modeling Sustainability Transitions on Complex Networks. *Complexity*, 19(5), pp.8–22.

Turnheim, B. et al., 2015. Evaluating sustainability transitions pathways : Bridging analytical approaches to address governance challenges. *Global Environmental Change*, 35, pp.239–253.

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.

UCL IEPL, 2013. *Could Australia's Future Submarines Be Nuclear-Powered?*, Adelaide: University College London Australia and International Energy Policy Institute.

UK Trade and Investment, 2012. *Offshore Wind Energy : A UK Success Story*, London: Crown Copyright.

UK Trade and Investment, 2015. *UK Offshore Wind: Opportunities for trade and investment*, London: Crown Copyright.

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

UNSC, 2016. Current Members. *United Nations Security Council Webpages*. Available at: http://www.un.org/en/sc/members/ [Accessed September 1, 2016].

Urry, J., 2003. *Global Complexity*, Cambridge: Polity Press.

Valikangas, L., 2010. *The Resilient Organization: how adaptive cultures thrive even when strategy fails*, New York: McGraw Hill.

Vasagar, J., 2015. Compromise and opposition on road to Germany's renewable energy. *The Financial Times Online*. Available at: http://www.ft.com/cms/s/2/6a254194-47e9-11e5-af2f-4d6e0e5eda22.html#axzz4J0818D00 [Accessed September 1, 2016].

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 [Accessed September 1, 2016].

Vaughan, A., 2010. UK government approves eight sites for new nuclear power stations. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2010/oct/18/uk-government-new-nuclear-power [Accessed September 1, 2016].

Velazquez, A.C.S., 2014. Brazil and Mexico in the Non-Proliferation Regime: Common Structures and Divergent Trajectories in Latin America. In J. R. Fields, ed. *State Behaviour and the Nuclear Nonproliferation Regime*. Georgia: University of Georgia Press, pp. 218–250.

Walker, G. & King, D., 2008. *Hot Topic: How to Combat Global Warming and Still Keep the Lights On*, London: Bloomsbury.

Walker, P. & Stewart, H., 2016. Labour facing prospect of three-way split over Trident vote. *The Guardian Online*. Available at: http://www.theguardian.com/politics/2016/jul/18/labour-facing-prospect-of-three-way-split-over-trident-vote [Accessed September 1, 2016].

Walker, W., 2000. Entrapment in large technology systems: institutional commitment and power relations. *Research Policy*, 29(7-8), pp.833–846.

Watts, D.J., 2011. *Everything is Obvious - once you know the answer: how common sense fails us*, New York: Crown Business.

Wedel, J., 2014. *Unaccountable - how elite power brokers corrupt our finances, freedom, and security*, New York: Pegagus Books.

Weible, C.M. et al., 2011. A quarter century of the advocacy coalition framework: An introduction to the special issue. *Policy Studies Journal*, 39(3), pp.349–360.

Welsh, I., 2001. Anti-nuclear movements: failed projects or heralds of a direct action milieu? *Sociological Research Online*, 6(3).

Vander Weyer, M., 2016. France can't build its own nuclear power stations, let alone ours. *The Spectator*. Available at: http://www.spectator.co.uk/2016/02/france-cant-build-its-own-new-nuclear-power-stations-let-alone-ours/ [Accessed September 1, 2016].

Wheeler, B., 2007. Labour and the nuclear lobby. *BBC News Online*. Available at: http://news.bbc.co.uk/1/hi/uk_politics/5149676.stm [Accessed September 1, 2016].

Whitehead, A.N., 1948. *Science and the Modern World*, New York: The New American Library.

Winner, L., 1977. *Autonomous Technology: technics out of control as a theme in political thought*, Camb MASS: MIT Press.

Winskel, M., 2002. Autonomy's End: Nuclear Power and the Privatization of the British Electricity Supply Industry. *Social Studies of Science*, 32(3), pp.439–467.

Woods, N., 2006. *Describing Discourse: a practical guide to discourse analysis*, London: Hodder Arnold.

World Nuclear Association, 2016a. Nuclear Development in the United Kingdom. *World Nuclear Association Country Profiles*. Available at: http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/appendices/nuclear-development-in-the-united-kingdom.aspx [Accessed September 1, 2016].

World Nuclear Association, 2016b. Nuclear Power in China. *World Nuclear Association Country Profiles*. Available at: http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx [Accessed September 1, 2016].

World Nuclear Association, 2016c. Nuclear Power in India. *World Nuclear Association Country Profiles*. Available at: http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx [Accessed September 1, 2016].

World Nuclear Association, 2016d. Nuclear Power in the European Union. *World Nuclear Association Country Profiles*. Available at: http://www.world-nuclear.org/information-library/country-profiles/others/european-union.aspx [Accessed September 1, 2016].

World Nuclear Association, 2016e. Nuclear power in the UK. *World Nuclear Association Country Profiles*. Available at: http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/united-kingdom.aspx [Accessed September 1, 2016].

World Nuclear Association, 2016f. Safeguards to Prevent Nuclear Proliferation. *World Nuclear Association Webpages*. Available at: http://www.world-nuclear.org/information-library/safety-and-security/non-proliferation/safeguards-to-prevent-nuclear-proliferation.aspx [Accessed September 1, 2016].

World Nuclear Association, 2015. The Nuclear Renaissance. *World Nuclear Association Webpages*. Available at: http://www.world-nuclear.org/information-library/current-and-future-generation/the-nuclear-renaissance.aspx [Accessed September 1, 2016].

World Nuclear Association, 2016g. World Nuclear Association Reactor Database (ABWR). *World Nuclear Association Reactor Database*. Available at: http://www.world-nuclear.org/information-library/facts-and-figures/reactor-database.aspx [Accessed September 1, 2016].

World Nuclear News, 2011. Last Decade of German Nuclear Power. *World Nuclear News Website*. Available at: http://www.world-nuclear-news.org/np_last_decade_of_german_nuclear_power_3105111.html [Accessed September 1, 2016].

World Nuclear News, 2015. New legal challenge for Hinkley Point C. *World Nuclear News Website*. Available at: http://www.world-nuclear-news.org/NN-New-legal-challenge-for-Hinkley-Point-C-0307157.html [Accessed September 1, 2016].

World Nuclear News, 2008. Rolls-Royce steams into nuclear market. *World Nuclear News Website*. Available at: http://www.world-nuclear-news.org/C_Rolls-Royce_steams_into_nuclear_market_1707081.html [Accessed September 1, 2016].

World Nuclear News, 2014. UK government paves way for Chinese nuclear plant. *World Nuclear news*. Available at: http://www.world-nuclear-news.org/NP-UK-government-paves-way-for-Chinese-nuclear-plant-18061401.html [Accessed September 1, 2016].

Wynne, B., 2010. *Rationality and Ritual: Participation and Exclusion in Nuclear Decision-Making* 2nd ed., London: Earthscan.

Wynne, B., 2002. Risk and environment as legitimatory discourses of technology: reflexivity inside out? *Current Sociology*, 50(3), pp.459–477.

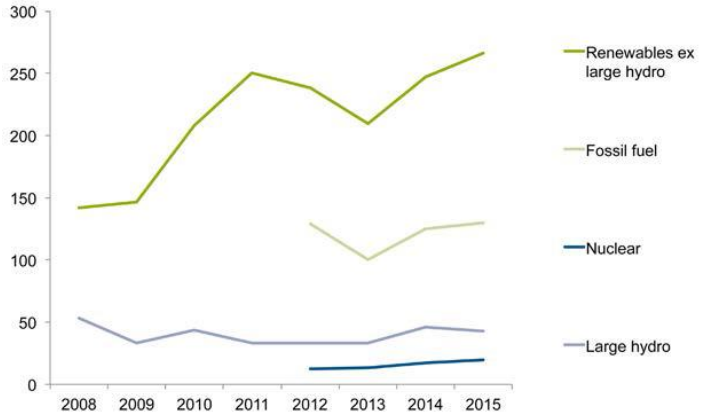
Wynne, B., 1975. The Rhetoric of Consensus Politics: a critical review of technology assessment. *Research Policy*, 4(2), pp.108–158.

Yang, K. & Miller, G.J. eds., 2008. *Handbook of Research Methods in Public Administration*, London: Taylor and Francis.

Young, O.R., Schroeder, H. & King, L.A. eds., 2008. *Institutions and Environmental Change: principal findings, applications and research frontiers*, Cambridge Mass.: MIT Press.

Endnotes

[1] Investment in power capacity – Renewable, Fossil-Fuel and nuclear (2008-2015 $billion)



Source: Frankfurt School-UNEP (2016).

[2] The UK is not just fitting in with the prevailing pattern elsewhere in Europe. Despite many pointing towards Germany as the exception in its attempted phase out of nuclear power, in the European context the scale of the UK's nuclear ambitions, mean that arguably represent the exceptional case. Outlined below is the patterns of nuclear developments in Europe but it is important to also acknowledge the current EPR reactors under construction in Europe at Olkilouto and Flamanville which are both vastly over budget and behind schedule by 6 years in the case of Flamanville and 10 years in the case of Olkilouto.

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

[3] The UK is not just fitting in with a more widespread or global 'nuclear renaissance'. Following the events at Fukushima, many countries abandoned the construction or planned construction of new nuclear power including Germany, Switzerland, Belgium, Italy, Israel, Mexico, Venezuela. In fact, a 'nuclear renaissance' of any scale has been confined to China, Russia and India and it is not unreasonable to note that for all the immense efforts that have gone in to promoting a 'nuclear renaissance', in most instances this has been purely rhetorical than reality (van de Graff, 2016).

[4] There are several episodes in the UK's nuclear history which emphasise the particularly bad record of nuclear performance in a range of nuclear-related areas. It could reasonably be thought that the particularly bad history of UK nuclear in general would provide a basis to dissuade policy makers from further attempts at ambitious nuclear agendas especially given the presence of technological alternatives. Yet the UK's nuclear new build plans are far more ambitious than countries that do not have such chequered histories regarding nuclear cost overruns, accidents, and glaring technical errors, thus the historical mishaps briefly detailed below, add to the curious continued commitment towards nuclear demonstrated by the UK. These include:

- The *Windscale Fire of 1957*. This was the worst nuclear accident in the UK, and one of the most significant nuclear accidents in the history of nuclear power more globally. One of the Windscale 'piles' caught fire, and radioactive materials notably Iodine-131, Strontium-90, Caesium-137, as well as polonium-210. The surrounding environment was contaminated and the sale of milk banned as a precaution. It is very difficult to assess the entire costs of the Windscale disaster because much of the information surrounding the disaster was kept secret by government because of the essential role that Windscale played in the production of plutonium for the nuclear weapons programme. Also, in terms of life time costs, the piles have had to be continually monitored at the Sellafield for many decades, with new constructions to 'seal' the piles, and they have not yet been decommissioned, with highly radioactive uranium remains in the piles.

- *The AGR programme.* The Advanced Gas-cooled Reactor programme was referred to by the CEGB as one of "the major blunders of British industrial policy" (quoted in Brown, 2008). The reactors faced significant technical difficulties exemplified by Dungeness B which took 18 years to construct and had a lifetime load factor of 43% (IAEA Reactor Database, 2016). Despite the great hope of a global market for AGRs, no reactor was ever bought or constructed outside of the UK (Birmingham Policy Commission, 2015).

- *The legacy of UK fast breeder reactors.* Fast breeder reactors were the great hope of the British nuclear industry. A demonstration Fast Breeder reactor was set up at Dounreay on the north coast of Scotland. Patterson (2010) details the acute technical problems experienced throughout the lifetime of Britain's long commitment towards Fast Breeder technologies when the first prototype reactor was switched on in 1959, to numerous to mention. What is astonishing about the FBR programme is despite continual engineering problems, in the 1970s, announcements were made by the AEA that by the year 2000, over 75% of electricity generation would be coming from nuclear power, and over half of that nuclear generation coming from Fast Breeder Reactors. In fact, by the year 2000 the share of nuclear was 25% of the generation mix, and the proportion generated by the much vaunted Fast Breeder technology was 0% of the generation mix, with the Prototype Fast Reactor (PFR) reactor at Dounreay closing in 1994. The lifetime load factor for the PFR reactor was just 26.9% (IAEA Reactor Database, 2016). Nearly £5 Billion of R&D money went in to Fast Breeder activity between 1974-1995, and the project was constantly beset with delays and safety problems with serious issues including the discovery of radioactive

particles on nearby beaches, and there has been a string of legal cases against the Dounreay site due to the leakages of radioactive materials taking place over the past few decades (Edwards, 2011). The costs of the UK's fascination with Fast Breeder technology will continue for the foreseeable future due to the incredible problems of decommissioning the Dounreay Fast breeder reactor, which in 2009, the NDA announced would take place by 2025 at a cost of £2.6 billion (Ross, 2015). There are many more issues that could be discussed, but the underlying point stands that an immense amount of resource was devoted to fast breeder technology for very little reward in terms of civilian electricity supply, which was the ostensible reason for the pursuit of Fast breeder technology.

- *The legacy of UK nuclear waste and the Sellafield Facility.* Despite the declaration by DECC that there is a 'solution' for UK radioactive waste (BERR, 2008), no site has been found for the construction of a Deep Geological Disposal Facility (GDF) (DECC, 2014). The latest estimates for the cost of dealing with the UK's legacy waste is £110 billion (Gosden, 2014). The nuclear waste and reprocessing facility at Sellafield is widely considered to be the most 'hazardous industrial site in Europe' (McKie, 2009), not least because it is the location of 140 tonnes of reactor grade plutonium, as well as other dangerous radioactive materials in the form of radioactive 'sludge' created through circulating water in the storage ponds containing high level waste, making the process of keeping an inventory of the characterisation of waste at Sellafield an incredibly challenging task where "the exact contents of the ponds are unclear", according to Paul Howarth of the National Nuclear Laboratory (quoted in Pearce, 2015).

- *THORP and MAGNOX reprocessing plants and MOX fuel production.* The Thorium Oxide Reprocessing Plant (THORP) has been intensely controversial since the late 1970s due to proliferation and safety concerns. The idea behind THORP was to separate out useful uranium and plutonium from nuclear wastes, with the products could be sold to other countries as Mixed Oxide Fuel (MOX), or that the plutonium could be burned in (now hypothetical) fast breeder reactors. THORP took over 15 years to construct and has been shut down for a total of 6 years of its 21 year life so far. Both THORP and the MAGNOX reprocessing plant which reprocesses spent fuel from the UK's MAGNOX reactors have continually missed targets in terms of the amounts of spent fuel that were meant to be reprocessed (Public Accounts Committee, 2013). The MOX production plant, designed to produce MOX fuel so that nuclear waste can be used as fuel in MOX-capable nuclear reactors has widely been acknowledged as one of the other major industrial mistakes in UK history, a point conceded by energy minister Malcolm Wicks in 2008 (quoted in Lean, 2008). The plant was designed to produce 120 tonnes of MOX fuel a year, however it in fact produced less than 14 tonnes in ten years (Brady, 2013). An governmental internal report (only made available through a Freedom of Information Request in 2013), revealed that the plant had a lifetime net loss of £2.2 billion. There are currently no customers for MOX fuel which renders the business case for the plant flawed. The aim was to reprocess 400 tonnes of spent fuel a year but has in fact managed to only process around 100 tonnes a year.]

- *The Thatcher Government's nuclear new build agenda.* In 1979, one of the first major policies announced under the new Thatcher government by Geoffrey Howell, the minister for energy, was the construction of 8 new nuclear reactors within a decade that were an apparent 'necessity' with 15GW of new capacity planned (Hansard, 1979). In the end one new reactor was constructed (Sizewell B).

- *The very recent economic history of UK nuclear power.* The case for nuclear power collapsed in 1990 when it became apparent that Hinkley C could not be constructed and operated in a privatised electricity market. Nuclear had to be ring fenced from privatisation and given what was essentially a form of subsidy through the Non-Fossil fuels obligation which was dubbed the 'nuclear fuels obligation' (Watson, 2010). Attempted privatisation of the nuclear industry did not take place until the late 1990s with the creation of British Energy, but this experiment did not last long as British Energy had to be bailed out by the UK government to the tune of over £650 million in 2001 and guarantees were given that the tax payer would take on the costs of future liabilities arising from the operations of British Energy (The Guardian, 2002).

-

[5] The search terms used were: nuclear energy; nuclear power; civil nuclear; nuclear supply chain; nuclear skills; nuclear training; nuclear submarine; nuclear military; nuclear propulsion; nuclear defence; Trident. Documents were also

recommended to us by colleagues, contacts and interviewees. The bibliographies of all documents were searched for any additional documents relating to either civilian or military nuclear activity; the process continued until no further documents were found. Within these documents, key word searches were carried out to investigate cross-overs between civilian and military sectors. The civilian documents were searched for a set of military keywords: Military; Defence; Security; MoD; Submarine; Trident; Deterrent; Weapon. The military documents were searched for a set of civilian keywords: Civil; Energy; Electricity; Non-military; Power; Generation; New build; SMR. All the resulting quotes were coded according to a set of 13 themes, relating to skills, technologies, R&D, organisations, waste and decommissioning, design expertise, fuel, regulation, and new-build experience.

[6] Full quote:

> *"The world would be a better place if such weapons were not still necessary, but the conditions for complete nuclear disarmament do not yet exist… in present conditions nuclear deterrence still has an important contribution to make in insuring against the re-emergence of major strategic military threats, in preventing coercion, and in preserving peace and stability in Europe. The Government's General Election Manifesto therefore promised to retain Trident as the ultimate guarantee of the United Kingdom's security while pressing for multilateral negotiations towards mutual, balanced and verifiable reductions in nuclear weapons." SDR 1998 supporting essay 5, para 3-5*

[7] The White Paper states continued commitment to the deterrent, arguing essentially that the high costs were worth it for this 'ultimate assurance of our national security', as shown in this quote from Tony Blair in the foreword to the Strategic Defence Review (2006):

> *"Some of the old realities remain. Major countries, which pose no threat to the UK today, retain large arsenals some of which are being modernised or increased…. We also have to face new threats, particularly of regional powers developing nuclear weapons for the first time which present a threat to us… Those who question this decision need to explain why disarmament by the UK would help our security. They would need to prove that such a gesture would change the minds of hardliners and extremists in countries which are developing these nuclear capabilities".*

[8] It should be noted that these discussions were not without controversy, much of which surrounded the high costs of building a replacement nuclear submarine fleet (Mackinnon, 2016). The major Scottish political parties and many Scottish MPs are generally opposed to the fleet being based at Faslane. In 2007, a major House of Commons vote saw a number of Scottish Labour MPs rebel against the government, although the house backed plans for Trident renewal by a substantial majority of 409 to 161.

[9] As stated by Namtec:

> *"Rolls-Royce believes that its experience in nuclear power, which originates from its involvement in the development and support of the nuclear steam raising plant for the Royal Navy's nuclear submarine programme, is directly applicable to all phases of a nuclear new build programme"*. (Namtec 2009, p.51)

[10] Using the methodology shown in Section 4a large number of passages from documents were identified which indicate linkages between developments in the fields of UK civil nuclear power and submarine nuclear propulsion, a small selection of which are shown in section 5.2. These quotes are shown in full detail here:

> *"Expertise developed through the UK's nuclear security R&D programme and the nuclear submarine programme also has relevance to the nuclear fission programme"* (House of Lords 2011, p.18)

> *"Workstream 1 (Skills Coherence) will integrate the needs of the defence programme into existing cross-government and industry work to maximise the scope and value of skills training across the civil nuclear sector. Action will be taken to refocus and introduce*

greater collaboration in development of nuclear skills." (Office for Nuclear Regulation 2015, p.6)

"Whilst this study does not consider defence-related nuclear development there are nonetheless some capabilities from this sector that could be utilised in the civil nuclear market. ***For*** *example, the Light Water Reactor nuclear naval propulsion capability within Rolls-Royce has direct relevance to civil reactor build and operational support. The nonproliferation, materials detection, tracking and safeguarding work at AWE is also relevant to the development of advanced civil nuclear fuel cycles that are proliferation resistant. BAE Systems have developed modular construction techniques and virtual reality modelling to support construction, in addition to being actively engaged in reactor plant integration and commissioning"*. (Sherry et al 2008, p.3)

"Today there is untapped synergy between the civil and military missions. As the UK seeks to embark on a post-Trident era, and to maintain its capability in the years running up to this, there is much it could learn from practice in the civil sector in efficient 21st century project management, systems engineering and manufacturing in a contained environment. There are also significant synergies in the area of radioactive waste management and residue processing and recovery. The basic engineering requirements in both of these industries are the same and there would be obvious benefits in having a national education and skills programme that supported both industries. There is a need to ensure that the necessary engineering skills for both sectors are available." (HoC 2009 Engineering the Future, p.99, Written Evidence from RAEng)

"We believe that there is a strong technical overlap of engineering skills and technologies between the power sector and military… The requirements by the military/MoD for the above mentioned engineering skills overlap with those needed in the civil nuclear engineering field and AMEC supports cross-sector working which brings engineering and technical benefits in identifying best practice approaches. In addition to the overlap of engineering skills, there is also some commonality in R & D activities which if shared can be of mutual benefit to both civil and defence industry. In this respect, AMEC would encourage the Government to support stronger interfacing between civil Generation IV research programmes and the defence research programmes, again through co-ordinated participation of industry". (HoC 2009 Engineering the Future, p.70, Written Evidence from AMEC)

"…has also established a dialogue with the Ministry of Defence's (MoD) submarine nuclear reactor plant technical authority to understand the R&D work going on to support the naval propulsion programme. The aims of these discussions have been to ensure that, where possible, the civil and defence R&D programmes funded by Government are complementary. Potential areas for collaboration include modelling and simulation, control and instrumentation, chemistry and structural materials." NIRAB 2014 report

"It is important to note that we have not missed the boat because on the military programmes the R&D has started. The Government, through the Ministry of Defence, have already put in £25 million of R&D money into those programmes. So, that activity is going on and that is giving an unpinning to the skill base". ((HoC 2009 Engineering the Future, p.13)

[11] The full quote from INucE and BNES evidence to the 'Engineering the Future' enquiry (HoC 2009: EV445) reads:

"The question of overlap between civil and military can be divided into two sections, weapons and nuclear submarine propulsion. There is significant scope for interchange in

the latter as the power plant of a nuclear submarine is in general, similar to that of a modern power station. Many former nuclear submariners already occupy positions at all levels in the civil nuclear power and contracting industry and this is likely to continue. Thus the Royal Navy can be seen as a training ground for supporting the future UK nuclear power sector.

[12] The 'Engineering the Future' enquiry also pointed out the opportunities for transfer of capabilities between the two sectors:

> *"The reason being that we are now in a situation where the design of the military reactor plant is the same, in principle, as the design of the likely civil build programmes and this gives a great opportunity for more transfer than was historically the case. Also, as I said before, the dovetailing of design which we are currently doing in the military programmes whereas the new design was not required immediately on the civil programme, it will be later. So, you can balance the two programmes quite nicely together, if that is done skilfully". (HoC 2009 Engineering the Future, p.16)*

[13] A report by BASIC into nuclear skills and technology capabilities also noted the opportunities which could arise from exploiting these linkages more fully, for instance through technology transfers and spin-offs:

> *"Within the wider economic benefits, there are also examples of possible technology transfers and spin-offs arising from the UK nuclear submarine industry. Published examples include Weir Strachan and Henshaw supplying AWE; the possible application of Rolls-Royce technology on nuclear submarine reactors to civil nuclear power generation; the possible applications of AWE technology to civilian uses; and the transfer of 'best practice expertise' from nuclear submarines to civilian nuclear technology"* (Basic 2012 'Employment, Skills, Technology' p.21)

[14] The full quote from the Dalton Institute evidence to the 'Engineering the Future' enquiry reads:

> *"In the past, the military programme has been developed very much in isolation from the civil programme. This was due to concerns over classified information. However there is an opportunity for civil and military programmes to work together in developing a skills pool and supporting research, with only the truly classified aspects of the military programme kept separate. The UK is not now in the position of having financial or personnel resources to develop both programmes in isolation. For example, reactor physicists on the military programme can develop their skills and knowledge by researching civil systems, and then only when necessary divert to classified work to follow a specialist career path. This link does however need to be carefully managed to avoid the perception that civil and military nuclear programmes are one and the same. "* ((HoC 2009 Engineering the Future, p.61-2)

[15] The full quote from Dr Jeremy Stocker (International Institute of Strategic Studies , written evidence to House of Commons "Future of the Deterrent" enquiry) reads:

> *"Just as a public debate is emerging about the future of the UK's nuclear weapons, a parallel debate is beginning about the future of civil nuclear power in the light of concerns about global warming and the security of future energy supplies. This is relevant because ballistic missile-firing submarines, together with the smaller attack boats, are all nuclear-powered. With a total planned force of just 12 submarines (four SSBNs and eight SSNs) the British submarine force may barely be large enough to sustain a viable nuclear submarine building capacity. This will especially be so if, despite renewed calls for them, a new generation of civil nuclear power stations is not constructed. As older stations are decommissioned, the Royal Navy might, in future decades, face the prospect of being the UK's only operator of nuclear reactors. It would therefore have to shoulder the entire burden of the whole nuclear safety and regulatory regime*". (HoC 2006 [Future of the Deterrent: Strategic Context], p.EV103)

[16] The full quote from Dan Plesch (SOAS; oral evidence to the House of Commons defence enquiry) reads:

> *"For most of the post-war period governments denied there was a connection (between military and civilian uses of fissile materials). Finally under the Clinton administration a series of barter agreements involving the exchange of tonnes of material were made public, so the precedent is not good to say "we actually know what is going on here". Secondly, there are a number of specialist nuclear materials required for nuclear weapons which are imported from the US at a minimum. I think those points to my mind also go to the larger question that, when it comes to the United States looking at renewing support for Britain, Britain is required to show that it is a serious nuclear power and the question will I think arise immediately in the mind of John Bolton and his colleagues as to how can Britain be an independent nuclear state of any description if it has decided to phase out its civil nuclear industry"*. (HoC 2006 Strategic Context, p. EV18)

[17] The full quote from the Oxford Economics report (2013: 13) reads:

> "*The UK nuclear supply chain grew from investment in reactor technology to develop nuclear weapons, then into civil reactors, then submarines, a new generation of civil reactors and finally more investment in a new class of submarine. Without this synergy the UK supply chain would not have been sustainable."*

[18] Document analysis found a number of further quotes regarding concerns over skills predation, shown here:

> *By the counter argument, MOD are subject to the same issues of demographics as the rest of the industry and they are part of the pool calling for an adequate supply of engineering skills and providing training for them. There is also an overlap between the nuclear weapons sector and civil in certain specialised engineering fields, decommissioning and waste management area. The nuclear skills agenda for the UK therefore needs special attention to satisfy all parties". (HoC 2009 Engineering the Future, p.88, Written Evidence from INuc and BNES)*

> *"On the defence side of the industry, Ian Mitchell, Director of Quality at BAE Systems Maritime – Submarine, is faced with the same issue. He says: "A major worry for me is losing people to the civil sector. There is a real problem in terms of a skills drain from defence to higher-paid jobs in the civil sector."* (Chartered Quality Institute 2012, p.8)

> *"A shortage of skilled workers will create competition for specialist skills, pushing up labour prices. This threatens to increase the cost of critical national projects and potentially raise the UK's reliance on foreign expertise for civil projects. It will raise particular challenges for defence, where security considerations require UK nationals. There is a strong case, therefore, for building a suitably qualified and experienced workforce within the sector"* (DECC 2015, p.4)

> *"A very significant source of existing nuclear engineering, technical and manufacturing capability is currently also employed in the defence sector. BIS will therefore engage proactively with MoD on future resource planning to mitigate the effect of pressure from the civil nuclear programme on the defence nuclear skills base"* (BIS 2013 'Nuclear future', p.79)

[19] The following extracts illustrate concerns about the state of the nuclear skills base in the UK as the result of reductions in R&D budgets over the past 20 years:

> *"The severe cuts in naval nuclear R&T programmes in the 1990's, combined with the steady reduction of manpower and research laboratory closures in the civil nuclear sector, have affected the long term skills base in the UK"* (HoC 2006, p.EV59, written evidence from BAE)

"Over the last 20 years there has been a massive reduction in the R&D associated with the civil nuclear sector. The privatisation of the electricity supply industry and the demise of the UKAEA as a research organisation removed a cornerstone of the R&D supply chain which impacted heavily on the academic sector in the UK. This affected the skill base available to serve both military and civil sectors particularly in the area of reactor technology where skills are most at risk." (HoC 2006 p. EV107, written evidence from RAEng)

[20] Additional quotes suggesting that, rather than being a disadvantage, skills cross-overs could be seen as a further opportunity for the defence sector:

"The UK is entering a new stage in its nuclear history. The construction of new nuclear power plants, a growing decommissioning portfolio and delivery of the Successor submarine class to sustain our deterrent will create enormous investment in the sector over the next decade. The result will be massive growth in the sector matched by vast economic opportunities. The Government estimates that businesses will invest more than £45 billion to develop the first three nuclear power plants, in Anglesey, Cumbria and Somerset, alone. This surge of nuclear investment will create thousands of jobs, drive regional growth and help to build the UK's supply chain capability. The Government and industry are working to build a skills base capable of meeting the demands of the new nuclear sector. There are substantial challenges to overcome. The nuclear workforce is ageing and attrition rates are high and growing as a result. Industry's own research forecasts that the workforce must grow by 4,700 people a year over the next 6 years. Over the same period 3,900 people are expected to leave the sector, mostly due to retirement. This means that the sector must recruit 8,600 people every year. This is a sizeable challenge, but one which we must grasp. If we fail to do so, we will be doing the sector, and the UK as a whole, a disservice. A shortage of skilled workers will create competition for specialist skills, pushing up labour prices. This threatens to increase the cost of critical national projects and potentially raise the UK's reliance on foreign expertise for civil projects. It will raise particular challenges for defence, where security considerations require UK nationals. There is a strong case, therefore, for building a suitably qualified and experienced workforce within the sector. This will meet the future needs of the sector and create jobs for thousands of young people who might otherwise miss out on a rewarding career in the nuclear sector." Nuclear Skills Strategy Report

"Other than the design and manufacture of nuclear warheads, virtually all the nuclear skills needed to support the UK's Strategic Deterrent are also found in the civil nuclear sector in the UK." (HoC 2006 Manufacturing base, written evidence from Nexia Solutions, p.154)

"However, there is much common ground and this is sufficient for the UK nuclear industry, across both civil and defence sectors, to develop and apply strategies and processes for workforce assessment, planning, management and development. This will ensure that the UK nuclear industry not only meets the workforce challenge that it faces, but does so effectively and efficiently" (Cogent 2011 foreword)

"After more than 60 years of exploitation in both civil and defence sectors, nuclear energy production remains a critical technology; and the skills to support it a strategic resource." (Cogent 2011, p.4)

[21] It is worth noting that the MoD has been planning to source components from the US, but that this strategy comes with challenges. The NAO (2008) says: "The procurement challenges associated with this procurement route are entirely different. While the Department can in some cases gain considerable savings from being part of much larger United States orders, it may have less control over the specification of requirements and the delivery timetable." (NAO 2008)

[22] The full quote from the NAO (2008: 28) reads:

> *"The 2005 Defence Industrial Strategy established the principle that, for the foreseeable future, the United Kingdom would retain all of those capabilities unique to submarines and their nuclear reactors, to enable their design, development, build, support, operation and decommissioning. Suppliers of submarine, nuclear propulsion and other equipment constitute a highly specialised industrial sector whose sustainability requires careful management. The industry is made up of a number of monopoly suppliers, including BAE Systems and Rolls-Royce, the likely suppliers for the future submarine class and nuclear reactor respectively. This sector is dependent on a sufficient and continuous flow of Ministry of Defence business to maintain submarine-building capacity and preserve the relevant specialist skills. The effect of not managing this flow effectively is shown by the ongoing Astute submarine programme which suffered from a gap in production between the Vanguard and Astute classes This led to industrial decline and meant that the Astute programme bore the cost and timescale implications of restoring the skills base and infrastructure to build submarines. One assumption of the future deterrent programme is that the United Kingdom submarine industry will be sustainable and that the costs of supporting it will not fall directly on the future deterrent programme. The Department's submarine build programme is designed to ensure that there is no gap between Astute and the future deterrent. The Department intends to continue monitoring this risk to ensure that there is no recurrence of the damaging consequences of the significant gap in production that occurred between Vanguard and Astute. The Department will also use the opportunities presented by the Astute programme to save money and de-risk new technology for the future deterrent. In addition, as delivery of the Astute programme builds submarine manufacturing skills and capability, confidence should grow among government and industry partners that the future deterrent will be delivered on time and to budget. In addition to the challenges of procurement within the United Kingdom, the Department is planning to source a range of components from the United States and draw on American technical expertise and information. The procurement challenges associated with this procurement route are entirely different. While the Department can in some cases gain considerable savings from being part of much larger United States orders, it may have less control over the specification of requirements and the delivery timetable. The Department will have to factor this unpredictability into its planning."*

[23] The full quote from this interviewee (code 3, 2015) reads:

> *"Both [civilian and military] rely on a good drumbeat; both are stop-start industries; if the drumbeat slows, the supply chain drains away… Companies who supply components, nuclear tends to be just a small piece of their overall turnover. If they get excessive demands from the nuclear industry, for instance if they get too many requests to keep their equipment or supply chain on standby, or the business is not frequent enough, they will start to feel that the nuclear aspect of their business is too much like hard work, and will move away from supplying nuclear components to other less challenging parts of their business."*

[24] As stated in The Environmental Audit Committee's report, *Keeping the lights on:*

> *"The history of civil nuclear power in the UK over the last 50 years has been characterised by extensive government subsidies, time and cost overruns, and poor operational performance. While the first generation Magnox power stations built during the 1960s proved somewhat less problematic, the second generation Advanced Gas Cooled Reactors (AGRs) built from the 1960s to the 1980s were beset with difficulties. In the worst case, that of Dungeness B, it took 24 years from the start of construction to commercial operation, and the plant has only operated on average at 37% of its planned generating capacity since then. In operational terms, almost all UK nuclear reactors perform badly in international comparisons. This is reflected in an overall average load factor for all nuclear" plants of 71% in 2004."* (Environmental Audit Committee, 2006: 29).

[25] Lobbying practices are something that certainly require further extensive exploration, and concerns over the influence that informal networks within Whitehall play in the formation of public policy have been routinely raised (see Whyte 2015). In relation to lobbying and the nuclear sector the Public Administration Select Committee report evidence from

Greenpeace points towards politicians and civil servants including Geoffrey Norris, Jamie Reid, Jack Cunningham, Ian McCartney, Richard Caborn, Brian Wilson, Alan Donnelly and Jack Cunningham who have switched between politics and the nuclear industry. John Hutton has also switched between the Nuclear Industry Association (NIA) and government, and more recently Tom Greatex has moved from being in Government to chairing the Nuclear. In reference specifically to the remarkable 'about turn' in nuclear policy between 2003-2007 the Public Administration Committee report states the following:

> *"The nuclear industry certainly seems to have been banking on this in its choice of those advising it and lobbying on its behalf. It is also the case that the Government's policy on the future of nuclear power has undergone a remarkable about-face since 2003, when the Government announced that it was "not going to build a new generation of nuclear power stations now". In 2007, the Government said in contrast that it would be a "profound mistake" to rule out nuclear power and that a decision was needed by the end of the year.35 It may simply be that the policy environment changed, and with it the policy. However, some of the concerns that exist around improper influence are closely linked to the power of informal networks of friendships and relationships." (House of Commons Public Administration Select Committee, 2009: 13-14).*

[26] This reasoning points towards the increasing pressures that are being exerted on the French nuclear industry. The financial situation at EDF is not good, the company is heavily indebted and will soon there will be costs related to the decommissioning of France's huge fleet of nuclear reactors, when reactor life extensions become economically or politically unacceptable. The theory runs that through the extremely generous 'Strike Price' of £92.50/ MWh paid by British consumers, EDF (France) can partly fund the decommissioning efforts from profits made through owning the UK's new nuclear power fleet, as well as profits made through life extensions of existing plants, because the problems will arise when French nuclear reactors are switched off as these will transform from 'assets' to 'liabilities' as noted by Brown (2009).

Recent papers in the SPRU Working Paper Series:

April 2016

Funding Data from Publication Acknowledgements: Coverage, Uses and Limitations. Nicola Grassano, Daniele Rotolo, Joshua Hutton, Frédérique Lang, Michael Hopkins.

Reviewing the Evidence on the Innovation Impact of the EU Emission Trading System. Karoline Rogge.

June 2016

The Role of Community Leadership in the Development of Grassroots Innovations. Mari Martiskainen.

Fossil Energy in Economic Growth: A Study of the Energy Direction of Technical Change. Gregor Semieniuk.

Financing Renewable Energy: Who is Financing What and Why it Matters. Mariana Mazzucato, Gregor Semieniuk.

July 2016

User-made Immobilities: A Transitions Perspective. Laur Kanger, Johan Schot.

Precaution in the Governance of Technology. Andy Stirling.

September 2016

Johan Schot, Laur Kanger. Deep Transitions: Emergence, Acceleration, Stabilization and Directionality.

Suggested citation:
Emily Cox, Phil Johnstone, Andy Stirling (2015). Understanding the Intensity of UK Policy Commitments to Nuclear Power. SPRU Working Paper Series (SWPS), 2016-16: 1-93. ISSN 2057-6668. Available at www.sussex.ac.uk/spru/swps2016-16

SPRU – Science Policy Research Unit
University of Sussex
Falmer, Brighton, BN1 9SL,United Kingdom
SWPS Website: www.sussex.ac.uk/spru/research/swps
SPRU Website: www.sussex.ac.uk/spru
SPRU Twitter: @SPRU