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The impacts of non-energy policies on the energy system: a scoping paper

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Executive Summary

Energy systems are not only affected by energy policies, but by a wide range of other policies. Yet there has been little systematic analysis of this issue, and the knowledge that does exist is often not integrated across disciplines and sectors. The aims of this scoping paper are to i) produce a comprehensive review of existing research on the impact of non-energy policies on energy systems; and on the basis of this ii) propose a future research agenda. The review employed a literature search using a set of keywords (shown in Appendix A), together with a snowball approach (using article bibliographies) and review of selected journals. In total, 576 relevant documents were found.

Sectoral review: key findings

Part 1 of this report provides a sector-by-sector review of literature on the impact of non-energy policies on energy systems. It reviews work relating to thirteen non-energy sectors: Agriculture, marine and land-use policy; Communications and media policy; Culture and sport policy; Defence, military and foreign policy; Economic policy; Education policy; Health policy; Industrial, business and innovation policy; International development and overseas aid policy; International trade policy; Non-energy-related environmental policy (e.g. air pollution, water and forestry); Planning, building and construction policy; and Work, welfare, population and equality policy.

The papers are from diverse disciplines and do not form a coherent literature, with virtually no referencing across sectors, and a diverse range of methods used. Of the 576 documents found, only 49 conduct dedicated analysis of the impact of non-energy policies on energy systems, and only 25 of these focus specifically on the UK. Within the wider literature, 'economic policy' and 'defence policy' were the areas in which the review found the greatest number of dedicated analyses. By contrast, within the UK-focused literature, 'planning policy' and 'work policy' were the areas in which the review found the greatest number of dedicated analyses. The categories with the smallest number of dedicated analyses found were communications, culture and sport, education, health, industry, and international trade. Key findings from the sectoral review are shown in Table 1.

Cross-sectoral review: key findings

Part 2 of this report provides a review of literature on cross-sectoral themes. These are not specific policy sectors, but rather span many sectors, and also relate to processes of policy-making:

- **Liberalisation**: including many dimensions, such as marketisation, privatisation, deregulation, globalisation, the promotion of consumer choice, and various forms of diversification and outsourcing, all of which affect diverse policy areas.
- **Devolution, decentralisation and centralisation**: these cross-cutting policy agendas relate to the diverse scales at which social activity is governed and undertaken; they have wide-ranging implications for energy supply and demand.

- **Governance processes and structures:** literature draws links from governance issues (such as political processes, capacity and stability) to energy system impacts; for example, the impact of Local Authority capacity on low carbon heat networks.
- **Brexit:** Brexit will clearly affect energy systems in a number of ways, and concerns about the impact of Brexit on energy systems cut across multiple sectors. However, impacts are currently highly uncertain, and research in this area is inevitably preliminary.

See Table 1 for key findings on these cross-sectoral themes.

Conceptual and methodological reflections

Part 3 of this report highlights methodological and conceptual issues arising from the sectoral and cross-sectoral reviews, including:

Non-energy policy as largely invisible

It is rare for a paper to focus explicitly on a link between non-energy policy and energy systems and there is a neglect of non-energy policy in some apparently "holistic" papers about energy systems. Policy is often framed as "context" rather than a causal factor; this contributes to the presentation of changes such as urbanisation, liberalisation or economic growth as inevitable and non-negotiable. There is also a tendency to view energy and non-energy systems in separate silos.

Unintended consequences and integration

More papers look at negative interactions than positive ones: non-energy policies are normally seen as having undesired effects on energy systems. Key "win-wins" include positive links between air pollution and health policies and carbon emissions, and between social welfare policy and fuel poverty alleviation. However, policy integration does not receive much dedicated analysis in the literature reviewed.

Systems, scales and sites: narrowly-focused approaches

Most papers focus on a single element of the energy system, e.g. siting of nuclear power stations or innovation in solar technology. There seems to be a lack of holistic research that link elements together. The majority of papers also focus on a single geographic location or case study.

How to assess the causal effects of policies?

This is not an issue that receives much attention in the documents found. In cases where there is a dedicated analysis of the effects of specific policies, there are three main approaches:

1) a modelling approach in which the effects of policies are estimated or predicted
2) a qualitative approach in which stakeholders are asked to reflect on policies' impacts

3) an interpretive approach based on logic and chronology

How to assess the tractability of policy areas?

Tractability refers to the likelihood of changes in policy, and is complex and shifting. Very few papers explicitly discuss tractability, or explore what is currently seen as (non)negotiable within political discourse, with what implications for energy systems.

Recommendations for future research

In highlighting future research needs, this section considers two factors: gaps in knowledge and potential energy impact. Table 1 shows where gaps lie for each policy sector and cross-sectoral theme; these could be topics for future research. The huge number of papers that mention non-energy policy's links with energy systems show how important this topic is. However, few papers set out to address this topic in an explicit way: i.e. making the link from non-energy *policies* through to energy impacts. This makes the energy effects of non-energy policies invisible, and hard to challenge. We therefore recommend work that spans both the relationship between non-energy policies and non-energy phenomena, *and* the relationship between non-energy phenomena and energy impacts. Specifically, we recommend research that is:

- **Comparative:** to draw lessons from the similarities and differences experienced across sectors, sites, technologies and policies; to identify and disseminate good practice; and to help evaluate the causal effects of policies.
- **System-based:** to explore interactions and feedbacks between sectors, and between supply and demand impacts; to examine unintended consequences and tensions; and to assess how energy is integrated into non-energy policy structures and processes.
- **Multi-scalar:** exploring the interactions of non-energy policies with energy systems at different spatial and temporal scales; and the relationships between these scales.

Table 1: Summary of key gaps in knowledge, and significance of the sector/issue in shaping energy systems

Policy sector	Key gaps in knowledge	Energy impact
Agriculture, marine and land-use	- 32 relevant articles included in the review, but just 6 dedicated analyses of the impact of non-energy policy on energy systems - Several analyses of the impact of food policies on energy and transport demand; less research on the impact of food policies on energy supply - Little literature on the impacts of marine policy on oil or gas supply, and no literature on the impact of marine policy on energy demand. - Lack of dedicated analysis of the impacts of non-energy agricultural policies on biomass	- Food, farming and land-use make major contributions to energy and transport demand, especially when seen in global perspective - The agricultural sector accounted for 5.7% per cent of UK services energy consumption in 2015 (Department for Business, Energy and Industrial Strategy [BEIS], 2016a) - Marine environments could be increasingly important for offshore energy supply and for transport demand
Communications & media	- 38 relevant articles included in the review, but just one dedicated analysis - Much literature focuses on the use of ICT to support or change transport or energy policy - Literature tends to view the internet as a technology rather than a policy - There is a lot of literature on media coverage of energy issues, but it focuses on media trends, not policy	- ICT devices/infrastructures are estimated to consume 5% of global electricity production (and this is growing) (Hazas and Morley, 2016) - The ICT sector extends into many other policy areas - Media impacts on energy are likely to be indirect, and therefore hard to quantify
Culture and sport	- 17 relevant articles included in the review, but no dedicated analysis - Most articles relate to general processes rather than policies	- Energy consumption of this sector is likely to be much lower than that of some other sectors reviewed here.
Defence, military & foreign policy	- 39 relevant articles included in the review, including 9 dedicated analyses. - Several papers discuss the energy consumption of the military but only one analyses the impact of defence policies on military energy demand	- Impact is likely to be high because the latest available data shows the military uses around 2 billion kWh per year of electricity and gas, plus around 0.8 billion litres of fuel (Ministry of Defence, 2016) - This was one of the most challenging sectors within which to search for literature, so further work may be needed to assess gaps and

	- There is research on defence policy and energy security, but the link is often merely mentioned in passing - Review only found one dedicated analysis of the potential impact of defence policy on nuclear power	impacts
Economic	- 36 relevant articles included in the review, including 12 dedicated analyses - Few papers on how financial or taxation policies affect expenditures on energy - Little research on impacts of non-energy tax policies on energy/transport - Papers often consider economic trends rather than policy	- Given the central role of economic policies within national and international governance, and the ramifications for all other sectors, energy impacts are potentially large (though hard to quantify)
Education	- 19 relevant articles included in the review, but just one dedicated analysis - No peer-reviewed or dedicated analyses of the impact of education policy on energy supply	- Education is the second largest consumer of energy in the UK service sector (Royston, 2016)
Health	- 15 relevant articles included in the review, but just one dedicated analysis - Few papers focus on the link between health policy and transport demand - There is research on the energy consumption of health sector institutions but little dedicated analysis on the impact of policies - There is little research on the impacts of health policies on supply, for both energy and transport	- The health sector is responsible for 7% of energy use in the UK service sector (BEIS, 2016a) - Multiple win-wins or co-benefits could be achieved in this area, including between energy, carbon, pollution, health, safety and equity.
Industrial, business and innovation	- 12 relevant articles included in the review, but just one dedicated analysis - Analysis is largely limited to energy policies that form part of industrial policy, or firms' responses to sustainability policies - Research on innovation policy tends to examine energy and non-energy policies separately - Much work focuses on industrial patterns or trends, rather than	- In 2015 the industrial sector accounted for 16% of the UK's final energy consumption (BEIS, 2016b) - Industry also contributes to the production of energy supply infrastructure

	policies	
Int. development & overseas aid	- 14 relevant articles included in the review, but just 2 dedicated analyses - The majority of papers on international aid and development focus on energy-specific aid programmes - This review did not find any articles which address the impact of aid or development policy on the energy systems of the aid-giving country	- Lack of research makes it hard to assess potential energy impacts - There are precedents for policies with sustainability and development goals, e.g. Clean Development Mechanisms in climate treaties
Int. trade	- 27 relevant articles included in the review, but no dedicated analyses - Large amount of work on international trade and energy consumption - Papers tend not to discuss trade policies, but rather a general policy approach of trade openness	- International trade has major energy impacts, including through freight transport demand - Trade policy affects where energy is used – important for how energy use and emissions are measured
Non-energy-related environmental policy	- 19 relevant articles included in the review, including 4 dedicated analyses - Little research on impacts of air pollution policies on extractive energy industries - Little analysis of the impacts of water policies on energy and transport - No research on impacts of UK forestry policies on energy or transport	- Environmental policies span many sectors (including industry) so their impact is potentially high, but hard to assess - Co-benefits are common; e.g. a policy may simultaneously address air pollution, energy demand and carbon reduction
Planning, building and construction	- 39 relevant articles included in the review, including 8 dedicated analyses - Large body of literature on the impacts of planning, building and construction policies on energy systems - Little academic literature on shale gas and non-energy planning policy	- Planning issues underlie many other policy sectors, so potential impact is high (though difficult to quantify)
Welfare, work,	- 49 relevant articles included in the review, including 7 dedicated analyses	- There is little available information on energy impacts, but existing literature suggests potential impacts; e.g. welfare policy may affect

population & equality	- Demand-side focus; little literature on impacts of welfare, work, families and equality policy on energy supply - Work on welfare policy's impacts on fuel poverty is mainly grey literature - Lack of academic literature on the impact of immigration policy on energy or transport - No explicit link drawn between labour market policy and energy consumption	transport demand; migration impacts on population may affect energy and transport demand; labour market policy could affect wages or employment which could affect energy consumption
Cross-sectoral themes	**Key gaps in knowledge**	**Policy links and energy impacts**
Liberal-isation	- Many empirical articles explore the links between energy consumption and international trade, but tend to refer to a general policy approach of trade openness (associated with liberalisation) rather than specific policies - Literature tends to be very specific to particular sectors, despite the cross-cutting nature of liberalisation agendas. For example, no papers examine impacts of liberalisation on both health and education, and the similarities, differences and interconnections	This broad agenda is linked with several areas of policy: - In relation to trade and industry, key dimensions are deregulation and removal of barriers, which can be linked with changes in energy markets and "off-shoring" of manufacturing energy use. - Other policy areas include education (where a choice agenda may increase transport and energy demand), health and land-use policy. - Impacts of liberalisation on energy are likely to be long-term, wide-scale and diffuse
Devolution, decentral-isation and central-isation	- Many papers analyse the impact of Scottish devolution on various issues but only one conducts dedicated analysis of energy, and none are peer-reviewed (fewer look at Wales) - City/region devolution deals are fairly new; this review found no peer-reviewed literature and few reports on the potential impacts - Only two papers conduct analysis of the impact of the Localism agenda, and in both cases energy impacts are analysed among other issues. Dedicated analysis of the energy impacts of the Localism agenda is lacking	- Any policy area that is subject to devolution, decentralisation or centralisation could be affected by this issue - Key policy sectors where devolution/decentralisation have energy effects are land-use, planning, environmental, taxation and investment policy. - Contradictions between UK and devolved policies can affect the efficiency and outcomes of energy policy-making - UK Localism Act has had both positive and negative effects on renewable and community-based energy supply projects - Centralisation in the siting of services such as schools, and of

		production, can have major impacts on transport demand - Impacts are likely to be as long-term and wide-ranging as decentralisation itself
Governance processes and structures	- While there is extensive research on this topic, the majority relates to non-UK contexts - In particular, the review found little research into the impact of governance processes and capabilities on transport in the UK/EU context - The review found two articles with a global focus; one highlights the lack of inclusion of energy issues in Global Political Economy research	- This is a very broad theme affecting every policy sector because it addresses how policies are made and implemented; its effects are ongoing and multi-scalar - Political and institutional effectiveness can affect energy supply and, to a lesser extent demand (e.g. links between political stability and energy security) - The capacity of governance actors (e.g. Local Authorities) affects their role in energy supply projects - Political structures and processes (e.g. federalism) affect energy-related decision-making (e.g. support for renewable/nuclear supply projects)
Exit from the EU	- This review found no peer-reviewed literature (as of yet); reports tend not to provide detailed analysis	- Brexit may (depending on how it is implemented) give the UK increased freedom e.g. from EU renewables targets; competition law - Brexit has caused uncertainty in markets, potentially affecting investments in energy infrastructure - Interconnection with Europe could be affected, affecting the UK's energy security - Ireland's energy systems may be affected (e.g. by market distortions; conflicting sets of energy regulation) - Migration barriers may affect energy industries - Loss of UK influence on EU energy policies (e.g. carbon reduction commitments; energy market integration) could undermine these

Contents

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Introduction

Aims, scope and definitions

It is almost a statement of the obvious that energy systems are not only affected by energy policies, but by a wide range of other policies. Yet there has been little systematic analysis of this issue. The knowledge on it that does exist is often confined to academic or policy niches focused on specific issues, rather than being integrated across disciplines and sectors. The aims of this scoping paper are to i) produce a comprehensive review of existing research on the impact of non-energy policies on energy systems; and on the basis of this, ii) propose a future research agenda on this issue. In doing this, we build upon, and broaden out from, ongoing research within the research centre on "Dynamics of Energy, Mobility and Demand" (DEMAND).1

For the purposes of this report, our understanding of 'energy systems' is broad, and includes diverse social, technical and economic elements and their interactions. Our definition includes the whole energy lifecycle, from resource production to transportation and distribution to end-use. It includes all fuel types, and all energy services. It also includes many different kinds of effects on energy systems, including (most obviously) quantities of energy, but also timings, prices, perceptions, locations and so on. Specifically, the following elements are considered:

- generation of electricity and heat using renewables and biofuels, nuclear power, and fossil fuels of all kinds
- distribution networks, storage and supply infrastructures
- innovation and technology
- prices, taxation, markets and investment
- regulation and compliance
- demand, behaviour and consumption practices
- fuel poverty
- energy policies, programmes and initiatives
- energy security
- electricity theft
- transport modes, fuels and distances
- public and media perceptions of energy-related issues

It is important to note that our definition of 'energy systems' includes transport systems. The relationships between energy, transport and other policy areas are extremely complex, and this review does not have scope to explore them. Therefore, it was decided to include

[1] 'DEMAND' is a 5-year EPSRC-funded centre led from Lancaster University. Its research aims to take a distinctive approach to end use energy demand, recognising that energy is not used for its own sake but as part of accomplishing social practices at home, at work and in moving around. See www.demand.ac.uk

all aspects of transport (walking and cycling as well as fuel-driven modes) within the "energy" category. In other words, transport is positioned as a dependent variable, rather than an explanatory variable. This enables us to explore the impacts of non-transport policy on transport systems - an extremely important issue. The consequence of this is that we cannot explore the impacts of transport policy on energy systems; however, this has been extensively covered elsewhere. Papers that look at the impact of non-energy policies on greenhouse gas emissions are also included in our review, but are not the main focus (we did not specifically seek out papers looking at impacts on emissions).

The term 'non-energy policies' refers to policies relating to all other sectors. These may have an effect on energy systems, but they are not explicitly designed to do so. Therefore, any policies that are explicitly about energy, transport or carbon are *not* within the scope of this review (for example, Zero Carbon Homes, free bus passes, or taxes on energy). There are inevitably many grey areas here, so we have used case-by-case judgement to label policies as "energy policies" (excluded from the review) or "non-energy policies" (included).

Policy is commonly understood as both an outcome and a process, and we follow this approach. 'Policy' here refers both to the outcomes of things that government bodies do (executive decision-making, legislation, regulation, standard-setting, etc.), and the governance processes and structures through which these are done. This covers all scales from local government to transnational governmental institutions, and includes some quasi-governmental or hybrid bodies where relevant. We do not consider policies of NGOs or corporations. However, it should be emphasised that the lines between policy and non-policy are very blurred. As well as specific policy instruments, processes and structures, we have included some longer-term governmental agendas or projects (such as liberalisation). However, a political ideology would not be included within our scope (as this is another step removed from policy outcomes). Drawing these distinctions is obviously a matter of interpretation and judgement.

There are also many social trends or phenomena (such as digitalisation and the growth of the internet) within which government policies play a role, but where the impact of this role is extremely hard to disentangle from non-policy drivers. This is reflected in our discussion of the evidence. It is also worth noting that an absence of policy can itself be a policy (for example, lack of regulation of a market is a "policy" of promoting an unregulated market). These cases are included in the review where they were identified; however, the nature of absence means a) there may be fewer papers on this and b) they may not be accessed through our method.

Methods

The method used is a literature review. It should be noted that this is a small scoping review, rather than a systematic review, and as such, provides an indicative overview of key issues, rather than a fully comprehensive assessment of literature.

The review used a set of keywords (shown in Appendix A). To select keywords, we first identified the policy sectors that we would consider (drawing largely on the UK government departmental remits). We identified thirteen policy sectors. We then identified 2-6 keywords for each sector. These were selected to cover the main dimensions of the policy sector, and were necessarily high-level rather than detailed or specific. For example, one policy sector was Agriculture, Marine and Land-use. Within this, we identified the keywords: agriculture; agricultural; food; land use and marine; but did not, for example, include the words 'cattle' or 'fish'. Meanwhile, within the policy sector Planning, Building and Construction, we identified the keywords: building; construction; planning; and housing; but we did not include the keywords 'city', 'town', 'countryside' or 'green belt'.

This approach was chosen in order to provide a systematic and broad-ranging review, within a limited time. Carbon was not included as a keyword, because it is not the main focus; however, this keyword could reveal extensive additional literature in a future study. Further research using a more detailed set of keywords would be valuable.

An initial search was carried out using Web of Science, the University of Sussex library, Google Scholar, and Google (for the Google searches, the suffix 'pdf' was used to separate documentation from websites and blogs). The bibliographies of relevant articles were also searched (a snowball method). The focus of the review is on academic literature such as journal articles, books and working papers, although policy documents and grey literature articles such as reports from consultancies, law firms and policy bodies have also been included. In addition, we reviewed every issue of the journal *Energy Policy* published in the last three years and every published issue of *Energy Research and Social Science* (from March 2014). These were identified as the most relevant journals to the subject. A review of their contents was useful as it provided additional breadth to the method (compared to a solely search-engine based method) and ensured we did not miss important literature through using a limited set of keywords based on *a priori* knowledge. Clearly, the literature presented in this report is somewhat dependent on the search terms used and the sources searched; although an extensive list of keywords was used, the literature found will not be exhaustive. In particular, our keyword-based method may not fully reflect the rich literature on transport - a more extensive list of transport-related keywords would be desirable in a future study.

Papers were included in the review if they met the criteria defined by our scope, namely they must:

- mention at least one non-energy policy; and
- mention at least one effect of this policy on energy systems

In practice, many papers fell into a grey area, almost meeting these criteria, or meeting them in a rather tenuous or implicit way. We therefore used judgement in determining which to include (within the limits of a short review) and have, in some cases, provided a brief commentary on work that did not quite qualify for inclusion. Throughout this report,

the words used to describe each paper have been chosen to reflect the extent to which each paper meets our exact remit (i.e. analysing the impact of non-energy policies on energy systems). There are four categories:

a) 'provides dedicated analysis' (i.e. completely meets our remit)
b) 'analyses amongst other issues' (i.e. part of the work meets our remit but is not the main focus of the article)
c) 'suggests / argues' (i.e. addresses the issue but without using actual research or analysis)
d) 'states in passing' (i.e. not the main focus, and doesn't use research or analysis)

Because of the challenges of presenting such a large body of literature in a limited space, the main focus of this review is on the UK context. However, we have some included EU and international-focused papers if their findings are particularly relevant to the issue of non-energy policy impacts on energy systems. The main purpose of this review was to identify gaps in the literature to inform a research agenda. Therefore in some cases, for instance where we have identified a very large literature on a subject, we cite just a selection of relevant publications out of the wider body of literature. In all these cases, the citations are prefixed by 'e.g.'. Because of this, the number of articles cited should be treated with some caution, as they do not always reflect the full number of articles in areas in which there is a large body of literature. It should also be noted that several topics exist at the interface of multiple categories; particularly prone to this are the 'agriculture', 'environment' and 'planning' categories.

We did not set any chronological boundaries to our review - we included papers from any year, about phenomena or trends from any period. However, the methodology involved only online literature searches, and therefore is likely to exclude pre-digital work. In addition, recent decades have seen more research published than previously, and most of this work is focused on the present and recent past, not historical analysis. There is therefore a bias towards recent phenomena and trends. It is also notable that very few papers involve in-depth reflection on the historical context of their subject matter.

Overview of results

The results of the literature review are presented in Parts 1 and 2. Each section of Part 1 represents a policy sector, and begins with a summary paragraph for that sector. This provides an overview of the type, quantity and character of work within that sector, the aspects of energy systems that are covered and the degree of consensus (where relevant). A similar approach is used in Part 2, where literature on four cross-sectoral issues is reviewed. Two of these issues (Brexit and devolution) were identified *a priori* because of their current significance to UK political debate; these were the subject of dedicated keyword searches. The other two themes (governance and liberalisation) emerged through an inductive analysis process, after the collection of literature.

In total, 576 documents were found which were in some way relevant to our enquiry. However, only 49 documents conduct dedicated analysis of the impact of non-energy

policies on energy systems, and only 25 of these focus specifically on the UK. Within the wider literature, 'economic policy' and 'defence policy' were the areas in which the review found the greatest number of dedicated analyses (mostly relating to the impact of economic policies on commodity prices, and the impact of foreign policy on energy trade respectively). Within the UK-focused literature, 'planning policy' and 'welfare/work policy' were the areas with the greatest number of dedicated analyses. The areas with the least number of dedicated analyses are: culture and sport (0), international trade (0), health (1), education (1), communications (1) and industry (1).

The papers identified are from diverse disciplines, including economics; policy studies and politics; geography; and the specific literatures on each policy sector (e.g. industrial policy; planning policy; foreign policy). Many papers also come from energy studies and transport studies. The papers overall do not form a united or coherent literature, with virtually no referencing across the sectors. Even within each sector, there does not tend to be an "energy" literature, but rather small pockets of related work on a specific issue, such as the effects of school choice policy on transport. The methods used are also diverse, including: modelling and use of large datasets; scenario analysis; qualitative methods; and documentary and historical research. Because most papers do not provide dedicated analysis of how non-energy policies affect energy systems, the way they conceptualise policy and its impacts is often not entirely clear. Some papers mention specific policies, while others mention more generalised policy approaches or agendas; this is reflected in our discussion of the literature. Very few papers explicitly reflect on issues of complexity and uncertainty in causal relationships. Some issues around causation are discussed further in Part 3.

Structure of the report

Part 1 of this report provides a sector-by-sector review of literature on the impact of non-energy policies on energy systems. It reviews work relating to thirteen non-energy sectors. Part 2 provides a review of literature on cross-sectoral themes, namely: liberalisation; centralisation, decentralisation and devolution; governance processes and structures; and the UK's decision to leave the European Union ("Brexit"). These are not specific policy sectors, but rather span many sectors, and also relate to *how* policy is made. It is important to consider the impacts of these agendas on energy systems, because their impacts are likely to cover large spatial and temporal scopes, but also to be diffuse and challenging to analyse (often mediated through specific policies). Because of their different scale and effects, they are discussed separately from the policy sectors.

Part 3 highlights methodological and conceptual issues arising from the sectoral and cross-sectoral reviews, including: non-energy policy as largely invisible; unintended consequences and integration; systems, scales and sites; assessing the causal effects of policies; and assessing the tractability of policy areas. Finally, Part 4 provides a framework for a future research agenda. It first explains our approach to developing this research agenda, which is based on an assessment of knowledge gaps and consideration of energy system impacts. Its structure then mirrors the preceding three Parts, providing reflections regarding: 1) sector-

based research; 2) cross-sectoral research and 3) methodological and conceptual approaches.

Part 1: Sectoral review

1.1 Agriculture, marine and land-use policy

In this category, we found a total of 32 relevant articles; of these, 6 conduct dedicated analysis of the impact of non-energy policies on energy systems. This sector is connected with the construction sector discussed in section 1.12: for instance, there is a large body of literature on the connected impacts of land use and planning policies on various aspects of the energy system, such as transport (e.g. Croucher et al., 2012; European Commission, 2006; Litman, 2007; Newman and Kenworthy, 1996; Santos et al., 2010) and nuclear power (e.g. HSE, n.d.). This review found several analyses of the impact of various food policies on energy and transport demand (including food miles), with a particular focus on energy demand in the agricultural sector. There is rather less research on the impact of food policies on energy supply: the issue of competition between the food and energy sectors for resources is often mentioned, but the impacts of food policies are not analysed in detail. This review found literature on the energy consumption of food such as livestock, and the energy consumption of food transportation; however, these papers tend not to conduct dedicated analysis of the impacts of food policies, but rather to analyse the impacts of food *trends* and to provide recommendations for policy based on the results. Finally, this review found literature on the impacts of marine policy and recent marine governance changes on offshore energy developments, with a particular focus on renewable energies; the review found much less literature on the impacts of marine policy on oil, gas or transport supply, and no literature on the impact of marine policy on energy demand.

Predictably, there is a significant body of literature on biomass; however, many of the agricultural policies which govern biomass are specific to energy crops (see for example Alexander et al 2014). The Environmental Audit Committee (2007) published a report on biomass which noted that the Single Farm Payment is a non-energy policy which affects biomass in the UK (although the report does not conduct any analysis of its impacts). The Single Farm Payment (also known as the Single Payment Scheme) requires farmers to leave some land fallow, but allows them to grow non-food energy crops such as miscanthus on this land, thus providing a potential incentive for energy crops. This is mentioned in passing in several documents (Augustenborg et al., 2012; Bartolini et al., 2015; Environment Agency, 2009; Manning et al., 2015; Sherrington et al., 2008), but this review did not find any dedicated analysis on the impact of this policy on energy crops.

There are several papers which discuss the impact of land use and agricultural policy on energy in a general sense. For instance, Garnett (2008) analyses (amongst other issues) the potential energy impacts of a variety of food policies, such as: Common Agricultural Policy (CAP) payments are shifting to 'area payments', which are conditional on compliance with environmental standards; the integrated pollution prevention and control directive (IPPC) has regulations which affect energy use of farms; the Food Industry Sustainability Strategy aims to improve the environmental performance of the food industry; and DFID's 'export

horticulture' policies have sparked debate over the merits of supporting farmers in developing countries over reducing food transport emissions.[2] A policy brief by POST (2011) provides an overview of the impact of land use policy on multiple sectors including energy and transport, suggesting that there could be competition between sectors for land, and recommends the Scottish Land Use Strategy as an example of an "innovative, integrated" policy approach (p.4). A peer-reviewed article by Sutherland et al. (2015) assesses interactions of agriculture and electricity 'regimes', and argues that both sectors are characterised by policy intervention (for 'food security' and 'energy security' respectively), and that the two sectors may come into conflict with each other for resources. Smith et al. (2010) model competition for land between food and bioenergy (as well as forestry and conservation), and argue that liberalised land-use policy is likely to increase competition for land uses; however, they also suggest that a common theme in agricultural policies is the protection of farmers' incomes, which tends to lead to maintenance of status quo farm practices and may limit competition.

Clearly, the food and agriculture sector is a major source of energy consumption and carbon emissions, and therefore there is plenty of research which examines the impact of various food and farming policies on energy and emissions. For instance, Rounsevell and Reay (2009) analyse amongst other issues the impact of land-use policies, finding that intensification of land management has increased agricultural energy use and the use of energy-intensive fertilisers. White (2007) focuses mainly on the impact of climate policies on food, but includes a section which argues that direct payments under the CAP led to agricultural intensification and overproduction, which in turn increased energy demands from the sector. Meanwhile Bailey et al. (2014), Gill et al. (2010) and Strapasson et al. (2016) all discuss means of reducing greenhouse gas emissions from livestock, for instance by increasing efficiency of livestock or by reducing meat consumption; however, these papers tend to focus on proposing policy recommendations, rather than conducting research specifically to analyse a policy's energy effects.

On a similar note, there is research which analyses energy consumption related to transporting food. Concerns about sustainability have led to calls to reduce 'food miles', but some of the literature suggests that this may be an overly simplistic way of accounting for emissions. Edwards-Jones (2010), Foster et al. (2006) and Saunders and Barber (2008) all caution against policies to reduce food miles, because local food is not always more environmentally friendly. Yet it may depend on the product (Dalin and Rodríguez-Iturbe, 2016; Sim et al., 2007); for example, Jones (2002) finds that local dessert apples are far less energy intensive, because much of their embodied energy comes from transport. Once again, the aim of these papers is not to conduct dedicated analysis of the impacts of food policies, but rather to analyse the impacts of food trends and to provide recommendations for policy based on the results. Food miles are also likely to be linked to trade and economic policy, rather than just agricultural policy.

[2] See Table 12 in Garnett (2008: 142-46) for an overview of all relevant policies

On the subject of marine policy, this review found a number of articles relating to the impact of marine policies on offshore energy developments, with a particular focus on renewables such as offshore wind and wave energy. Todd (2012) conducts dedicated analysis of the impact of marine navigation and fishing legislation on the implementation of the Energy Act 2004, especially on achieving the renewable energy ambitions in the Act. Several other articles analyse amongst other issues the impact of changes in UK marine governance on renewable energy development, with a particular focus on recent changes to marine governance policies (including the Marine and Coastal Access Act 2009) and potential conflicts with offshore renewable energy development (Abad Castelos, 2014; Scarff et al., 2015; Wright, 2015, 2014). The review also found a couple of articles which conducted dedicated analysis of potential conflicts between the international Law of the Sea Treaty and marine energy developments (Abad Castelos, 2014; Kerr et al., 2015).

The review found much less literature on marine policy and non-renewable energy: Milligan (2014) conducts dedicated analysis of the UK's marine planning and consenting laws on CO_2 injection into deep sea-bed geological formations, and an Australian article by Techera and Chandler (2015) includes a section analysing the impact of marine policy on oil and gas decommissioning in UK waters. Finally, a much older article by Brown (1978) conducts dedicated analysis of ownership rights and policies in the North Sea, and the possible implications for Scotland's oil ownership in the event of Scottish independence. In general, many of the articles on the interactions between marine policy and energy developments focus on the impacts of energy on marine activities (such as fishing), rather than vice versa, for example Fletcher et al. (2014) and Rodwell et al. (2014), although both of these articles do make passing reference to the impact of the Marine and Coastal Access Act 2009 on renewable site selection.

This review also found some articles relating to this topic outside of the UK context: Lin and Lei (2015) (emissions from the Chinese food industry); Dogan et al. (2016) (agricultural emissions in Turkey); and (Nilsen, 2016) (the impact of fishing policies on offshore oil in Norway).

1.2 Communications and media policy

In this category, we found a total of 38 relevant articles, but only one which conducts dedicated analysis of the impact of non-energy policies on energy systems. There is therefore very little dedicated analysis on this topic, compared to some other categories. Much of the literature in this category focuses on the use of ICT to support or change *transport* or *energy* policy (i.e. not 'non-energy' policy). Of the literature we did find, articles mainly relate to two major themes. Firstly, there are analyses of media coverage of energy and climate change, although these generally focus on media *trends* rather than media policy. Secondly, there is much literature on various impacts of the internet and digitisation; for example, this review found literature examining the impact of the internet on energy and transport demand; 'smart' systems and the 'internet of things'; and cyber security. However, for all these topics, the literature tends to view the internet as a *technology* rather than a policy: the internet is seen as the result of broader technological and societal trends, but is

not explicitly linked to any policies. While this focus may be justifiable to an extent, it means that there is a lack of dedicated analysis of the impact of communications policy on energy and transport.

There is some existing research which analyses media coverage of energy issues, especially regarding climate change and also particular technologies such as nuclear and carbon capture and storage, including the impact that media coverage may have on aspects such as public opinion (e.g. Anderson, 2009; Friedman et al., 1999; Smith, 2005). However, these articles generally don't view media trends as the result of policy; rather, they are seen as the result of a convergence of broader societal factors such as globalisation, concentration of ownership, and the decline of print media and media profits.

There is a considerable body of literature which discusses the impact of the internet on energy demand. For instance, Andreopoulou (2012); Mansell and Raboy (2011); Moreno and Xu (2011); Morley and Lord (2016); Murugesan (2008); Ozturk et al. (2011); and Riaz et al. (2009) all analyse the electricity demands of ICT, which is creating a strain on electricity networks in some areas due to the electricity requirements of computers and servers. A similar body of literature analyses the energy implications of increasing digitisation, which may increase overall energy demand (Bento, 2016; Hazas and Morley, 2016), although policies are generally only mentioned in passing. All this research focuses mainly on making policy recommendations to mitigate the environmental impacts of ICT and digitisation, rather than conducting research to analyse a policy's energy effects. However, a few articles do focus on the UK's national roll-out of high-speed broadband, which is directly connected to policy. For instance, an LSE Enterprise report for Convergys (Dini et al., 2012) carries out dedicated analysis of the energy impacts of a high-speed roll-out, including a large section directly analysing broadband policy. A consultancy report commissioned by the Department for Culture, Media and Sport (SQW, 2013) carries out dedicated analysis of a variety of impacts of the broadband roll-out policy, including a section on environmental impacts. Finally, a peer-reviewed article by Røpke (2012) researches the energy impacts of the broadband 'transition', although broadband policy is only mentioned in passing.

Similarly, there are many articles which research the impact of the internet on travel and transport, with a focus on various topics including personal leisure and activity patterns (Ren and Kwan, 2009), social and sectoral equality and exclusion (Anable et al., 2016; Kenyon et al., 2002), teleshopping and teleworking (Lyons, 2002; Select Committee on Communications, 2013; Travesset-Baro et al., 2016) and international trade and exports (Bojnec and Fertö, 2009; Freund and Weinhold, 2004; Primrose and Fawcett, 2007). However, as noted above, these generally view the internet as a *technology* rather than a policy, and analysis of the impact of communications policy on transport is lacking. It is also interesting to note that the articles cited here include two major public-sector evaluations of the impacts of the broadband roll-out policy (Primrose and Fawcett, 2007; Select Committee on Communications, 2013), yet neither include analysis of the energy impacts of this policy.

A further body of literature concerns the 'internet of things' (i.e. the idea that everyday objects and appliances could have network connectivity, allowing them to exchange data). In

theory, this could reduce energy demand by allowing appliances to operate on a 'smart' basis, using energy when required and potentially reducing electricity system peak load (Gubbi et al., 2013; Iera et al., 2010; Mattern and Floerkemeier, 2010; Miorandi et al., 2012; Vermesan and Friess, 2013). However, such a high-tech integrated system may also have high energy requirements (Atzori et al., 2010; Mattern and Floerkemeier, 2010; Miorandi et al., 2012). Again, this is a somewhat grey area between active policy and technology development. There is one report by the Government Office for Science (Walport, 2014) which does look into UK policy and regulation on this matter; however, the main focus is on recommending policies and regulations for operationalising or managing the 'internet of things', rather than analysis of existing policy, and the section on 'energy' does not mention non-energy policies.

Finally, and tightly connected to the 'internet of things', there is a considerable body of literature on cyber security. Much of this literature is connected to energy security, with a particular emphasis on smart grids; in this way, ICT policy could clearly impact energy systems by influencing the resilience of energy networks (Månsson, 2015; Sagiroglu et al., 2012; Science and Technology Select Committee, 2015; Umberger and Gheorghe, 2008; Wang and Lu, 2013; Yan et al., 2012). In the UK, concerns have been growing about cyber security and electricity system resilience due to the increasing penetration of sophisticated information technology in the electricity system (Cabinet Office, 2011; Science and Technology Select Committee, 2015). However, in common with the rest of the literature in this section, dedicated analysis of the impact of communications policy on energy is lacking.

This review also found some articles relating to this topic outside of the UK context: Lewandowsky (2011); McChesney (2008); and Rotherham and Mullally (2008) (media communication of climate change in Australia, US and Europe respectively); and Yardley et al. (2012) (energy impacts of carrier integration in Finland).

1.3 Culture and sport policy

In this category, we found a total of 17 relevant articles, but none which conducts dedicated analysis of the impact of non-energy policies on energy systems. There is therefore very little dedicated analysis on this topic, compared to some other categories. Within this category, this review found a small number of relevant articles, most of which relate to general processes rather than policies *per se*. The main theme relates to the energy demands of sporting and music events and facilities. Most of the articles in this category mention policy only in passing, and where policy is mentioned, the focus tends to be on recommendations rather than analysis of the impacts of existing policies.

On the subject of sport, this review found a few articles discussing the energy demand implications of large sporting events such as the Olympics and the football World Cup (Bob and Swart, n.d.; Gratton et al., 2006; Mallen et al., 2010). There are also a few articles addressing the energy consumption of sports centres, which tend to be highly energy intensive (Boussabaine, 2001; Boussabaine et al., 1999), but which could equally be the focus of efforts to reduce energy, either within the sports centre itself (Boussabaine, 2001;

Boussabaine et al., 1999) or through policies to provide local sports centres which could reduce transport requirements (Mattioli and Anable, n.d.). In all these articles, where policy is mentioned, the focus tends to be on recommending policies to mitigate or regulate the environmental impacts of sporting events or facilities, rather than analysing the energy impacts of sports policies.

The review found several articles regarding the energy demands of music, arts and museums (Bottrill et al., 2010; Camuffo et al., 2001; Crosbie, 2008; Fleming et al., 2014; Malmodin et al., 2010; Weber et al., 2010). However, within all these articles, the link to explicit policies is somewhat tenuous; for instance, the digitisation of music is seen as the result of overriding processes rather than specific policies.

1.4 Defence, military and foreign policy

In this category, we found a total of 39 relevant articles, including 9 dedicated analyses of the impact of non-energy policies on energy systems. This is the second largest amount of literature in any category; however, most of the relevant documents are global in focus, with only 3 of the dedicated analyses based specifically in the UK context. This was actually one of the most challenging sectors within which to search for literature. On one hand, transparency regarding the defence sector tends to be low (Cox et al., 2016). On the other hand, for the 'foreign policy' part of the category, the potential search terms and literature are huge, because foreign policies may be listed according to the country or region in question; therefore for practical reasons, the search on this specific issue has only been carried out using the search terms "foreign policy".

This review found several papers discussing the energy consumption of the military, although only one of these actually analyses the impact of defence policies on military energy demand. There is also research on defence policy and energy security, although the link is often merely mentioned in passing and the two bodies of literature tend not to be intermeshed, especially in Europe and the UK. There is a considerable body of research on the impact of foreign and defence policy on energy supplies from major export regions such as the Middle East and Russia (although much of this research analyses this issue alongside various other impacts of foreign policy and geopolitics). The review also found several papers analysing the impacts of military R&D spending on the development of a number of important energy technologies, although again, energy tends to be discussed alongside multiple other technologies, although one paper conducts dedicated analysis of the impact of military nuclear capabilities on civilian nuclear development.

One of the most obvious linkages between defence and energy demand is in the energy consumption of the military, which is highly dependent on oil, and increasingly dependent on electrical devices used in the field (Breede, 2015; Closson, 2013; Young et al., 2001). This tends to leave the military vulnerable to fossil fuel price volatility and budgetary constraints (Closson, 2013; Murgatroyd, 2012; Strakos et al., 2016). Of these, only the Murgatroyd paper actually conducts specific research into the impact of military policy on energy demand, with an analysis (amongst other issues) of the impact of defence budget

cuts on energy demand and oil dependency. The other papers mainly focus on recommending policy interventions for the future, rather than conducting research to analyse a policy's energy effects.

This review found numerous passing references to defence policy and energy security or energy resilience. In some cases, these focus on potential military responses to energy security issues (Chaudry et al., 2011; Foreign & Commonwealth Office, 2003; Shaffer, 2013; Taylor et al., 2011; The Quaker Council for European Affairs, 2010). A working paper by Youngs (2007) conducted dedicated analysis of EU defence policy and energy policy, and found that, at that time, energy policy and defence policy tended not to be intermeshed, especially in Europe and the UK. Similarly, the risk to energy infrastructures from terrorism is frequently discussed, and the impact of foreign policy on terrorism is also discussed, but in separate literatures with little evidence of a direct linkage being drawn between the two. Finally, it is possible that defence policy could impact energy consumption by creating flows of migrants or refugees, but this review did not find any reference to this in the UK context.

Predictably, there is considerable literature on oil and the Middle East. In this respect, Western foreign policy has clearly impacted energy around the world through changing relations in the Middle East and changing global oil and gas markets, including increases in the cost of oil and gas as a result of military intervention in the Middle East. Many articles conduct dedicated analysis of this issue (Gharehbaghian, 1987; Grossman, 2015; Shepherd, 2000; Stiglitz and Bilmes, 2010; Stokes and Newton, 2014; Strakos et al., 2016; Williams, 2004). The majority of these papers analyse the energy impacts amongst several other issues; only the Gharebaghian paper conducts dedicated analysis of the energy impacts of foreign policies in the Middle East.

Another major area of geographical focus is Russia. For instance, Goldthau and Boersma (2014) analyse EU / US foreign policy relations with Russia and their impact on Russian energy exports. Noël (2013), Skalamera (2016) and The Bow Group (2015) all analyse the impacts of European foreign policy on Russian energy exports, particularly in relation to the sanctions which will impact both Russian and European companies working in energy production sectors. Related to this is the issue of energy exploration in the Arctic, in which Russia is a major player: Keil (2014), Murgatroyd (2009), and Wood-Donnelly (2016) all analyse the potential impacts of states' foreign policies on future energy exploration in the Arctic, with both the Keil and Murgatroyd papers conducting dedicated analysis of this issue. There is also considerable research on the impact of foreign policy on cross-border oil and gas pipelines, with a particular emphasis on the Central European and Asian regions (e.g. Agnia Grigas, 2013; Bonin, 2007; Cooley, 2008; Grewlich, 2011; Hancock and Vivoda, 2014; Heinrich and Pleines, 2015; Kardas, 2011; Kropatcheva, 2014; Kulkarni and Nathan, 2016; Lee, 2014; Oliker and United States. Air Force, 2009; Orttung and Overland, 2011; Shaffer, 2013; Tayfur and Göymen, 2002; Umbach, 2010).

There is a body of literature on military R&D spending, which has benefitted the development and cost reduction of a number of energy technologies, thereby indicating the impact of defence spending policy on energy (e.g. Bergek et al., 2008; Braddon, n.d.; Breede, 2015; Eames and McDowall, 2006; McConnell, 2007; Mowery, 2010; Saritas and

Burmaoglu, 2016; Te Kulve and Smit, 2003; Unger and Herzog, 1998; Watson, 2001, 1997). Notable impacts on energy supply technologies include the Combined Cycle Gas Turbine (which has its roots in jet engine technology), hydrogen and photovoltaic fuel cells (being developed for a variety of military applications including in-field electronics and unmanned vehicles), lithium ion batteries, and atomic energy. All these papers also discuss a number of non-military aspects of technology development; the review did not find any dedicated analysis on the impacts of military R&D policy on energy. In the case of atomic energy, despite historic links between the military and civilian sectors (nuclear power stations were originally designed to produce fissile materials for atomic weapons [Heffron and Talus, 2016; Leveque and Robertson, 2014]), the sectors are now separated to mitigate risks of weapons proliferation. However, Cox et al. (2016) conduct dedicated analysis which finds that the military and nuclear power sectors in the UK are interlinked via a broader network of skills and capabilities, and that therefore UK defence policy may provide an additional incentive for ambitious nuclear energy programmes; this is also suggested briefly in Thomas (2016).

1.5 Economic policy

In this category, we found a total of 36 relevant articles; of these, 12 conduct dedicated analysis of the impact of non-energy policies on energy systems. This category represents the greatest number of dedicated analyses; however, most of these are global in scope (impacting the UK), with only 2 documents having the UK as their main focus.

This is a large and complex category, because fiscal, monetary and other economic policies and actions tend to impact widely across all sectors. The main theme addressed in existing research is the impact of taxation and exchange rates on the costs (and therefore demand and supply) of energy goods and commodities, on which this review found a relatively large amount of peer-reviewed dedicated analysis. The review also found research on liberalisation, privatisation and government intervention, much of which provides dedicated peer-reviewed analysis of the impacts on energy supply but which (as in many sectors), tends to view liberalisation as an overarching process rather than a policy. Interestingly, there is rather little research on the impact of *non-energy* taxation policies on energy and transport, because the literature tends to refer to specific oil and gas or transport taxes, without referring to broader tax regimes or policies. The review did not find any literature linking energy or transport demand with income tax policy.

At its most basic level, as Solow (2005) points out in a general research paper on the impact of economic policy on multiple sectors, "*No one doubts that changes in taxes and expenditures can affect relative demands for military and civilian goods, for foreign and domestic goods, for alternative sources of energy, for agricultural and industrial goods*" (p.511). However, within this, there are relatively few papers focusing on different ways in which such changes can affect relative expenditures on energy. Of the few examples we did find, Painuly (2001) provides dedicated analysis of potential macroeconomic barriers to deployment of renewable energies, including high inflation rate, unstable currency, balance of payments problems and uncertain exchange rates, and suggests some policy approaches

for removing these barriers. Meanwhile Hall et al. (2016) provide dedicated analysis of the barriers to financing small-scale renewables in the UK financial system; however, they suggest that the barriers are due to structural factors such as the large, centralised and "market-based" nature of the UK finance system (which, for example, makes participation by non-specialist market entrants difficult), rather than policies *per se* (p.12).

One area in which there is certainly no dearth of research regards the impact of macroeconomic policies on commodity prices, particularly oil. Many academic papers provide dedicated analysis of the link between oil prices and exchange rate or interest rate policy (e.g. Adewuyi, 2016; Darby and Phillips, 2007; Frankel, 2006; Rosa, 2014; Tokic, 2015), as do some papers from the grey literature (e.g. Krichene, 2007; Mason, n.d.). For instance, high interest rates may reduce the demand for storable commodities, which in turn may reduce the market price. Interestingly, there are also some dedicated analyses which counter that financial policies have less of an impact on oil prices than expected (Chang et al., 2013; Chevapatrakul, 2015). A 'loose' monetary policy (i.e. one which expands the money supply and makes it more accessible in order to encourage economic growth) may also impact oil prices. For instance, Quantitative Easing may contribute to higher commodity prices, for example by encouraging a move into 'safe' commodities such as oil in response to fears of liquidity-fuelled inflation (dedicated analysis by Halkos and Paizanos, 2016; Yoshino and Taghizadeh-Hesary, 2016; analysis amongst other issues by El-Erian, 2012). However, a dedicated analysis by Szilagyiova et al. (2013) found that although the impact of UK monetary policy on oil supply is comparable to that of larger economies, it surprisingly doesn't impact European oil supply (although it does impact OPEC supply); furthermore, an analysis by Khalifa et al. (2015) found that monetary policy has limited impact on gas prices, mainly because gas is usually traded under long-term contracts. Finally, Butler et al. (2014) look at drivers for change in energy consumption practices, and find (amongst many other issues) that interest rate policy has an impact on people's decision-making about solar PV investment.

One of the key overarching themes relating to economic policy centres on the liberalisation and privatisation of utilities including energy and electricity. Research exploring this in the UK context includes Eikeland (1998); Jamasb and Pollitt (2008, 2011); Joskow (2008); Newbery (2005, 1997); however, these articles tend to view liberalisation as an overarching process which had an impact on many sectors (including energy), rather than as a specific policy. Several papers talk about liberalisation in the context of the UK's membership of EU markets, which is seen as a driving force of some changes in the energy sector: for instance, dedicated peer-reviewed analysis by Clifton et al. (2006) finds that Europeanisation was a driving factor in electricity system reform, as does analysis of this, amongst other issues, by Schmidt (2001). Meanwhile a working paper by Reardon and Marsden (2016) carries out dedicated analysis of the impact of liberalisation on market competition in sectors such as the air industry, which has led to an increase in demand for air travel. It should be noted that numerous aspects of 'Economic sector' policies are connected to issues of international trade, discussed below.

Interestingly, the review did not find any literature linking energy or transport demand with income tax policy, even though there is a clear link between levels of take-home earnings and energy consumption. The only reference to the link between income taxes and energy consumption seems to be when discussing energy-specific taxes such as a carbon tax, for instance by seeking to reduce regressiveness via reductions in income tax. There are, however, many references to a link between council tax policy and energy efficiency, because council tax reductions or surcharges are often recommended as a potential means of incentivising retrofits. However, this has not actually been carried out in the UK (as critiqued briefly in Sayce et al., 2007), therefore the issue tends to be raised in terms of policy recommendations, rather than analysis of the impacts of existing policies. Dresner and Ekins (2006) analyse various policies to incentivise retrofits, and find that levying a council tax surcharge on inefficient houses would be one of the most effective policies (although their methodology for concluding this is unclear, and it seems to be a proposal rather than an analysis). Council tax measures are also proposed by survey respondents in Killip (2008), Roy et al. (2008) and Zhang et al. (2012), and proposed in passing by Balcombe et al. (2014), Caird et al. (2008), Herring and Roy (2007) and Wallace et al. (2010); and have also been one of the key recommendations of the Energy Saving Trust (according to Darkin, 2006; and Pickvance, 2009).

This review also found some articles relating to this sector outside of the UK context: Brown (2001); Lovins (1992) and Coughlin et al. (2010) (impact of macroeconomic policy on buildings efficiency in the US); Rosa (2014) and Mason (n.d.) (impact of US monetary policy on commodity prices); Abbasi and Riaz (2016), Adom and Bekoe (2013) and Ahlfeldt et al. (2015) (impact of financial sector reforms on energy consumption in developing countries); Chang et al. (2013) and Adewuyi (2016) (impact of exchange rate policy on energy demand, in Taiwan and Nigeria respectively).

1.6 Education policy

In this category, we found a total of 19 relevant articles, but only one which conducts dedicated analysis of the impact of non-energy policies on energy systems. There is therefore very little dedicated analysis on this topic, compared to some other categories. Research in this category relates to three main themes: energy consumption of education sector institutions such as universities; the impacts of education policies on transport; and the need for education policies to ensure that there are sufficient skilled workers for the energy sector. The review found only one paper which provides dedicated analysis of the impact of education policy on energy demand. The review found no peer-reviewed or dedicated analyses of the impact of education policy on energy supply, although there are many policy documents and grey literature reports which discuss the link between education and training, and the skills required to build, operate and maintain energy infrastructures. However, much of this literature focuses on recommending policy interventions for the future, rather than analysing the impacts of non-energy policies.

Similarly to the 'health' sector (below), there is some literature examining energy demand in the education sector (and policies and initiatives to reduce it), although dedicated research

on the link between education policy and energy demand is not abundant. A paper by Royston (2016) does analyse the impact of education policies on energy demand, and notes that energy demand in Higher Education is affected by a wide range of non-energy policies, including national-scale funding policies. Royston suggests that the increasing marketisation of Higher Education may lead to increased energy demand, for instance through longer opening hours, larger accommodation and the development of energy-intensive new buildings. The paper also suggests that shifts in funding have changed the status of pre-existing carbon targets, because the Higher Education Funding Council for England (HEFCE) can no longer enforce or incentivise these due to its lack of funding. A grey literature report by Audit Scotland (2014) mentions in passing that Scottish councils have adopted various strategies for dealing with national cuts to education funding, including seeking improved transport efficiency; this is especially important in isolated rural areas where transport costs make up a larger proportion of institutional spending. It is worth noting that institutional energy consumption tends to be governed by energy-specific policies and legislation such as buildings efficiency regulations.

A second area of research focuses on the impacts of education policy on student transport modes, often linked to imperatives for making transport to school more environmentally sustainable and increasing physical activity levels. This issue has received a lot of attention in the US, due to the 2002 legislation 'No Child Left Behind' which promotes free choice of schools regardless of geographical location (citations given at the end of this section). A similar shift has taken place in UK education policy; Hallsworth et al. (1998), in a research paper on the 'unintended consequences' of various policy initiatives, state:

"Through the 1980s and early 1990s, British education policy all but destroyed the notion of 'secondary school catchment areas' in England and Wales… 'Liberalisation' of education policy means that parents of secondary school children, in particular, may express 'choice' of preferred school. This has led to vastly increased numbers of children being driven some distance from their homes to 'preferred' schools." (p.162).

On the same topic, Van Ristell et al. (2013) provide dedicated modelling analysis of the impact of school choice on transport, and find that if all children attended their nearest school, this would reduce vehicle miles travelled and would increase the use of non-motorised transport. The paper finds that local school choice could reduce congestion and CO_2 emissions, and could also help to mitigate the current "epidemic" of childhood obesity (p.20). This review also found one article which analyses (amongst other issues) a possible link between education policy and declining car use in advanced economies ('peak car'), suggesting that higher education policy in the UK has led to young people spending more of their lives in the less car-dependent environment and norms of university towns (Lyons and Goodwin, 2014). Passing mentions of this link are also made elsewhere, but generally link it to lifestyle and demographic shifts, rather than policy.

A third body of literature relates to education and training of workers for the energy sector. This is an issue which has gained prominence in the UK due to the considerable number of skilled workers which may be required in order to build, maintain and operate new energy

generation infrastructures. For instance, a number of policy and public sector body reports suggest that there may be skills shortages when attempting to realise ambitious new-build programmes for nuclear (Cogent Sector Skills Council et al., 2008; Harrison, 2015; Innovation, Universities, Science and Skills Committee, 2009; Nuclear Energy Skills Alliance, 2015) and renewables (Energy Research Partnership, 2014; Goulden and Isola, 2009; International Labour Office and Skills and Employability Department, 2011; IRENA, 2014; Vokes and Limmer, 2015). In this way, education policies may directly impact the adequacy of supply of workers to energy supply infrastructures, thus influencing the development of these sectors. There is also some grey literature (including one Select Committee enquiry report) which suggests that demand for STEM graduates in the UK may be outstripping supply, which will have a knock-on impact into sectors which require skilled STEM workers, such as energy (Herrmann, 2009; Kumar et al., 2015; Royal Academy of Engineering, 2011; Select Committee on Science and Technology, 2012; Wakeham, 2016). However, none of these reports provides dedicated analysis of the impact of education policy on energy skills provision. This issue is also connected to the industrial sector (the issue of skills for energy infrastructures is frequently mentioned in the various Energy Industrial Strategies), and also to 'Brexit' due to concerns about the future free movement of workers.

This review also found some articles relating to this topic outside of the UK context: Coleman et al. (2012), Marshall et al. (2010); Wilson et al. (2010, 2007) and Center for Cities & Schools (2015) (impacts of school choice policy on transport supply and demand in the US); Müller et al. (2008) (impacts of school choice policy on transport supply and demand in Germany); and Alyahya and Irfan (2016) (impact of education policy on solar skills in Saudi Arabia).

1.7 Health policy

In this category, we found a total of 15 relevant articles, but only one which conducts dedicated analysis of the impact of non-energy policies on energy systems. There is therefore very little dedicated analysis on this topic, compared to some other categories. Much of the literature on health refers to the impact of transport or energy policies on health, rather than vice versa. This review found literature on health policies, physical activity and transport; however, there is a divide between research which analyses policy interventions to promote physical activity for health reasons, and research which analyses the impact of increased physical activity on transport demand. The review also found a relatively large amount of literature on the energy consumption of health sector institutions such as hospitals, which are public sector institutions and hence are shaped by governmental policies; although again, dedicated research or analysis on the impact of policies is lacking. This review found little existing research on the impacts of health policies on energy supply or on transport supply.

There are a number of articles on how best to improve levels of physical activity for health reasons, although in many of these the impacts on transport (i.e. increasing walking and cycling) are merely mentioned in passing (Kahn et al., 2002; King, 1998; Morandi, 2009; Pretty, 2006; Task Force on Community Preventative Services, 2002). Pretty (2006) conducts

a dedicated analysis of the potential environmental benefits of increasing physical activity, but the paper doesn't explicitly link this to public health policies. De Meester et al. (2014) focus on children's activity levels; their analysis (amongst other issues) suggests that health education policy and certain institutional policies in schools can increase physical activity such as cycling and walking to school (note also the link with education policy, discussed in section 1.6). Lawlor et al. (2003) conduct dedicated analysis of promotion of cycling by public health policies such as the creation of cycle networks; the potential for this to reduce motorised transport demand is mentioned, but there is no dedicated analysis of that particular issue. Sallis et al. (1998) conduct dedicated analysis of the effectiveness of policy interventions to increase physical activity, although impacts on transport are only mentioned in passing. Finally, a grey literature report by SQW (2007) analyses the health and environmental benefits of cycling, although links to policy are only made in passing.

Another couple of articles focus on the energy demand of health institutions, especially hospitals which are large energy users. As public sector institutions, these are shaped by government policies, yet this review did not find any dedicated analysis of the impacts of health policy on institutional energy demand. For example, Brown et al. (2012) note that certain health institutions such as hospitals run for 24 hours a day, contributing to their high energy demand; there is little mention of policies in this paper, although they do point out that the NHS in the UK has introduced sustainability policies including sourcing green energy, green travel policies, and sourcing of local food for catering. A policy report by the UK (Department of Health, 2015) also argues that the NHS is one of the only public health organisations worldwide which actively has a policy to reduce its energy consumption. One of the motivations for institutional energy demand reduction is to reduce costs, thus indicating the impact of a non-energy policy issue (i.e. budgetary constraints on the NHS) on energy demand in the health sector. However, much of the literature focuses on recommending policy interventions for the future, rather than analysing the impacts of non-energy policies.

1.8 Industrial, business and innovation policy

In this category, we found a total of 12 relevant articles, but of these, only one conducts dedicated analysis of the impact of non-energy policies on energy systems. There is therefore very little dedicated analysis on this topic, compared to some other categories. Policy documents tend to focus on particular technologies (for instance, the UK has a 'nuclear industrial strategy' and an 'oil and gas industrial strategy'); because of this, it is somewhat challenging to separate trade and industry policy from energy policy. Of the relevant literature which we did find, key themes involve liberalisation and government intervention, including the potential for energy supply to act as a key strategic industry to boost manufacturing output. Much of the research on industrial policy focuses on the impact of industrial patterns or trends, rather than policies; analysis of the impact of specific policies tends to be from the grey literature, and impact on energy supply and demand tends to be just one of several topics discussed. Research on innovation policy tends to examine energy-related policies and non-energy-related policies separately, despite the fact that non-energy innovation policies could have an impact on energy supply

and demand. The review found little research on the impacts of industrial, business and innovation policy on transport.

On the broad theme of liberalisation and government intervention, Warwick (2013) provides a paper on general industrial policy which argues that there may be an increasing role for government intervention, although significant challenges to this remain; their paper includes a section on 'green growth' which analyses amongst other issues the impact of various industrial policies and strategies on energy systems. Ydersbond and Korsnes (2016) provide dedicated analysis of the promotion of 'green jobs' as a strategic investment area in the EU and China, which they find has promoted innovation and growth in this sector; however, the paper is on industrial strategy more generally, and does not mention specific policies. A policy document from the Department for Business, Industry and Skills (BIS, 2012) suggests that the government sees the energy sector as an 'enabling sector' which could add value to the UK economy; therefore the document suggests that government industrial policy can support new technologies which are dependent on subsidies, for instance via procurement policy. Similarly, a report by the Scottish Government (Scottish Government, 2014a) suggests that energy is one of the sectors which the Scottish Government has identified as offering particular opportunity for growth, and argues that targeted regulation and Intellectual Property support could benefit many sectors including energy. A grey literature report by Mason and Nathan (2014) notes that the UK Government has created seven new 'Catapult' centres with a focus on 'strategic' industries to boost UK manufacturing output, three of which relate to energy; in this way, industrial policy seeks to support energy as a strategic sector for economic growth more broadly.

On a similar topic, a grey literature report by Watson Farley and Williams (2016) looks at the integration of energy policy with industrial policy, and suggests that countries other than the UK are more eager to allow industrial policy to support certain energy technologies; for instance, several EU countries support 'national champions' despite the fact that they are limited in their ability to provide direct subsidies. Interestingly, a peer-reviewed paper by Finon and Locatelli (2008) actually argues that EU industrial policy revolves around liberalism and multilateralism, and tries to discourage industrial policies based on 'national champions'; their article analyses amongst other issues the impact of EU industrial strategy on gas systems. Several papers discuss the broader issue of UK liberalisation in industrial policy (e.g. Jamasb et al., 2008; Nuttall et al., 2011; Pourvand, 2013; Smith, 2013); however, these articles tend to view liberalisation (and globalisation) as an overarching global process which has an impact on many sectors (including energy), rather than as a specific policy.

1.9 International development and overseas aid policy

In this category, we found a total of 10 relevant articles; of these, only 2 conduct dedicated analysis of the impact of non-energy policies on energy systems, and none are based specifically in the UK context. This review found several articles linking development assistance and foreign aid with energy developments such as renewables and electrification. However, the majority of papers on international aid and development focus on energy-specific aid programmes, rather than aid policy more generally. The literature focuses on the

impact of development policies on sustainable development, which often includes multiple aspects of supply and demand for both energy and transport. This review did not find any articles which address the impact of overseas aid or development policy on the energy systems of the aid-giving country.

Much of the research on the energy implications of overseas aid policy refers to the aid policies of certain donor countries and of global institutions such as the World Bank. Several articles analyse the impact of aid policies on various sectors, and find (amongst other issues) that in recent years aid policies have become focused on poverty alleviation (food, water etc.) rather than infrastructure such as energy and transport (Chatterjee and Turnovsky, 2007; Tarp, 2003; Thorbecke, 2000; Yu, 1997; Yu and Taplin, 1998). Cao and Tamer (2013) conduct a dedicated analysis of the environmental impacts of foreign aid, and find that structural reform conditions attached to aid can improve energy efficiency, but can also increase short-term unemployment and poverty which can result in over-exploitation of natural resources. Niles and Lloyd (2013) and Smith and Hemstock (2012) both conduct dedicated analysis on the impact of foreign aid on small island states, and find that reliance on foreign aid means that developing nations struggle to build the capacity for sustainable energy systems (although the link between this dependence and foreign aid policies is less clear). Marquardt (2015) conducts dedicated analysis of the impact of diversified development aid (i.e. multiple donors and multiple projects) on renewable energy development, and finds both positive and negative results in a case study of the Philippines.

Finally, Cook (2011) suggests that the aid policies of major international development agencies tend to emphasise cost recovery and the private sector; they argue that this has hindered electrification progress. It is worth noting that this is linked to a longstanding debate and considerable literature on the various impacts of World Bank 'structural reform' aid policies (i.e. the attaching of liberalisation conditions to aid), in particular the impacts on electrification. This literature falls somewhat into the grey area between 'energy' and 'non-energy', because the majority of articles specifically analyse structural reform of *energy* sectors (e.g. Karekezi and Kimani, 2002; Nhete, 2007; Wamukonya, 2003; Williams and Ghanadan, 2006), yet this falls within a broader policy approach of cost recovery, privatisation and liberalisation.

1.10 International trade policy

In this category, we found a total of 22 relevant articles, but none of these conduct dedicated analysis of the impact of non-energy policies on energy systems. There is therefore very little dedicated analysis on this topic, compared to some other categories. This review found a number of empirical, peer-reviewed articles which provide dedicated analysis of the link between international trade and energy consumption from products and transportation; however, these papers tend not to discuss trade policies in detail, but rather refer to a general policy approach of trade openness. There is also a body of literature on the impacts of international trade on transport emissions. The review found little research on the impacts of international trade policy on energy supply.

Several articles provide dedicated empirical analysis which finds that international trade results in an increase in energy consumption (e.g. Keho, 2016; Lean and Smyth, 2010; Machado et al., 2001; Najarzadeh et al., 2015; Narayan and Smyth, 2009; Sadorsky, 2012, 2011), although none of these articles focus on the UK or EU, and only one (Ben Jebli and Ben Youssef, 2015) focuses on a global selection of countries. Four additional articles provide dedicated empirical analysis which finds that the increase in domestic energy consumption due to international trade tends to be much greater in less developed countries, whereas developed countries can actually reduce their domestic energy consumption through international trade, for example by sourcing energy-intensive goods from overseas (Baek, 2016; Le et al., 2016; Shahbaz et al., 2014; Suri and Chapman, 1998). Because of these issues, Arto et al. (2014) suggests that trade issues should be included in international climate negotiations, because of the potential economic benefits of producing export goods which could accrue to developing countries. There is also a body of literature on the emissions embodied in trade, which seeks to quantify the UK's 'consumption-based' emissions as opposed to 'production-based' territorial emissions (e.g. Barrett et al., 2013, 2011; DEFRA, 2016; Scott et al., 2013; Wiedmann et al., 2008). This work tends to focus on quantitative analysis of emissions rather than analysis of policies *per se*. Finally, Perkins and Neumayer (2009) analyse potential 'spillovers' of environmental efficiency via international trade, and find that some of the optimism around the potential for positive spillovers may be displaced.

Connected to this, there is a body of literature on the impacts of international trade on transport emissions. This is also closely connected to the theme of liberalisation and globalisation, and also has links with the 'economic policy' section. Cadarso et al. (2010), Cristea et al. (2013) and Vöhringer et al. (2013) all conduct dedicated analysis of the impacts of liberalised global trade policy on carbon emissions from international freight, finding that transport is a crucial yet under-studied component of countries' carbon emissions when importing and exporting goods. In particular, trade policies which influence choice of trading partners will have an impact on transport demand and emissions, because air freight is much more energy-intensive and the choice of transport mode is determined by trade routes. Hecht and Andrew (1997), International Transport Forum (2006) and Levinson (2009) (of which only the Levinson paper is peer-reviewed) all also analyse this, amongst other issues. This issue is connected to literature in the 'agriculture policy' section, because much of the empirical analysis into international transport emissions involves food products.

Finally, there is a body of literature concerning EU competition law (e.g. Cameron and Brothwood, 2002; Johnston and Block, 2012; Kuzemko et al., 2012; Schmidt, 1998; Sousa Ferro, 2011; Stern, 2005; Thomas, 2016). The papers on this topic analyse some major impacts that EU competition law has on UK energy supply, in particular relating to government support and subsidies for particular projects, and the EU's elimination of destination clauses (i.e. clauses within gas contracts which prevent the buyer from reselling the gas outside of a specified geographical area).

This review also found a number of articles relating to this topic outside of the UK context, especially on the link between international trade openness and energy consumption, with the geographical focus variously on developing countries (Baek, 2016; Le et al., 2016; Nasreen and Anwar, 2014; Shahbaz et al., 2014; Suri and Chapman, 1998); OPEC (Najarzadeh et al., 2015); Africa (Keho, 2016); the Middle East (Narayan and Smyth, 2009; Sadorsky, 2011); South America (Machado et al., 2001; Sadorsky, 2012), China (de Souza and Cavalcante, 2016; Liu et al., 2010; Ren et al., 2014; Yang et al., 2014); East Asia (Zhang, 2015); Malaysia (Lean and Smyth, 2010); Switzerland (Kander and Lindmark, 2006); and Germany (Masters thesis, Hagen, 2013).

1.11 Non-energy-related environmental policy (air pollution, water and forestry)

In this category, we found a total of 19 relevant articles; of these, only 4 conduct dedicated analysis of the impact of non-energy policies on energy systems. Clearly, there are many connections here with the agricultural sector discussed in section 1.1, and in the UK these two sectors fall under the remit of the same department (DEFRA). There are several analyses of the impact of air pollution policies on various sources of CO_2 emissions, including energy supply and demand and transport. On the other hand, this review found relatively little research on the impact of air pollution policies on extractive industries (such as shale gas extraction). There is also plenty of research on the 'nexus' of water, food and energy, although the bulk of it appears to focus on the impact of energy policies on water rather than vice versa; of the papers which do address the energy impacts of the water industry, the focus tends to be on recommending policies for improved energy conservation in the future, rather than conducting research specifically to analyse a policy's energy effects. There is also little research on the impacts of water policies on energy supply or on transport. Finally, this review found research on the impacts of floods and flood defences on the resilience of energy supply and transport, but less research on the impact of flooding policy on energy demand. This review did not find any research on the impacts of forestry policies on energy or transport in the UK context.

One of the main bodies of literature within this sector concerns air pollution policy and its potentially significant impact on transport and energy. For instance, Beattie et al. (2001), Beevers and Carslaw (2005), Begg and Gray (2004), and Hitchcock et al. (2014) all conduct dedicated analysis of the impact of various air pollution policies on transport. Of these, the Beevers and Carslaw and Beattie et al. papers both analyse areas in which air quality policies have successfully reduced transport demand and emissions (with a focus on the London congestion charging scheme and on local authorities respectively). On the other hand, the Begg and Gray paper analyses congestion policies as an example of an area in which air pollution policies haven't been as effective as hoped. Meanwhile, Bollen et al. (2009) conducts dedicated analysis of the impact of air pollution policies on carbon emissions, whilst Bollen et al. (2010) and Brand (2016) both analyse amongst other issues the impact of air pollution policies on carbon emissions from the energy sector and the transport sector respectively.

This review found relatively little research relating to the impact of air pollution policies on extractive industries for energy resources such as shale gas, because most of the literature looks instead at the *health* impacts of these policies. Only Watterson and Dinan (2016) explicitly draw the link, in a dedicated analysis of Health Impact Assessments (used by unconventional fossil exploration to secure approval for their projects), which finds that these assessments are not always objective and can be bought by exploration companies, whereas the local communities often can't afford them. Another (non-peer-reviewed) article by Watterson and O'Neill (2012) argues that the UK government is 'obsessed with deregulation' and therefore has reduced air pollution regulations in many sectors including electricity generation and transport.

The second major body of literature focuses on the impact of water policies on energy. This is unsurprising considering that a major emerging strand of research concerns the 'Nexus' between water, energy and food (it is therefore worth noting the connections with the 'food' sector in section 1.1). However, the bulk of this research appears to focus on the impact of energy policies on water rather than vice versa. Nevertheless, several papers analyse amongst other issues the energy demands of the water sector, noting that pumping, cleaning, treating and heating water is highly energy intensive and thus water conservation policies can be linked to energy conservation (Batterbee et al., 2012; DEFRA, 2008; Energy Saving Trust and Environment Agency Wales, 2012; Farmer et al., 2012; Rothausen and Conway, 2011; Zakkour et al., 2002). The Energy Saving Trust report links this issue to fuel poverty, arguing that water conservation measures and regulations can reduce water heating bills; meanwhile the Zakkour paper (a dedicated review of the UK legislative framework for water) finds that political efforts to improve water quality have led to increased electricity demand from water companies. The DEFRA water strategy also suggests that water conservation policies can impact the kinds of biomass feedstock grown, for instance by incentivising less water-intensive crops such as miscanthus. However, it is worth noting that of all this literature on water conservation, only the Zakkour and Rothausen and Conway papers are peer-reviewed; moreover, the focus tends to be on recommending policies for improved energy conservation in the future, rather than dedicated analysis of the impacts of water policies on energy demand.

There are a number of papers which look at the impact of flood defences and flood policies on the resilience of energy networks and transport (e.g. Bissell, 2010; CREW: Centre of Expertise for Waters, 2012; Department for Transport, 2014; Environment, Food and Rural Affairs Committee, 2013; Ofgem, 2014; Royal Academy of Engineering, 2011; Science and Technology Select Committee, 2015; Walker et al., 2014). This issue has received considerable policy attention in the UK following significant disruption to transport systems and electricity supplies as the result of severe floods in recent years. Meanwhile, literature on the impacts of flood policies on energy demand is more sparse, although one report for DEFRA finds (amongst numerous other issues) that improved energy efficiency can be a co-benefit of installing property-level flood protection measures (Twigger-Ross et al., 2015).

This review also found several articles relating to this topic outside of the UK context: Greenblatt (2015); Ackerman and Fisher (2013) (impact of water policies on energy supply

and emissions in the US); Berman and Bui (2001); Giuliano and Linder (2013) (impact of air pollution policies on energy supply and demand in US); Henneman et al. (2016) (impact of air pollution policies on emissions in South Africa); Newell et al. (2011) (impact of water policy on energy supply resilience in Australia); Beagle and Belmont (2016) and Mittlefehldt (2016) (impact of forestry policy on energy supply in US); Hildingsson and Johansson (2016) (impact of environmental quality policies on energy and transport in Sweden); and Kotikalapudi (2016) (impact of environmental norms on energy supply in Bangladesh).

1.12 Planning, building and construction policy

In this category, we found a total of 39 relevant articles; of these, 8 conduct dedicated analysis of the impact of non-energy policies on energy systems. Unlike most of the other categories, all of the dedicated analyses were based specifically in the UK context. This sector tends to cut across many other sectors, in particular involving land use, but also including health, education, culture and possibly others. There is a relatively large body of literature on the impacts of planning, building and construction policies on energy systems. Several academic articles analyse the impact of various planning policies on energy and transport supply and demand, with particular themes emerging around localism and sustainable development, and the impact of urban planning policies such as urban intensification. There is considerable peer-reviewed research which analyses the impact of building stock policies on energy demand, and to a lesser extent energy supply. Finally, there is some research on the impacts of planning policy on energy supply and electricity networks; however, some important energy supply issues such as onshore mineral extraction tend to be governed by energy-specific planning policies. It is also worth noting that a large body of literature exists on the impact of building regulations on energy demand; yet the majority of this literature focuses on energy-specific buildings regulations, with a particular focus on efficiency regulations.

There are a number of papers and policy documents which take a general look at the ways in which various planning policies can impact energy and transport. For instance, Wilson and Piper (2010) have written an entire book on the impact of spatial planning on climate change, including large sections analysing the impact of planning policy on energy and transport supply and demand. Shove et al. (2015) analyse (amongst other issues) the impact of urban planning on transport. A number of planning policy documents such as the National Planning Policy Framework consider the impact of planning policy on energy systems, in particular focusing on issues such as transport and energy supply infrastructure (Department for Communities and Local Government, 2011; Great Britain and Department for Communities and Local Government, 2012; Scottish Government, 2014b), although these policy documents do not contain dedicated research or analysis.

There is also some research on local and devolved planning policies and their impact on energy and transport: for instance, Fudge et al. (2012) analyse progress towards localism and the impact that this might have on energy and climate change, including analysing amongst other issues the impact of planning policy on energy and transport supply and demand; they suggest that the appearance of the UK Government's Planning Policy

Statement 1 (PPS1) in 2005 represented progress toward the recognition of a key role for local planning in the delivery of sustainable development. Cowell (2013) conducts dedicated analysis of the sustainability impacts of the Coalition administration's planning reforms (2010 onwards), and finds that a move towards decentralisation may allow for more innovative environmental responses, but that it also raises dilemmas of coordination, capacity and accountability. Finally, Bale et al. (2012) suggest that despite the fact that energy is implicated in a whole range of local planning decisions, energy provision and management has not historically been a priority for local authority planners. It is worth noting the link here with the Localism Act, discussed as part of 'devolution and decentralisation' in section 2.2.

There is also a body of literature on urban planning and urbanisation and its impacts on energy and transport. Several articles provide dedicated analysis of the impact of 'urban intensification' policies on energy and transport supply and demand. Three articles suggest that whilst in theory more compact urban environments should reduce energy and transport demand, actually the benefits may be small (Mitchell et al., 2011) or non-existent (Melia et al., 2011; Williams, 1999). The Williams article also argues that urban intensification policies are 'fraught' with contradictions and unintended consequences, including potentially allowing less space for renewable energy supply. On a similar note, Cheshire et al. (2011) analyse the impact of planning policies on the retail sector (including energy impacts); they argue that focusing retail development in the town centre tends to actually increase overall energy use, because of congestion and a general increase in the number of shopping trips. On a slightly different topic, a briefing paper by Carlsson-Hyslop et al. (n.d.) discusses amongst other issues the opening hours of shops and workplaces (which are framed by policies), which have had a big impact on people's routines and thus on their energy patterns and demand.

There is considerable peer-reviewed research regarding planning and the housing stock. For instance, Hall and Purchase (2006) analyse amongst other issues the adoption of sustainable building practices into the 'day to day' building policies of local authorities; Baek and Park (2012) analyse the impact of renovation policies on four variables, one of which is energy efficiency; and Carlsson-Hyslop (2016) analyses drivers of electric heating uptake since the 1940s, including the impact of planning policies such as the decision to build tall blocks of flats. Power (2008) and Sunikka-Blank and Galvin (2016) both conduct dedicated analysis of the impact of government housing regeneration and heritage policies on energy demand. There is also other work on building conservation and heritage policy, and its role as a barrier to energy efficiency retrofits in both domestic and non-domestic buildings (e.g. Fabbri et al., 2012; López and Frontini, 2014; Murgul, 2014); and contributions to a 2014 special issue of *The Historic Environment* journal on the energy efficiency of heritage buildings [Fouseki and Cassar, 2014]). However, this work tends to mention heritage/building conservation policy as a barrier to efficiency, and discuss responses, rather than conducting research specifically to analyse a policy's energy effects.

There is also some research on the impacts of planning policy on energy supply, especially renewable infrastructure and mineral extraction. For instance, Hedger (1995) analyses

upland wind power controversies, and argues that the regulatory bias of planning policy is incoherent with the supply-side bias of energy policy, meaning that wind power controversies are usually dealt with site-by-site in a manner which fails to address wider strategic issues posed by the rapid development of upland wind power. Kellett (2003) provides dedicated analysis of the impact of planning policy on renewable developments; he points out that the UK Energy White Paper (Department for Trade and Industry, 2003) identifies planning policy as a potential barrier to low-carbon energy development, and argues that planning policy needs not only to include specific guidelines on renewables, but also needs to become generally more inclusive and to work alongside local communities so that local opposition can be reduced. Ritchie et al. (2013) analyse amongst other issues the impact of planning policy on transmission lines, with a case study of the Beauly Denny controversy in Scotland. Meanwhile Bloodworth et al. (2009) analyse amongst other issues the impact of various UK planning policy guidelines on onshore mineral and fossil fuel extraction. Other than this, however, this review found little relevant research on fossil fuel industries and planning policy; this is probably due to the fact that most planning policy which impacts fossil fuels relates to fuel-specific policies, rather than 'non-energy' policies.

This review also found some articles relating to this topic outside of the UK context: Travesset-Baro et al. (2016) (impact of spatial planning on transport demand in Andorra); Copiello (2016) (impact of buildings refurbishment on energy demand in Italy); de la Hoz et al. (2013) (impact of landscape policy on solar PV in Spain); Shove et al. (2014) (impact of planning strategies on energy demand for air conditioning in the US); Gudipudi et al. (2016); Lee and Lee (2014) (impact of urban intensification on urban energy consumption in the US); Liu et al. (2015); Wang (2014); Yan (2015) (impact of urbanisation on energy consumption in China); and Verdejo et al. (2016) (impact of Daylight Saving Time on energy consumption in Chile).

1.13 Work, welfare, population and equality policy

In this category, we found a total of 49 relevant articles, including 7 dedicated analyses of the impact of non-energy policies on energy systems. These 7 documents actually represent a relatively high number of dedicated analyses compared to some other categories, and 6 of these focus specifically in the UK context.

Though there is a relatively large amount of literature in this category, it mostly relates to a small set of rather specific themes. As argued by Butler et al. (2016), welfare policy has implications for energy demand, for instance by reproducing particular patterns of demand (e.g. through employment policies), and reducing demand (e.g. by improving standards in housing). However, other than this one paper, literature on this topic tends to focus on three main topic areas. Firstly, there exists research on the impact of welfare policy on fuel poverty (although much of this is grey literature, and only a small proportion provides dedicated analysis). Secondly, there is research which looks at the impact of equalities policy on transport supply and demand. Thirdly, there are a small number of articles looking at the impact of pensions policy on transport demand and on energy utilities. This review found little existing research on the impacts of welfare, work, families and equality policy on

energy supply. This review also found a distinct lack of academic literature which analyses the impact of immigration policy on energy or transport, nor any explicit discussion of the potential impacts of labour market policy on energy consumption.

Regarding fuel poverty, welfare and work policy can have a direct influence on energy demand, because more expendable income is one of the key factors which can reduce fuel poverty (Hills, 2012). In particular, a body of both academic and grey literature has recently arisen analysing the impact of welfare policies in the UK on fuel poverty, in particular recent reforms to benefits payments (e.g. Bates and Freeman, 2014; Butler et al., 2016; Garthwaite and Bambra, n.d.; George et al., 2013; Guertler and Jansz, 2012; Hills, 2012; Hills and Stewart, 2005; Lambie-Mumford et al., 2016; Middlemiss and Gillard, 2015; Power et al., 2014; Snell et al., 2015). However, of these, only Snell et al. (2015), peer-reviewed), Guertler and Jansz (2012), and Lambie-Mumford et al. (2016) provide dedicated analysis. Finally, peer-reviewed research by Kuzemko et al. (2016) suggests (amongst many other topics) that redistributive welfare policies could successfully redistribute the effects of energy system change more equitably, leading to a higher chance of energy transition success.

On the subject of work and welfare, it is plausible that labour market policy could impact energy systems, for instance by increasing levels of employment or wages, and thus increasing spending power and energy consumption. However, this review did not find any explicit analysis of this link. There are several papers on energy efficiency and rebound effects which note the importance of labour market structure on the results from their economic models (Allan et al., 2007; Hanley et al., 2006; Turner, 2009); however, these do not explicitly draw the link with policy, with labour market assumptions being viewed as the result of market mechanisms rather than policy. On the transport side, literature focuses on the impacts of transport policy on the labour market, rather than vice versa. It is important to note here the links with the 'tax policy' issues discussed in section 1.5, and also with the 'education and skills' issues discussed in section 1.6.

There is a large body of literature which links poverty and inequality to issues of transport access, although the majority of the policies mentioned are specific *transport* policies (i.e. not 'non-energy'). However, this review did find some analysis on the impact of equalities policy on transport, especially regarding disabilities and gender. For instance, Cole (2006) gives a history of disability equality policies, including analysing (amongst other issues) money spent on accessible transport programmes; similarly, Lowe et al. (2015) suggest that equality policies have led to a distinct approach to designing the Greater Manchester transport network. Amongst the major disability policies discussed, analysis often focuses on the Disability Discrimination Act (1995) and Article 13 of the Amsterdam Treaty amendment at European level (Roberts et al., 2006; Vanhala, 2006; Wilson, 2003); however, both these pieces of legislation were heavily criticised by disability activists for the fact that they did *not* cover transport, but rather focused on employment (Vanhala, 2006; Wilson, 2003). Meanwhile Hamilton et al. (2005), in a dedicated analysis of the role of gender in transport demand, point out that the government has drafted legislation to introduce a gender equality duty for the public sector which will require public authorities to promote gender equality and will impact transport planning.

Further papers look at the impact of pensions policy on transport and energy demand. Hitchings et al. (2016) analyse the impacts of retirement on transport; amongst other issues discussed in the paper, they directly discuss policy when they point out that new pension arrangements now allow retirees to 'draw down' pension monies as tax free lump sums, which could increase transport demand (especially for air travel).[3] Finally, two papers provide dedicated analysis of a possible link between pensions policy and energy bills (Hughes, 2012; Thurley, 2014): they discuss 'protected persons regulations' which guarantee certain pension benefits to employees of regulated utilities such as electricity, and raise the concern that this could lead to a pensions shortfall which would be passed onto consumers in these regulated industries, for instance by increasing energy bills.

On the subject of population, this review found a distinct lack of academic literature which analyses the impact of immigration policy on energy or transport. The links made are usually very indirect, for instance in pointing out that parliamentary discourse has recently been dominated by immigration and economy issues at the expense of climate change. The review found several grey literature reports (of generally rather low quality), but these do not conduct analysis of the impact of migration policy on energy and transport; rather, they discuss the impact of migration on population growth, and then separately point out the impacts that population growth can have on energy and transport demand (Le Vine and Jones, 2012; Madden et al., 2010; Population Matters, 2013; Population Matters, n.d.; Sessa and Enei, 2009; Transport for London, n.d.). Reports for the UK Migration Advisory Committee (Migration Advisory Committee, 2012; Tsang and Rohr, 2011) include large sections on the impacts of migration on transport, but the purpose is to inform rather than analyse policy.

Finally, it is worth noting that there are a number of papers on the impact of population control policies on energy consumption (e.g. Bradshaw and Brook, 2014; Mayhew et al., 2009; O'Neill et al., 2005; Shaw, 1992; Stephenson et al., 2010; Wang, 2010; White, 2007), with a body of literature focusing on the Chinese one-child policy (e.g. Guan et al., 2008; Hubacek et al., 2007; Lin et al., 2009; Liu, 2010; Liu and Diamond, 2005), although dedicated analyses of the energy impacts of the one-child policy are somewhat lacking. However, it is worth noting that these are only linked to actual policies (rather than non-policy trends) outside of the UK context, in countries such as China and India which have implemented population control policies.

[3] It is worth noting that this may simply concentrate transport demand in the shorter-term rather than necessarily increasing overall demand in the long-term, although this aspect is not mentioned in the article.

Part 2: Cross-sectoral review

This Part discusses four substantive issues that emerged from the literature review and which are cross-cutting agendas or themes rather than sector-specific policies. It is valuable to consider these separately from sector-specific policies, because they are often longer-term and wider in scope, and have different kinds of energy impacts (often more diffuse and mediated through their influence on sectoral policies). However, we do not claim that sectoral policies and cross-sectoral themes are entirely distinct; it is notable that land-use planning (considered here as a policy sector) actually has quite wide-ranging, long-term and sector-spanning impacts, while Brexit (considered here as a cross-sectoral theme) actually has a specific UK government department responsible for it. Despite these matters of interpretation, it is helpful to draw some boundaries to structure the review. This Part presents some new material drawn from the literature, but also draws together some material already discussed in Part 1, to highlight issues that span sectors. It also highlights some interconnections between the four themes.

2.1 Liberalisation

This theme emerged through an inductive analysis of the sectoral literature. Liberalisation is a broad concept, and we understand it here to include several related dimensions, specifically marketisation, privatisation, deregulation, globalisation, the promotion of consumer choice, and various forms of diversification and outsourcing. Aspects of this broad policy agenda are linked with several specific areas of policy. First, in relation to trade and industry, key dimensions are deregulation and removal of barriers, which can, for example, be linked with changes in energy markets and with the "off-shoring" of manufacturing energy use and carbon emissions. Liberalisation is a key theme within the industrial sector research, where it generally refers to free market policies, and is contrasted with interventionist policies (e.g. Warwick, 2013; Ydersbond and Korsnes, 2016) which may affect the manufacturing of energy generation and supply infrastructure and materials. Other relevant policy areas include education, health and land-use policy.

Many papers (Cameron and Brothwood, 2002; Johnston and Block, 2012; Kuzemko et al., 2012; Schmidt, 1998; Sousa Ferro, 2011; Stern, 2005; Thomas, 2016) discuss some major impacts that EU competition law has on UK energy supply, in particular relating to government support and subsidies for particular projects, and the EU's elimination of destination clauses (i.e. clauses within gas contracts which prevent the buyer from reselling the gas outside a specified geographical area). Finon and Locatelli (2008) state that EU industrial policy revolves around liberalism and multilateralism, and discourages industrial policies based on 'national champions' (such as the energy sector).[4] A key overarching theme within the economic policy literature centres on the privatisation of utilities including energy and electricity, and several papers talk about the liberalisation of utilities in the

[4] Though it is questionable to what extent this EU policy actually determines the actions of member states.

context of the UK's entrance into the EU single market. For example, Clifton et al. (2006) and Schmidt (1998) both refer to the idea that Europeanisation was a driving factor in electricity system reform, whilst Reardon and Marsden (2016) find that entrance into the single market removed restrictive trade practices and operating barriers in the air industry, which has increased market competition and led to an increase in demand for air travel.

As noted in Part 1, there are also many empirical articles exploring the links between energy consumption and international trade, which tend to refer to a general policy approach of trade openness (which is associated with liberalisation in the sense of globalisation and the removal of trade barriers). Several articles suggest that international trade may result in an increase in energy consumption, especially in less developed countries, while richer countries may in effect outsource their emissions through imports (see section 1.10 for references). Meanwhile, Perkins and Neumayer (2009) find that 'spillover' effects of environmental efficiency through international trade are limited.

Liberalisation, in a different form, is also a theme in the education sector. Royston (2016) suggests that the increasing marketisation of Higher Education may lead to increased energy demand, for instance through longer opening hours, larger accommodation and the development of energy-intensive new buildings. This paper also suggests that outsourcing of campus services can potentially create complexity and slow the implementation of energy efficiency/generation measures. (The review did not find any other papers on outsourcing and energy, but this was not used in a specific keyword search). Meanwhile, Hallsworth et al. (1998) describe how 'liberalisation' of education policy (in yet another form) means that parents of secondary school children, in particular, may express 'choice' of preferred school. Liberalisation here refers to a policy agenda that privileges consumer choice. This has led to increased numbers of children being driven some distance from their homes to 'preferred' schools.

Finally, one other paper mentions liberalisation in a totally different context: Smith et al. (2010) argue that "liberalised" land-use policy (i.e. removal of tariffs and subsidies) is likely to increase competition for land uses. They explain that;

"Agricultural policy in many developed countries is dominated by protectionism, established through trade tariffs and producer support (subsidies).... subsidies tend to limit competition for land. Subsidies also distort markets on a global scale and influence the competitiveness of agricultural land use in other regions of the world. Conversely, policy liberalization often leads to land-use diversification ... In doing so, however, a liberalized land-use policy is likely to increase competition between land uses" (p.2944).

This includes competition between bioenergy production and food production. EU agricultural policy is mentioned in this paper as one example of an interventionist (not liberalised) policy; this suggests a possible link with Brexit, as discussed in section 2.4).

2.2 Devolution, decentralisation and centralisation

This policy agenda was the subject of a dedicated literature search, because of its importance to the current UK context (although it could be considered a sub-category of the governance processes theme). It includes devolution to UK nations, cities and regions, as well as issues of decentralisation more generally (and the converse 'centralisation'). In general, any policy area that is subject to devolution or decentralisation (or indeed a lack thereof) could be affected by this theme, but key policy sectors seem to be land-use, planning, environmental, taxation and investment policy.

Firstly, a number of articles discuss the devolution of certain powers to Scotland, and their impact on energy and transport. Many articles (Cairney, 2012; Commission on Scottish Devolution, 2008; Cowell et al., 2015; Mooney and Scott, 2012; Paun and Murray, 2008; Scottish Labour Devolution Commission, 2014; Tsagas, 2013) all analyse the impact of Scottish devolution on various issues (of these, only the Cowell paper conducts dedicated analysis of energy, and none are peer-reviewed). All these articles point out that although environmental policy is fully devolved to Scotland's parliament, energy policy is reserved to Westminster, which can result in numerous contradictions. There are also a few articles which analyse devolution in Wales, with energy once again appearing alongside multiple other issues (Andrews and Martin, 2007; Mainwaring et al., 2006; Osmond and Upton, 2013; Wales Governance Centre, 2016). Small energy planning consents are devolved to Wales, but large energy projects remain with Westminster because of their importance to the UK as a whole (Wales Governance Centre, 2016). Osmond and Upton (2013) argue that this distinction is 'arbitrary' and creates uncertainty over policy direction and inconsistency of process for developers; meanwhile Mainwaring et al. (2006) argue that Wales' ability to pursue sustainable development is hampered by its lack of tax-varying powers and its goal of GDP convergence with the UK.

A second body of literature focuses on the shift toward greater powers for cities and regions within the UK, and the potential impacts on transport and energy supply. Many of these articles analyse Transport for London, which is widely seen as a success in terms of the impact of devolution on sustainable transport development (Centre for Cities, 2014; Docherty and Shaw, 2008; Gash et al., 2014; Haughton et al., 2008; Marlow, 2015; Trench, 2004). To date, 10 further 'devolution deals' have been agreed for cities and regions outside London (National Audit Office, 2016); of these, the majority include plans to devolve transport planning, whereas only Cornwall's deal includes an energy component (Communities and Local government committee, 2016; Ernst & Young, 2016; Sandford, 2016). These devolution deals are fairly new, therefore this review could not find any peer-reviewed literature and only a scattering of reports on the potential impacts of further devolution, most of which are rather preliminary (Bonar, 2015; Communities and Local government committee, 2016; Scott and Copeland, 2016).

A third body of literature focuses on the impact of the UK Localism Act on energy supply. In particular, this literature is concerned with community energy projects and community resistance to infrastructure such as wind turbines. Rydin et al. (2013) suggest that whilst the localism agenda could been seen to encourage different kinds of renewable, sustainable and

decentralised energy initiatives, there may also be problems for local government seeking to coordinate and manage various investment patterns, including from the private sector and the third sector. Hannon et al. (2015) suggest that the Localism Act has helped some Local Authorities to implement energy projects, and has also assisted some community groups to establish their own energy initiatives. Allen et al. (2012) are also relatively supportive, suggesting that the Localism Act (and the broader agenda of localism in general) helps to 'empower' local authorities and communities to retain local services and resources for sustainable local development. However, others are more critical. For instance, Cowell (2013) argues that the localism agenda was constructed to privilege economic growth, and state that "*the overall effect could be summarized as seeking to reduce or contain the environmental role of planning*" (p.40). Williams et al. (2014) argue that the localism agenda has had "mixed" impacts on energy: on the one hand, it has allowed more radical ecological views and eco-localism (such as in energy co-ops), but on the other hand, it has allowed communities and 'NIMBYs' more of a veto over local energy projects. Tomozeiu and Joss (2014) argue that under the Localism Act, eco-towns policy shifted from being a national policy to a devolved one, meaning that central government funding was reduced and some projects have folded as a result. Finally, Groves et al. (2013) argue that the Act delegates decisions regarding future energy risk to privatised utilities, thus rendering decision-making non-transparent, and that the opportunity for participation in the planning process comes long after a piece of infrastructure has been judged nationally necessary. It should be noted that of all the references in this paragraph (all of which are peer-reviewed), only two of them actually conduct analysis of the impact of the Localism agenda, and in both cases energy impacts are analysed amongst other issues. All the others simply make 'suggestions' or 'arguments' – in other words, dedicated analysis of the energy impacts of the localism agenda is lacking.

It is important to note that, as there is literature on the impacts of decentralisation policy on energy systems, there is also literature on the impacts of *centralisation.* This is a central issue in the 'education policy' section, in which the review found a body of literature on the energy impacts of increasing distances travelled to school, of which one major driver is the centralisation and growth in size of schools. This issue also cuts across many other sectors: for example, McKinnon and Woodburn (1993), McKinnon (2007) and Piecyk and McKinnon (2010) all analyse (amongst other issues) the impact of centralisation of production on road freight; and Kenyon et al. (2002) mentions in passing the impact of centralisation of health institutions on transport patterns (although the health policy literature on this topic tends to focus on impacts on social exclusion rather than transport). As can be seen, the literature focuses mainly on transport demand; in general, research on the energy supply/demand impacts of centralisation tends to relate to the highly centralised nature of the UK energy system (i.e. not 'non-energy'). However, issues around centralisation are mentioned by Hall et al. (2016), who point out that the centralised nature of the UK financial system could present a barrier to financing small-scale renewables. Related issues about the sites and scales of governance also emerged within the next theme: governance processes and structures.

2.3 Governance processes and structures

This theme emerged inductively during the literature search. 'Governance processes and structures' refers to the ways in which policies are made and implemented, and the political and administrative structures through which this is done. Consistent with our understanding of policy, we include the processes and structures of governmental bodies of all types and scales; but not of non-governmental bodies. This is a very large category, encompassing many different issues around policy-making practices, organisations and capacities. We do not have scope here to disentangle and explore these in detail, but aim to highlight some of their key influences on energy systems.

While there is extensive research on this topic, the majority of it relates to non-UK contexts and is therefore simply listed at the end of this section. This work aside, the review found a number of dedicated, peer-reviewed analyses of the energy impacts of various governance processes in the UK/EU context; the articles cover a broad range of issues, although a common theme appears to be the impacts of political and institutional effectiveness on energy supply and, to a lesser extent, energy demand. The review found little research into the impact of governance processes and capabilities on transport in the UK/EU context. Interestingly, we only found two articles with a global focus (Hancock and Vivoda, 2014; Sander, 2013), and of these, Hancock and Vivoda actually discuss the *lack* of inclusion of energy issues in Global Political Economy research.

A common theme in the UK/EU literature (all peer-reviewed) relates to political and institutional stability and effectiveness. For instance, Menegaki and Ozturk (2013) conduct dedicated analysis of political stability and energy consumption, and find a correlation between capital and political stability, and between capital and energy consumption; meanwhile Cox (2016) suggests that policy stability is important for the pursuit of energy security in the UK. Ambrose et al. (2016) analyse the drivers of low-carbon heat networks in the UK, and find that they are limited by low levels of Local Authority capacity. Meanwhile Ratinen and Lund (2015) conduct dedicated analysis which finds a correlation between policy 'inclusiveness' and the development of renewable niches. Kuzemko et al. (2016) suggest that PR voting systems can assist in prioritising climate change when devising new energy policies, whilst Schaffer and Bernauer (2014) conduct dedicated analysis of the underlying politics behind renewable energy expansion in the EU, and find a correlation between federalist political structures and renewable energy promotion, as well as between EU membership and renewables. Puka and Szulecki (2014) and Austvik (2016) both conduct dedicated analysis of EU governance processes and their energy impacts, with a focus on electricity interconnection and EU energy security respectively. Finally, Thomas (2016) analyses the various governance processes which have contributed to the UK government's continued support for the new nuclear power plant at Hinkley Point C.

This review also found many articles relating to governance processes and capabilities outside of the UK context, with the geographical focus variously on Sub-Saharan Africa (Adams et al., 2016; Ahlborg et al., 2015; Power et al., 2016), Ghana (Ramana and Agyapong, 2016), South Africa (Baker, 2016; Baker et al., 2014), India (Gaur and Gupta, 2016; Min and Golden, 2014; Srinivasan, 2013), South Asia (Bhattacharyya and Palit, 2016), China (Chen et al.,

2016), Turkey (Jewell and Ates, 2015), Denmark (Eikeland and Inderberg, 2016), Germany (Schubert et al., 2015), Norway (Roettereng, 2016), the US (Hughes, 2014; Spinardi, 2015), Australia (Cheung et al., 2016), and finally Fiji (Dornan, 2014).

2.4 Exit from the EU

This policy agenda could be considered a sub-category of the governance theme (as it relates specifically to the withdrawal from EU governance) but was the subject of a dedicated literature search, because of its importance to the current UK context. On 23 June 2016, the UK public decided in a referendum to leave the EU. This will likely have a significant impact across the board, including on energy and transport, and a specific department has been set up in the UK government to manage the UK's exit ('Brexit'). Due to the short timescale, this review found no peer-reviewed literature on this issue; literature is mostly from think tanks, consultancies and law firms, including a number of reports written before the referendum, looking at potential implications. Similarly, the Brexit process is ongoing and many potential impacts have not yet occurred, meaning that reports tend to explore and suggest possible impacts rather than providing detailed analysis. Unlike the other issues explored in this report, the large body of literature on this topic all tends to make a number of similar key points; this section lists the key points and in each case cites all the articles in which it appears.

Many articles note that energy was never the main focus of the Brexit debate, and that the UK has its own unilateral energy, environmental and climate plans (some of which are very ambitious) (Aurora Energy Research, 2016; Buchan and Keay, 2016; Ekins et al., 2016; Renewables Consulting Group, 2016; Slaughter and May, 2016; Watson Farley and Williams, 2016). However, others point out that the UK has been a leading voice in some European energy and environmental policies including carbon reduction commitments and energy market integration; there are concerns that the UK's exit could undermine these policies (Baldock et al., n.d.; Bond et al., 2016; Burns et al., 2016; Froggatt et al., 2016; Grubb and Tindale, 2016). Several articles suggest that Brexit may give the UK increased freedom over its energy policies, for instance through not having to comply with EU renewables targets or competition law (Irwin, 2015; Norton Rose Fulbright, 2016; Pycock, 2014; Slaughter and May, 2016; The Economist Intelligence Unit, 2016; Watson Farley and Williams, 2016). However, it is also noted that the impacts of Brexit on energy depends largely on whether or not the UK remains part of the EU Internal Market; it is assumed that the UK would prefer to retain access to the market, but this would mean that the UK is still bound by EU regulations and legislation (Addleshaw Goddard, 2016; Buchan and Keay, 2016; Burns et al., 2016; Ekins et al., 2016; Froggatt et al., 2016; Grubb and Tindale, 2016; Irwin, 2015; Mayer Brown, 2016; Norton Rose Fulbright, 2016; The Economist Intelligence Unit, 2016; Vivid Economics, 2016; Watson Farley and Williams, 2016).

A number of reports state that Brexit has caused high levels of uncertainty in markets and for investors, which means that there is a danger that crucial investments in energy infrastructure might be delayed or cancelled in the wake of the referendum (Addleshaw Goddard, 2016; Aurora Energy Research, 2016; Ekins et al., 2016; Flavell and Villanacci,

2016; Grubb and Tindale, 2016; Mayer Brown, 2016; Renewables Consulting Group, 2016; The Economist Intelligence Unit, 2016; Timetric, 2016; Vivid Economics, 2016). In particular, there is a concern that interconnection with Europe could be affected, which could have an impact on the UK's energy security (Aurora Energy Research, 2016; Ekins et al., 2016; Flavell and Villanacci, 2016; Mayer Brown, 2016; Vivid Economics, 2016). There are also some concerns that the UK's gas security could be affected (Aurora Energy Research, 2016; Grubb and Tindale, 2016; Vivid Economics, 2016), although Flavell and Villanacci (2016) argue that this will not be an issue because gas is governed by existing long-term contracts.

A common theme relates to the impact of Brexit on energy in Ireland, because Ireland remains part of the EU but is geographically separate and is heavily reliant on electricity imports from the UK (Barrett, 2015; Burns et al., 2016; Ibec, 2016; PriceWaterHouse Coopers, 2016; Purdue et al., 2015). Brexit could therefore create market distortions and potentially leave Ireland subject to two conflicting sets of energy regulation (PriceWaterHouse Coopers, 2016; Purdue et al., 2015). Some reports point out that the imposition of cross-border tariffs between the UK and Ireland would be extremely damaging, but they also note that this is generally deemed unlikely (Barrett, 2015; PriceWaterHouse Coopers, 2016; Purdue et al., 2015). It is also noted that the UK will now no longer be subject to EU laws on emergency stockpiles of oil and gas, meaning that Ireland may have to move its UK-based stockpiles to an EU state (Barrett, 2015; Ibec, 2016; PriceWaterHouse Coopers, 2016). Finally, Ekins et al. (2016) point out that the impacts of Brexit on energy could become much more complex if Scotland decides to have a second vote on Scottish independence.

This review also provides some indications that Brexit may have indirect effects on energy systems. For example, as explained in Part 1, there is literature concerning the need for STEM workers in the energy sector (Herrmann, 2009; Kumar et al., 2015; Royal Academy of Engineering, 2011; Select Committee on Science and Technology, 2012; Wakeham, 2016), and there are concerns that constraints on the free movement of people following Brexit could negatively impact the UK's ability to source sufficient skilled workers for building, operating and maintaining energy generation infrastructure (Norton Rose Fulbright, 2016; Shepherd & Wedderburn, 2015).

Themes of European governance (and potential consequences of changes to this) run through many of the sector-specific papers, but also intersect with the other three cross-sectoral themes discussed above. For example, liberalisation (in energy markets, trade and industry) and protectionism (in agriculture [see Smith et al. 2010]) are often linked with EU policies. Similarly, work on governance processes includes papers discussing European-level governance (including Austvik, 2016; Puka and Szulecki, 2014; Schaffer and Bernauer, 2014, as noted above), and issues of devolution are raised by the renewed debate about Scottish independence.

Part 3: Conceptual and methodological reflections

This Part discusses conceptual and methodological issues that arise from the literature reviews presented in Parts 1 and 2. This helps to lay the groundwork for the research agenda that is presented in Part 4.

3.1 Non-energy policy as largely invisible

It is relatively rare for a paper to focus explicitly on a link between non-energy policy and energy systems – the links we have identified are more often implicit within, or tangential to, the main argument of the paper. However, more papers look at non-energy *systems* and their effects on energy. For example, various papers associated with the DEMAND Research Centre (e.g. Anable et al., 2016; Blue, 2016) look at non-energy *systems* and energy (reflecting the Centre's understanding of energy demand as constructed by a wide range of social practices), but do not focus on non-energy *policy*.

There is a relative neglect of non-energy policy in some apparently "holistic" papers about energy systems. For example, Liu et al. (2015) aim to build a holistic model of urban passenger transport for Beijing, but among their numerous policy options only two are non-energy or non-transport policies (population control and town planning). Greenblatt (2015) aims to develop a comprehensive model of policy impacts on carbon emissions in California, but of the many policies considered, only a very few are not directly energy or carbon policies; those that are mentioned are water conservation, waste reduction and forest management. A similar gap is observed in the Månsson (2014) paper about the relations between energy and conflict, which does not consider the effects of conflict on energy at all. Even when a link between non-energy policy and energy systems is mentioned in a paper, the policy is often framed as "context" rather than a causal factor – the policy is taken for granted, and its effects are not questioned by asking, for example: what if that policy had been different? For instance, several papers discuss energy changes that occurred in China during a particular Five Year Plan, but without analysing the specific effects of the Plan. Focusing on "trends" or "phenomena", rather than on policies, contributes to a framing of changes such as urbanisation, liberalisation or growth as inevitable and non-negotiable. This reflects the way that the logic of 'predicting and providing' energy is implicitly woven into many non-energy policy areas. For example, in the health sector, there may be an assumption that power and transport will be provided as needed.

A greater number of papers look at the link in the other direction: energy policy's impacts on phenomena such as health, clean air and economic growth. It is not clear why this is the case, and not vice versa. The review also noted that many papers look at energy policies that are nested within non-energy policies: for example, within industrial policy there are some policies specifically on energy; similarly, policy on energy market regulation fits within the wider set of regulation policies. In this way the boundaries between energy and non-energy are blurred. Often, it is not made clear in the literature whether a policy that affects energy is actually a policy that affects other areas too. For example, the papers on energy market regulation do not discuss whether the same policies also apply to regulation of other areas. This may be a symptom of the tendency to view energy and non-energy systems as

two separate silos, even when they are actually integrated at a policy level. This implies a missed opportunity for comparative research (e.g. a taxation regime's effects on transport as compared to its effects on other areas). It also suggests that researchers may be left with an incomplete understanding of energy phenomena, through neglecting the bigger picture.

Finally, it is important to note that although the review set out to identify work on all kinds of policy, including standards, codes and regulations (as well as the more obvious legislation), relatively little research on these topics was identified. There are of course exceptions, and within the scope of this review it was not possible for a search to be exhaustive. It is possible that some papers on specific details of regulation were not reached through our (necessarily broad) keyword search. However, there is potentially a gap for research on these lesser-known, but nonetheless vital, forms of policy.

3.2 Unintended consequences and integration

On balance, more of the papers look at negative interactions than positive ones. In other words, the non-energy policies are normally seen to be having undesired effects on energy systems, acting as barriers or sites of conflict. These are very diverse, and include non-energy policies that promote practices that increase demand; that hamper the development of renewable systems; and that perpetuate unsustainable infrastructures. On the other hand, key "win-wins" include the positive links between air pollution and health policies and carbon emissions, and between social welfare policy and fuel poverty alleviation (although the flip side of this is that when welfare suffers, fuel poverty worsens too: a "positive" link is not always a good thing). There are also instances of good practice in governance processes promoting energy benefits such as development of renewables. However, some papers find that desirable effects are not in fact occurring: for example, Novikova (2016) notes that laws protecting indigenous peoples in Russia are failing to limit harmful energy developments.

Despite the attention to negative interactions and unintended consequences, integration or joined-up policy-making does not receive much dedicated analysis in the literature reviewed here (although it is often briefly mentioned in papers' policy recommendations). The literature on Environmental Policy Integration (which did not feature in the review, perhaps because it tends to focus on measures explicitly designed to address energy and carbon) suggests that fragmentation between government agencies (including between different levels of government) can be a major cause of inefficiency and poor policy outcomes. This suggests that attention should be paid to inefficient or harmful policy interactions, and ways in which these could be addressed, including through re-assessment of how boundaries are drawn within policy structures and processes (for example, which government departments and agencies have responsibility for energy and what types of measures are available to them).

3.3 Systems, scales and sites: narrowly-focused approaches

Most of the papers found by this review focus on a single aspect of the energy system, such as the siting of nuclear power stations, innovations in solar technology, disposable income spent on fuel, or passenger miles travelled. While such narrow focus may be essential in

providing rich and detailed accounts of phenomena, there seems to be a lack of more holistic approaches that link the elements together. Even within a relatively bounded scope such as "development of renewables" there are few papers that encompass more than one technology. The most commonly considered elements of energy systems are the amounts of energy supplied and consumed, while issues such as *when* and *where* energy is used are much more rarely discussed.

The majority of papers focus on a single geographic location (e.g. nation, region or city). Several focus on a specific case study (e.g. a power station or planning decision). This may be because the policies considered are often specific to a particular area. There are some exceptions to this, for example, a set of quantitative papers in *Energy Policy* that consider groups of countries (e.g. sub-Saharan Africa, East Asia). However, these papers rarely compare policies between countries.

3.4 How to assess the causal effects of policies?

This is not an issue that received much attention in the papers, since most do not have causation by policies as their main focus (as noted above). Many papers do attempt to model or measure causal effects, but these are generally not the effects of *policies*. Rather, they take a non-energy variable such as an exchange rate, volume of trade, or urban population, and quantify its relationship with an energy variable. Links may then be made with policy, in the form of background context, or policy recommendations, but these generally remain hypothetical.

In cases where there is a dedicated analysis of the effects of specific policies, there are three main approaches:

a modelling approach in which the effects of policies are estimated or predicted (e.g. Greenblatt, 2015)
a qualitative approach in which stakeholders are asked to reflect on policies' impacts (e.g. Royston, 2016)
an interpretive approach based on logic and chronology (e.g. many papers postulating links between developments in foreign policy and subsequent energy impacts)

A fourth possible approach, involving quantitative measurement of a policy's impact, would be challenging due to the complexity of real-world policy and energy landscapes, but could be possible, within limits, using a comparative methodology (for example, comparing two regions, or two time periods, as is sometimes done in transport research). A challenge for all these approaches is establishing the appropriate counterfactual, whether this consists of another time period, a comparison site, or a baseline scenario. Research approaches are discussed further in Part 4: Developing a research agenda.

A related issue concerns how researchers can compare the scale of impacts which may be very dissimilar. For example, is it possible to compare the energy impacts of the Gulf War with the energy impacts of a green-belt policy? There are challenges not only in comparing different policy sectors' impacts, but also in comparing these with the impacts of cross-cutting policy agendas, which may operate on completely different spatial and temporal

scales. Identifying such metrics and methodologies would need considerable further work and is beyond the scope of this review.

3.5 How to assess the tractability of policies?

Tractability refers to the likelihood of changes in policy. Tractability is complex and shifting, and is not an objective fact; rather it is constructed through political processes and varies depending on the scale of analysis. For example, defence policy is likely to be relatively intractable due to the value accorded to "security" in the UK's (and other states') priorities. In the current UK context, energy concerns will often be secondary to other core priorities, such as economic growth, employment or health. However, tractability varies over time (for example, with political changes and high-profile events), and there may be "windows of opportunity" during which change can happen. These may also occur as part of ongoing policy processes; for example, consultations.

Very few papers in this review explicitly discuss the issue of tractability, or reflect in detail on how realistic their policy recommendations are. Future research could explore what is currently seen as non-negotiable, and what as amenable to change, within political discourse. It could ask why this is the case, and what the implications are for energy systems. Tractability can also be increased by seeking co-benefits, win-wins or synergies that enable core priorities to be achieved as well as energy benefits. As noted in section 3.2, relatively few papers address these co-benefits, so more work could be valuable here.

Part 4: Developing a research agenda

This part of the report offers guidance on gaps to be addressed by future research, and on methodological approaches. It first considers the thirteen policy sectors, and then the four cross-sectoral themes, taking into account the existing state of research and potential energy impacts of each of these. As noted in Part 3, any comparison of impacts is extremely challenging, given the very diverse nature of the sectors and themes and of their energy impacts, and the fragmented nature and tangential relevance of much of the literature. Therefore, we make suggestions for further research rather than claiming that certain areas are the key priorities. Finally, this section proposes some conceptual and methodological underpinnings for this new research agenda.

4.1 Our approach to developing a research agenda: gaps and impact

In order to assess which research areas are of greatest practical and policy value, we adopt a two-stage approach, as follows:

1. Gaps

The first step in developing this research agenda is to assess where gaps exist in the literature. This is based on the detailed review presented in Parts 1 and 2. There are some areas where we found relatively little research. More commonly, though, there are areas where we found a large amount of literature that is of tangential or implicit relevance to our remit - for example, literature that looks at non-energy systems and their impacts on energy, but does not mention any of the policies involved; or literature on effects that operate in the opposite direction (i.e. energy policy impacts on non-energy systems). These are worth noting because they can suggest potential areas for further research. Even where causality is apparently in the opposite direction, there may be important questions to ask, because within complex social, economic and technical systems there are often feedback effects.

2. Potential impact

The second factor we considered is the significance of the impacts of non-energy policies on the energy system (both actual and potential). It should be noted that a quantitative assessment of energy impacts is beyond the scope of this review, and in many areas (where there is little existing research) there is little evidence by which to assess the scale of energy effects. We therefore offer cautious reflections about the energy impacts of the sectors and cross-sectoral themes. It is also worth noting that a third consideration for research funders and researchers could be the likely tractability of the policy area in question; however, analysing tractability is beyond the scope of this review.

The next section considers each policy sector in turn, highlighting where gaps in knowledge exist regarding this sector, and indicating the sector's potential energy impacts. A summary of these points is presented in Table 1, in the Executive Summary.

4.2 Sector-based areas for further research

Agriculture, marine and land-use policy

While this review found several analyses of the impact of various food and farming policies on energy and transport demand, there is less research on the impact of food policies on energy supply. The issue of competition between the food and energy sectors for resources is often mentioned, but the impacts of food policies are not analysed in detail. Papers tend rather to analyse the impacts of food trends and to provide recommendations for policy based on the results. As such, there is a need for focused policy analyses.

Food, farming and land-use make major contributions to energy and transport demand, especially when seen in global perspective. The agricultural sector accounted for 5.7% per cent of UK services energy consumption in 2015 (BEIS, 2016a), so the potential impact of this policy change in this sector is relatively high. Land-use policy also has many connections with other policy sectors, meaning that it may have widespread indirect impacts on energy systems.

Communications and media policy

Much of the literature in this category focuses on the use of ICT to support or change *transport* or *energy* policy (i.e. not 'non-energy'). Of the literature we did find, there is much literature on various impacts of the internet and digitisation. However, for all these topics, the literature tends to view the internet as a *technology* rather than a policy: the internet is seen as the result of broader technological and societal trends, but is not explicitly linked to any policies. Policy is one of the many factors that influences the evolution and effects of the internet, therefore there is room for research that explicitly seeks to understand the effects of internet and communication policies on energy consumption.

The potential impact of change in this sector is huge: Hazas and Morley (2016) report that information technology devices and infrastructures are estimated to consume 5% of global electricity production, and this figure is growing fast. Cyber-security is also a growing concern. This sector is also particularly relevant because this theme extends into a very large number of other policy areas (for example, Butler et al. [2016] mention digitalisation with the Department for Work and Pensions; Royston [2016] mentions ICT trends in Higher Education). There is therefore considerable potential for research in this area to have practical and policy impact.

There is also a lot of literature on media coverage of energy issues. However, these articles generally focus on media *trends* rather than media policy. The impacts on energy are likely to be indirect (e.g. mediated through public perceptions), and therefore hard to quantify.

Culture and sport policy

Within this category, this review found a small number of relevant articles, most of which relate to general processes rather than policies *per se*. The main theme relates to the energy demands of sporting and music events and facilities, but most of these articles mention policy only in passing, and where policy is mentioned, the focus tends to be on

recommendations rather than analysis of the impacts of existing policies. There is therefore a knowledge gap here.

The energy consumption of this sector is likely to be much lower than that of some other sectors reviewed here, so the potential for policy impact is probably relatively low.

Defence and foreign policy

This review found several papers discussing the energy consumption of the military, although only one of these actually analyses the impact of defence policies on military energy demand. There is also research on defence policy and energy security, although the link is often merely mentioned in passing and the two bodies of literature tend not to be intermeshed, especially in Europe and the UK. The gap in knowledge is exemplified by Månsson (2014) who discusses in detail the relations between energy and conflict, but only considers ways in which energy affects conflict, rather than vice versa. The review also found several papers analysing the impacts of military R&D spending on the development of a number of important energy technologies, although most papers are not dedicated to the energy aspects of this topic; just one paper conducts dedicated analysis of the impact of military nuclear capabilities on civilian nuclear development. This suggests a gap in knowledge; however, as noted in Part 1, the military is one of the most challenging sectors within which to search for literature, so further review work may be needed to assess this.

Potential policy impact is likely to be high because the latest available data shows that the military uses around 2 billion kWh per year of electricity and gas, plus around 0.8 billion litres of fuel (Ministry of Defence, 2016). The military is responsible for an estimated 5 per cent of UK aviation turbine fuel use (BEIS, 2016b). Policy interventions that save money while promoting sustainable energy supply/demand may prove most successful (as is the case in many sectors).

Economic policy

This area is well-researched on one particular topic: the impact of taxation, interest rates and exchange rates on the costs of energy goods and commodities (especially oil prices). There is also research on privatisation of utilities (especially in the UK). However, there are few papers on how financial policy changes can affect expenditures on energy by domestic and non-domestic consumers. There is also little research on the impact of *non-energy* taxation policies on energy and transport, because the literature refers specifically to oil and gas taxes, or transport taxation. For example, it might be expected that income tax policy would impact energy and transport demand (because higher earnings are associated with high energy consumption), but this review found no analysis of this. More widely, there is a lot of international research on economic phenomena (such as growth) and their effects on energy demand and carbon emissions, but far fewer papers consider economic *policy* in any specific sense. Research could also examine the energy impacts of investment policies. In summary, there are some major research gaps concerning the impacts of economic policies on energy supply and demand.

Given the central role of economic policies within national and international governance, and the ramifications for all other sectors, the energy impacts are potentially large (though hard to quantify). This is therefore an important area for future research.

Education policy

The review found only one paper which provides dedicated analysis of the impact of education policy on energy demand. It found no peer-reviewed or dedicated analyses of the impact of education policy on energy supply (although there are many policy documents and grey literature reports which discuss link between education policy and the skills required to build, operate and maintain energy infrastructures). There is therefore a clear gap in knowledge here.

Education is the second largest consumer of energy in the UK service sector so the potential impacts of policy change are significant (Royston, 2016).

Health

In the area of health, significant gaps exist. Much of the existing literature refers to the impact of transport or energy policies on health, rather than vice versa. There is also a marked divide between papers which analyse policy interventions to promote physical activity for health reasons, and papers which analyse the impact of increased physical activity on transport demand. Few papers explicitly focus on the link between health policy interventions and transport demand. There is a relatively large amount of research on the energy consumption of health sector institutions such as hospitals, but again, dedicated analysis on the impact of policies is lacking. This review also found little research on the impacts of health policies on the supply side, for both energy and transport.

Potential impact is relatively high: the health sector is currently responsible for 7% of energy use in the UK service sector (BEIS, 2016a). There are also multiple win-wins or co-benefits that can be achieved in this area, including between energy, carbon, pollution, health, safety and equity.

Industrial, business and innovation policy

Notably, this is a category in which our review found a relatively small amount of relevant literature. Academic analysis is largely limited to the effect of energy policies that form part of industrial policy (e.g. industrial sustainability regulations), rather than the effect of wider industrial policies. The same is true of work on the performance of businesses, which focuses overwhelmingly on firms' responses to new standards, regulations and taxation that are directly linked with sustainability (i.e. energy policies). Future research could explore energy impacts of business policy: for example, how does company legislation affect the ability / incentives for businesses to take a long-term view, as opposed to short-term profit maximisation? Research on innovation policy also tends to examine energy-related policies and non-energy-related policies separately, despite the fact that non-energy innovation and skills policies could have an impact on energy supply and demand. A further limitation is that much of the literature focuses on the impact of industrial patterns or trends, rather

than policies; analysis of the impact of specific policies tends to be from the grey literature, and impacts on energy supply and demand tend to be just one of several topics discussed.

In 2015 the industrial sector accounted for 16% of the UK's final energy consumption (BEIS, 2016b) and industry also contributes to the production of energy supply infrastructure. Despite the gaps in knowledge identified above, the work that does exist suggests that there are some opportunities for industrial policy to have positive effects; for example, for innovation policy to promote the manufacture of clean energy technology; or for training policy to provide skilled energy employees. There is even scope for "win-win" solutions that facilitate industrial development and employment alongside sustainable energy systems (e.g. through targeted subsidies, investment and training programmes). This is also of great relevance on a global scale, with the potential to inform policy in countries currently undergoing industrialisation. In the UK context, it is important to note the recent creation of the Department for Business, Energy and Industrial Strategy (BEIS), which brings energy and industrial strategy within the same departmental remit. This could create new opportunities for synergies between energy and industrial policies. We therefore highlight this policy sector as an important area for future research.

International development and overseas aid policy

The majority of papers on international aid and development focus on energy-specific aid programmes, rather than aid policy more generally. This review also did not find any articles which address the impact of overseas aid or development policy on the energy systems of the aid-giving country.

The lack of research makes it hard to assess the potential energy impacts; however, it is worth noting that there are precedents for policies that aim to achieve sustainability goals alongside development goals, such as the Clean Development Mechanisms within climate treaties.

International trade policy

There is a considerable body of peer-reviewed research which provides dedicated analysis of the link between international trade and energy consumption. However, these papers tend not to discuss trade policies in detail, but rather refer to a general policy approach of trade openness – this is therefore a gap in current knowledge, and new policy-focused research could build on the existing quantitative evidence in the field.

The volume of trade obviously has a clear impact on transport demand, so the global energy impacts of trade policy are potentially very high (though very hard to isolate from non-policy factors in order to provide a quantitative assessment). Trade policy will also affect *where* energy is used, which is an important issue in terms of how energy use and emissions are measured. Arto et al. (2014) argue that the intersections between trade and emissions need to be better understood in order to ensure they are effectively integrated into international agreements.

Planning, building and construction policy

This review found a relatively large body of literature on the impacts of planning, building and construction policies on energy systems. However, issues that would benefit from deeper exploration include those around the scales of planning (e.g. from local to national), and how this affects energy-related decision-making (closely linked with the decentralisation theme, discussed below). Research could also adopt an integrated approach to how urban planning shapes both transport *and* energy, and relations between them.

This sector underpins many of the other policy sectors, especially due to the wide-ranging effects of planning policy; therefore, energy effects are hard to quantify. However, they are likely to be very large and long-term (especially where they influence the provision of long-lasting infrastructure).

Non-energy environmental policies

This area is relatively well-researched, however, the review noted:

- little research on the impact of air pollution policies on extractive energy industries (such as shale gas extraction)
- relatively little dedicated analysis of the impacts of water policies on energy demand
- little research on the impacts of water policies on energy supply or on transport
- little research on the impact of flooding policy on energy demand
- no research on the impacts of forestry policies on energy or transport in the UK context.

Environmental policies span many sectors (including industry) so their impact is potentially high, but hard to assess. Co-benefits are also common; for example, a policy may simultaneously address air pollution, energy demand and carbon reduction.

Welfare, work, population and equity

The review found little literature on the impacts of welfare, work, families and equality policy on energy supply (as opposed to demand), and noted that the work on welfare policy's impacts on fuel poverty is mainly grey literature. This review also found a lack of academic literature which analyses the impact of immigration policy on energy or transport; the impacts of migration on population growth, and of population growth on energy, tend to be discussed separately. Finally, it is plausible that labour market policy could impact energy systems, for instance by increasing levels of employment or wages, and thus increasing spending power and energy consumption, but this review did not find any explicit analysis of this link.

Due to a lack of data, energy impacts of this sector are extremely difficult to assess; it is notable that desirable policy goals such as addressing fuel poverty, and promoting equitable access to transport, may both result in *increased* energy demand. It is especially important that research addresses tensions of this kind, in order to help decision-makers balance different goals and reduce unintended consequences.

4.3 Cross-sectoral areas for further research

Liberalisation

As noted in Part 2, liberalisation is a theme that spans many sectors, most notably industry, trade and economic policy, but also education and agriculture (with brief mentions of privatisation and diversification in the fields of aid and the media). A more focused review would probably find this theme arising in many more sectors. The pervasiveness of this theme may reflect the current political context, both in the UK (where market-based ideologies are dominant) and internationally (linked to ongoing processes of globalisation). This also suggests it is an important topic to understand, with potentially wide-ranging and long-lasting impacts on energy supply and demand.

Although the issue of liberalisation is mentioned in many papers, it is generally framed as a background to the phenomenon in question. There is a need for holistic and systemic research that can situate the various 'liberalisation' policies in relation to each other and to wider agendas; for example, assessing how the different aspects of liberalisation within UK education are interacting to shape energy demand in the sector. Given the global, cross-sectoral nature of liberalisation, comparative work could also evaluate the effects of similar liberalisation policies in different sectors and in different locations; for example, impacts of outsourcing on energy use in different industries, or impacts of agricultural liberalisation on biofuels in different countries. Further research could also aim to identify win-win situations (e.g. market mechanisms that reward energy efficiency).

Devolution, Decentralisation and Centralisation

Decentralisation and devolution is another theme that emerged from various sectors within our review, but research focuses almost entirely on its effects on energy supply and transport planning/provision, rather than issues of demand. There is little peer-reviewed literature on proposals for future devolution, and amongst the many articles on the Localism Act, relatively few provide dedicated analysis of energy issues. Further research should address these gaps, especially since, in the UK context, this is a topical issue, and its effects are likely to continue. Some of these effects are likely to be indirect and distributed (for example, occurring through shifts in priorities, constituencies or institutional knowledge), but to operate over large spatial and temporal scales. However, there may also be direct effects; issues of whether and how energy and transport are devolved to UK nations and regions have clear impacts on how energy systems are governed.

Again, there is a need for research that compares the impacts of decentralisation on different sites, sectors and scales; for example, how has regional governance affected transport in different regions? How and why does decentralisation affect different forms of energy generation in different ways? Research could aim to suggest ways in which decentralisation processes could achieve better energy outcomes; for example, by addressing inconsistencies within agreements on the allocation of powers. It could also seek ways to maximise potential co-benefits of decentralisation, such as development of

local renewable schemes. Further research could also consider how liberalisation and decentralisation agendas might contribute to the development of decentralised microgeneration and storage, and an increased role for "prosumers" in energy markets.

Governance processes and structures

Although this is a large category in the literature that we found, most research focuses on developing country contexts. This work highlights issues of capacity, stability, equity and participation; however, these are likely to be important in developed countries as well and future research could explore this further. Within the research that does exist on UK/EU contexts, the focus is on the impacts of political and institutional effectiveness on energy supply and, to a lesser extent, energy demand. The review found little research into the impact of governance processes and capabilities on transport in the UK/EU context. Hancock and Vivoda (2014) also identify a gap in knowledge, namely the lack of inclusion of energy issues in Global Political Economy research.

Energy impacts are difficult to assess for governance factors, but could be extremely large, especially considering that the effects of governance processes may cover large scales, span many sectors and persist over long timescales. For example, a characteristic of a state's parliamentary structure or process may affect whether that state develops a nuclear energy programme. Governmental processes may also affect the degree of lock-in or flexibility within energy systems. Research, especially comparative and systemic approaches, could highlight examples of best practice and potentially contribute to more effective policy processes. This research theme underlies many other research topics, and thus has an important part to play in a future research agenda.

Brexit

The decision to leave the EU was a very recent one; therefore it is unsurprising that no peer-reviewed literature has been published to date. The existing grey literature includes a number of reports written before the referendum looking at potential implications (including for energy supplies and markets), and some written afterwards, although these tend to be explorations rather than detailed analyses because the process and its impacts are ongoing. However, much research may be currently in progress, and it is therefore inappropriate to class this as a "gap" in existing work.

As the review notes, the impacts of Brexit could manifest through competition law, markets, investment, migration and employment, among other issues – all of which could have significant and long-lasting effects on energy supply and demand in industry, trade, agriculture, and many other sectors. Future research could build on the recent UKERC policy briefing (Ekins et al., 2016) and provide timely evidence to inform the UK's new policy frameworks and promote sustainable energy systems.

4.4 Conceptual and methodological approaches

Non-energy policy impacts on energy systems: bridging the gap

The huge number of papers which mention the links between non-energy policy and energy systems serves to show how important this topic is. However, the fact that a relatively small number of papers set out to address this topic in an explicit or in-depth way shows the gap that exists. In particular, few papers make the link from non-energy *policies* through to energy impacts. There are a lot of papers looking at the impacts of non-energy factors or phenomena on energy, but they very rarely consider what policies are driving those non-energy factors. For example, they ask: what is the impact of trade/growth/urbanisation on energy? They do not look at the policies driving trade/growth/urbanisation. Meanwhile in other parts of the literature (not within the scope of this review) authors are asking how policies affect trade, growth or urbanisation, without making any mention of energy.

To put it another way, we suggest there are causal links of this form:

Non-energy policies -----> Non-energy phenomena -----> Energy systems

There are papers looking at the first arrow, and papers looking at the second arrow, but very few looking at both. This disjuncture could be important, because it makes the energy effects of non-energy policies invisible, and so makes it difficult to challenge or improve the energy effects of these policies.

We therefore recommend work that is integrative and spans *both* relationships. This could include literature reviews that cover both arrows; for example, a review that includes papers on 1) how urbanisation policy affects urbanisation and 2) How urbanisation affects energy systems. It could also involve empirical work that addresses the complex ramifications of policy in a specific sector, such as that reported by Royston (2016) on HE policy and Butler et al. (2016) on welfare policy. This would address the problem of the 'invisibility' of non-energy policy in energy research, identified in Part 3. Research should also consider not only legislation, but regulation, standards, codes and policy-making processes, in order to fully understand policies' impacts on energy systems. This type of research would resonate with UKERC's programme on Future Energy System Pathways (for example, exploring sources of disruption and continuity that lie outside the energy system, as well as inside it) as well as with the Energy, Economy and Societal Preferences programme.

Comparative research

As noted in Part 3, a majority of papers focus on a single location. Despite some comparative work, many papers focus on a single technology or policy, and there is virtually no dialogue between the different sectors (excepting a few instances where boundaries are blurred; for example, agriculture, land use and planning). A detailed discussion of comparative methodologies is beyond our scope, however, we suggest that future research could draw useful lessons from the similarities and differences experienced across sectors, sites, technologies and policies. For example: How does planning policy produce different outcomes for different energy generation types? How does financial policy affect domestic

energy consumption compared to transport consumption? Which policies have the greatest effects on distance travelled to school? Comparisons between sites and between policies also create opportunities to identify and disseminate good practice. Finally, as noted in Part 3, this type of methodology offers some (albeit limited) opportunities to evaluate the causal effects of policies; for example, if two similar locations implement different policies, what energy impacts does each experience, and why? As noted in section 3, modelling methods can also be used to develop comparisons between policy interventions and counterfactual scenarios.

Multi-scalar approaches

We propose that future research should consider the interactions of non-energy policies with energy systems at different scales or levels. Our review has highlighted the importance of policies and policy-making at the transnational, national, devolved and local scales and also the potential for energy system impacts at all levels, from local renewable schemes through to global oil prices. The timescales that are relevant are also diverse, from foreign policy shifts or trade liberalisation over decades, down to specific planning decisions. As noted in the Methodology, few papers reflect on their historical context, and future research could address this by engaging with the ways in which policy trajectories influence past, present and future energy systems. In particular, there is currently a paucity of research which integrates processes and effects across different spatial and temporal scales. Work on this would complement UKERC's existing research theme on Energy Systems at Multiple Scales. However, it is important to note that there is a risk of reifying scales; research should therefore avoid assumptions about the nature, definition and stability of these sites of governance, and their relationships (which may not be simple hierarchies).

System-based approaches

A large number of the papers reviewed are concerned with either supply or demand (with the exception of many papers on transport), or with even more narrowly limited aspects of the energy system. There are understandable reasons for this, including the complexity of the issues at stake, data availability, and even the constraints imposed by journal article length; in any research project, there are trade-offs to be made between breadth and depth. While there is a place for detailed work, there currently seems to be an unmet need for more holistic and systemic research (albeit recognising that this requires some sacrifice of depth).

Many of the policies reviewed here (e.g. defence policy; industrial policy; planning policy) have effects on both energy supply and demand, and future work could explore these interactions and potential feedback effects. System-based work is also needed to build a deeper understanding of the unintended consequences and tensions that characterise most of the policy sectors: how and why these arise, and how they could be addressed. Research could also consider how non-energy policies interact with each other as well as with energy systems; for example, how urban planning links health and education via transport. On a related point, it has been noted that few papers recognise that energy policies are often "nested" within wider policies (e.g. energy taxation is part of wider taxation). Research that investigates these relationships and their energy impacts would be valuable, and could promote better understanding of how energy is integrated into non-energy policy structures

and processes. It would also help to break down the artificial and unhelpful silo that exists not only in policy but in academia, between "energy" and "non-energy" topics, and support UKERC's ongoing focus on energy systems. System-based research could take various forms, including holistic literature reviews, but also modelling and scenario analysis.

In order to maximise potential impact, we suggest that research should look for synergies, co-benefits and win-wins between energy and non-energy policies; some of these potential areas for further exploration have been presented throughout Part 4. Building on this idea of systemic approaches, a future research programme should also promote dialogues, interactions and the sharing of ideas between projects. In this way it could move beyond the rigid boundaries of sector, scale and so on, which currently render the literature fragmented and incoherent, despite the high volume of work that touches on non-energy policy impacts on energy systems. Finally, this review suggests that researchers should engage in conversations with policy-makers beyond the usual energy-focused officials and departments, ensuring that impact work is not limited by sectoral boundaries.

5 Appendix A: Keywords used in literature search

Sectoral terms	Policy terms	Energy terms	Sources
Agricultur(e/al)	Policy	Energy	Google
Air quality	Regulation	Electricity	Google scholar
Arts	Strategy	Fuel	Sussex Library
Brexit		Gas	Web of science
Building		Oil	
Business		Transport	
Commerce			
Communication			
Competition			
Construction			
Culture			
Cyber			
Decentralisation			
Defence			
Devolution			
Economic			
Education			
Enterprise			
Equality			
EU exit			
EU referendum			
Families			
Finance			
Fiscal			
Flood			
Food			
Foreign			
Freight			
Health			
Housing			
Industr(y/ial)			
Innovation			
International aid			
International trade			
IT			
Judicial			
Justice			
Land use			
Law			
Manufactur(e/ing)			
Marine			
Media			
Military			
Monetary			
Music *[List continues*			

6 Appendix B: Bibliography

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