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From exports to exercise: how non-energy policies affect energy systems

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Abstract

Because of existing policy silos, energy policy tends to be addressed from a narrowly energy-centric basis; yet energy systems are clearly also affected by a wide range of policies emanating from other sectors. This article explores the impacts of policies associated with various ‘non-energy sectors’ on energy supply and demand, using a systematic and wide-ranging review of academic, policy and grey literatures. We discuss six policy sectors where these impacts are, in our assessment, not sufficiently recognised by policymakers or researchers but have significant energy implications. Overall, we find that there is little acknowledgement or analysis of this issue, especially of the full causal chain from ‘non-energy policies’ through to energy system impacts; for whatever reason, consideration of the reverse links (e.g. of the health impacts of energy policies) is far more common. The upshot is that non-energy policy impacts on energy systems are not sufficiently visible within either research or policy. We argue that this serves as a barrier to change, and that increasing the visibility of these complex and multi-faceted connections is thus a vital task for researchers and policymakers alike.

Keywords: non-energy policy; policy integration; energy governance; co-benefits

1 Introduction

Energy systems are deeply interrelated with other domains of policy, and issues of energy supply and demand and their consequences span diverse sectors, sites and scales. For example, it is widely recognised that climate change represents a cross-cutting problem which cannot be addressed from any single sector alone (Adelle et al., 2009; Milman et al., 2017). Security issues within energy systems are another revealing

example: energy security crosses multiple scales and disciplines, and is affected by various non-energy sectors, including the military, regional planning, trade and technology (Cox, 2017, 2016). In recognition of the interrelated and cross-cutting character of many problems, policy integration has become a salient issue for decision-makers and researchers within diverse disciplines (Hjalmarsson, 2015; Tosun and Lang, 2017; Ugland and Veggeland, 2006). Work on environmental policy integration suggests that fragmentation between government agencies can be a major cause of inefficiency, unintended consequences and poor policy outcomes (e.g. Lafferty and Hovden, 2003; Lenschow, 1997; Persson, 2004; Runhaar et al., 2014). From such perspectives, it is therefore important to identify negative and unhelpful policy interactions, and to seek opportunities for resolving or mitigating them, including through critical appraisal of the boundaries that exist within governance processes and structures. However, despite a widespread recognition of the need to transcend policy 'silos', relatively little work to date takes a holistic view of the effects of policies across many sectors on specific policy problems.

It might seem an obvious statement that energy systems are not solely impacted by explicitly "energy-focused" policies, but are shaped by a broad range of other policies. However, there has to-date been little work systematically analysing these impacts. Where literature does exist, it is often limited to niches focused on specific issues; little work seeks to integrate knowledge across academic fields and policy sectors, or seeks to analyse the impacts of non-energy *policies* specifically. For example, policy initiatives aimed at cutting energy demand within the health, welfare, education or other sectors often emphasise the importance of improving energy efficiency and public awareness, but pay very little attention to the energy impacts of the broader mix of *policies* within those sectors (Royston et al., 2018).

This article explores the impacts of policies within multiple 'non-energy sectors' on energy supply and demand, and by extension the ways in which policies within these multiple sectors could potentially be shifted in accordance with environmental and social goals. In doing so, the article demonstrates that, in the existing literature, discussion of the energy impacts of 'non-energy policies' is often under-analysed, tangential or absent altogether: in other words, 'invisible'. The research for this article was carried out in

parallel with work from the DEMAND research centre on ‘Invisible Energy Policy’, which focuses largely on the impacts of Higher Education and health policies on energy demand in the UK (cf. Royston et al., 2018; Selby et al., 2015). The present article has a broader focus than this earlier work, considering both a wider range of non-energy areas and examining non-energy policy impacts on *supply* as well as demand.

The structure of the article is as follows. The next section describes the methods used and the scope of our analysis, and clarifies key terms. Section 3 then presents the results, addressing six specific policy sectors where there exist significant links between non-energy policies and energy systems which have not yet received sufficient attention from researchers or policymakers: communications and technology; education; health; work and welfare; economic policy; and international trade. The discussion section then brings together the main themes from these six sectors, draws overarching conceptual and methodological reflections, and proposes some directions for a future research agenda.

2 Methods, scope and definitions

Our analysis here builds on a systematic literature review of the existing research on energy impacts of non-energy policies, which was initially conducted during spring and summer 2016 and updated in 2018. To find the existing literature, we first identified a set of thirteen policy sectors, drawn mainly from existing UK government departmental remits. These were as follows: agriculture, land-use and marine; communications, technology and media; culture and sport; defence and military; education; economic, fiscal and monetary; health; industrial, business and innovation; international development; international trade; non-energy environmental (e.g. water, air, waste); planning and construction; and work and welfare. For each sector, a set of keywords was identified; the keywords used are shown in Appendix A. Searches were conducted using the academic databases Web of Science, Scopus, Google Scholar, and the University of Sussex Library catalogue, to identify work relating to the energy impacts of policies from within each policy sector. We also searched for grey literature using google.co.uk, using the qualifier ‘pdf’ to find documents rather than web pages; we only searched the first five pages of hits, because after that the search results tended to become increasingly irrelevant. We searched for all articles which refer to at least one non-energy policy, *and* mention at least one impact of this policy on the energy system. In order to

identify articles which could have been missed by relying solely on keywords and search engines, we reviewed five years' worth of articles from the two journals we deemed most relevant to the subject: *Energy Policy*, and *Energy Research and Social Science*. Once relevant literature had been identified, we then 'snowballed' further literature from the bibliographies of relevant articles. Finally, we gained input from an academic advisory board with expertise in a range of energy- and transport-related topics. During spring 2018, the literature search was updated using the same keywords and search strategy for papers published from 2016 to 2018, specifically for the six sectors covered in this article; however, due to resource constraints and the particularly time-consuming nature of google searches, this was only conducted using the academic databases. The initial phase of this research was conducted for a scoping review commissioned by the UK Energy Research Centre (UKERC), and a more detailed account of our methods and results can therefore be found in this earlier report (Cox et al., 2016). In that publication we focused on providing a wide-ranging multi-sectoral review of the existing literature, across all thirteen policy sectors mentioned above. The present article, by contrast, focuses on just six policy sectors. Here, we seek to draw conceptual and methodological insights on the topic as a whole, and consider the interactions between interconnected sectors, as well as including literature published since 2016.

In addition, although our search spanned all geographical contexts, for the practical purpose of bounding the topic the main focus of this paper is the UK. The UK makes for a useful case study for two reasons. Firstly, UK policymakers are currently struggling with the challenge of meeting relatively stringent energy and climate targets, not least in order to comply with the Climate Change Act which requires a 57% emissions reduction on 1990 levels by 2030 (HM Government UK, 2008; UK CCC, 2015). Secondly, energy policymaking in the UK is constrained by numerous factors, including political constraints on some supply technologies (e.g. onshore wind), economic constraints on others (e.g. nuclear), and significant economic, political and technological challenges relating to necessary improvements to transport and housing infrastructure. This means that understanding the connections between energy and non-energy policies is increasingly important, in particular in areas where non-energy policies may be having significant but under-examined impacts on the UK's ability to manage or improve its energy and transport systems.

Notwithstanding this focus on a single national context, many of the insights from this study are generalisable. Many of the issues discussed in this paper are present in all industrialised nations, such as the challenges posed by high demand from various sectors (health, education, technology etc.), and the increasing burden of energy demand reductions as the measures required become more and more onerous. For this reason, much of the literature discussed in this paper is not UK-specific: many of the issues discussed are international or cross-national, or are relevant to the UK despite focusing on different national contexts.

Our analysis is premised on a deliberately broad understanding of ‘energy systems’, including all components related to the production, conversion, delivery, and use of energy, and including interactions beyond just energy technologies (for instance social, political and economic aspects) (IPCC, 2014). Importantly, transport is included *within* our definition of the energy system, meaning that we explore the impacts of non-transport policy on transport systems, but not the impacts of transport policy on the energy system (since the links between transport and energy supply and demand are already well established). Thus transport is established as a dependent variable rather than an explanatory variable. We use the term ‘non-energy policies’ to refer to policies which are not explicitly formulated with energy system consequences in mind; such policies may and almost always do have some consequences for energy systems, but they are not primarily or explicitly designed to do so (Royston et al., 2018). Equally, we use the terms ‘non-energy sectors’ and ‘non-energy phenomena’ as short-hand for sectors and phenomena which are not defined by their energy use (agriculture, housing, digitalisation, etc.), however much they may be dependent on and have implications for it. Last, by ‘policy’ we refer to both policy objectives (that is, the substantive content of policies and the stated or unstated aims, intentions and agendas underpinning them) and policy processes (the practices, procedures and governance mechanisms through which policies are formulated, negotiated, coordinated and pursued) (Royston et al., 2018). Hence our analysis is about the energy system impacts of policy objectives and processes which have been formulated outside of the energy sector, without energy supply or demand being explicit or primary concerns.

Like any study of this kind, the results and conclusions presented in this article are somewhat dependent on the choice of search terms and sources. Despite the large number of keywords and systematic search methods used, the results are not exhaustive. Clearly there is scope for further, more in-depth research on this topic, for example using more detailed sets of keywords, a more extensive range of sources, and more researchers to conduct blinded double-extraction. In particular, we wish to note four limitations. First, our keywords may not fully reflect the rich body of transport-related literature. Second, whilst we have attempted to be as multi-disciplinary as possible, our disciplinary standpoint is rooted in the energy literature, and the two journals selected for our targeted journal search were both energy journals, which may have introduced some disciplinary bias in our results. Third, our journal searches only covered the past five years, and our findings are therefore somewhat biased towards recent phenomena and trends. Finally, ‘carbon’ was not included as a keyword, for two reasons: firstly, because the main focus of this study was on energy and transport systems, not carbon or climate change; and secondly, because carbon emissions are an *outcome* of energy systems, and we wished to avoid ‘fetishising’ carbon by including it and not including the huge number of other possible outcomes such as biodiversity loss and land-use change.

3 Results

A total of exactly 600 documents were found which meet our criteria, in that they mention at least one non-energy policy and also mention, at least in passing, the impact of this policy/policies on energy (or transport) systems.¹ The papers we found are from diverse disciplines, including policy studies and politics, economics, international relations, geography, social and behavioural sciences: there is no united literature on this topic, and we found very little cross-referencing between sectors. Of these 600 documents, only 73 provide dedicated analysis of the impacts of non-energy policies on energy and transport (while the remainder offer partial or tangential discussion of these relationships). These 73 documents were spread across the policy areas, but showed a tendency to cluster around specific issues. For example, there is a

¹ Our original search returned 576 documents; our updated search has identified an additional 24. Some of the 73 papers we found which conduct dedicated analysis of the topic relate to sectors not covered in this paper; these are discussed in Cox et al., 2016.

significant cluster of papers focusing on the impacts of urban planning policies on transport demand, and a smaller cluster focusing on the impacts of school choice policies on the transport practices of parents and children.

For the purposes of this review article, we have selected six of the original thirteen policy areas for discussion. We have chosen these six areas because they are categories in which the literature we identified indicates that a) policies in the sector have major energy system implications (for example, by contributing to high or growing energy demand or particularly challenging energy supply dynamics); and b) these impacts are not adequately recognised by policymakers or researchers, and constitute a significant gap in knowledge. For each policy area, we discuss the relevant analysis that does exist as uncovered by our review² and, crucially, highlight the gaps and current invisibility of many forms of impact. In doing so, we also draw out conceptual and methodological themes that span sectors.

3.1 Communications and technology policy

Nowhere has the pace of technological change been so apparent as in the communications sector. The energy impact of this sector, particularly in terms of ICT, cannot easily be understated: the most recent available figures from 2016 estimate that ICT consumes approximately 5% of global electricity production, and this figure has likely grown substantially since then (Hazas and Morley, 2016). The communications sector is also linked to a large number of other sectors, including industry, work, health and education. Importantly, this topic is not only relevant for industrialised nations: emerging economies are similarly facing changes to their economies and working patterns caused by digitalisation, a trend which is only likely to increase in pace in the near future.

Our review found a large number of articles on the energy impacts of the internet. For example, ICT is recognised as driving increases in electricity demand in almost all countries; in some areas the increasing

² This includes both the papers offering dedicated analysis (where these exist) and the other documents identified within that policy area.

electricity load from computers and servers is creating a strain on electricity networks, particularly when peak ICT load occurs at times of day previously not associated with high loads (for instance, when servers require energy for cooling during hot summer days) (Andreopoulou, 2012; Avgerinou et al., 2017; Belkhir and Elmeligi, 2018; Bhattacharjee et al., 2017; Mansell and Raboy, 2011; Moreno and Xu, 2011; Morley and Lord, 2016; Murugesan, 2008; Ozturk et al., 2011; Pothitou et al., 2017; Riaz et al., 2009; Santika et al., 2019). Pothitou et al. (2017) discuss a range of communications-policy solutions for reducing ICT energy demand, including energy-efficiency labelling and mandatory energy performance standards; they go on to argue that energy efficiency improvements alone are unlikely to be sufficient unless aligned with solutions which account for new social practices related to the use of ICT. There are also indications that some aspects of ICT policy may contribute to *reducing* demand: for example, the UK government commissioned an analysis which claimed that the UK's national roll-out of high-speed broadband is likely to result in annual carbon savings of 1.6 million tonnes by 2024, mainly from an increase in teleworking (using less transport fuel) and switching to cloud-based rather than on-site servers (using less electricity) (SQW, 2013). There is also a body of literature which examines the impacts of ICT on travel and transport, particularly focusing on personal activity patterns and teleworking (Lyons, 2002; Ren and Kwan, 2009; Select Committee on Communications, 2013; Snellen and de Hollander, 2017; Travesset-Baro et al., 2016).

That said, the existing literature generally views the internet as a *technology* rather than an outcome of policy. There is therefore little analysis of how policies in this sector affect energy demand: these policies remain 'invisible energy policies' (Royston et al., 2018). The evolution and impacts of the internet are affected by policy as well as technological development, and policy also influences important factors determining ICT energy consumption such as uptake and efficiency. Research in this area may in fact be starting to emerge: a paper by Morley et al. (2018) shows that everyday practices are shifting as ICT energy consumption grows, and that policies which encourage extra data traffic in homes currently lack consideration of the significant implications of this for electricity peaks and global energy demand.

Meanwhile Christensen and Rommes (2019) assess the negative impacts of ICT practices and policies in institutions such as schools on the plasticity of young peoples' energy demand in the Netherlands, thus

illustrating how ICT is tightly connected to other sectors. The similarity of this case study with trends in the UK and elsewhere also illustrates the generalisable nature of such impacts to other national contexts.

Internet policy may appear to be relatively intractable, because regardless of energy impacts, higher-speed broadband is generally considered to be a necessary goal. However, solutions could be found by looking at a wider nexus of interlocking policies from multiple sectors: for instance, *work* policies which support more spatial and temporal flexibility (e.g. teleworking) could reduce peak-time traffic congestion and transport emissions. This example illustrates that thinking beyond policy silos can open up new avenues for mitigating the energy impacts of non-energy policies.

3.2 Education policy

Education accounted for 11% of UK service sector energy consumption in 2016 (BEIS, 2017), and is one of the fastest-growing energy demand sectors (Ward et al., 2008), so the potential energy impacts of education policies are significant. The Higher Education sector in the UK has legally-binding targets to reduce emissions by 43% from 2005 to 2020; yet a 2017 report suggested that 59% of Universities would fail to meet this target (Brite Green, 2017).

Much existing research on this sector focuses on the impact of education policies on demand for, and patterns of, transport. This is a particularly salient issue in the US, which introduced legislation in 2002 to promote flexibility of school choice (the 'No Child Left Behind' initiative), in which children are no longer expected to attend their nearest school, thus leading to greater distances being travelled (Center for Cities & Schools, 2015; Coleman et al., 2012; Marshall et al., 2010; Wilson et al., 2007, 2010). As pointed out by Hallsworth et al. (1998), the UK has experienced similar changes in education policy towards promotion of free school choice. A modelling analysis by Van Ristell et al. (2013) finds that school choices which are more closely aligned with geographical location (i.e. the opposite of the free choice policies) reduce transport-related emissions, due to increased use of walking and cycling and fewer vehicle miles travelled. This is a clear example of the significant impacts that education policy can have on one particular type of energy demand; yet beyond this specific topic, the links are largely invisible in both research and policy literatures.

The only other dedicated analysis we found in this sector is by Royston (2016), who finds that the shift to tuition fees and the marketisation of Higher Education have led universities to focus increasingly on ‘student experience’, which means new buildings, longer opening hours and larger student accommodation – all of which leads to increased energy demand. Most of the literature on the energy demand of education institutions consists of grey literature from the sector itself and, in common with many of the sectors discussed here, tends to focus on particular energy policies or energy interventions, rather than looking at the impact of *education policies* on energy demand.

Another topic which has received attention in the literature, particularly in the UK, is that of the availability of skilled workers for the energy sector. There are concerns regarding potential skills shortages for large new-build energy infrastructures such as nuclear and renewables, although most of the literature on this topic comprises non-peer-reviewed policy and think tank reports (Cogent Sector Skills Council et al., 2008; Energy Research Partnership, 2014; Goulden and Isola, 2009; Harrison, 2015; Innovation, Universities, Science and Skills Committee, 2009; International Labour Office and Skills and Employability Department, 2011; Nuclear Energy Skills Alliance, 2015). Clearly, the supply of workers to these energy sectors (and thus the future development of these sectors) could be substantially influenced by education policies, for instance policies to increase the number of people gaining STEM and energy qualifications in further and higher education; however, none of the reports cited here conduct dedicated analysis of the impact of education policy on energy skills provision. In an emerging theme which is common to multiple sectors, the focus tends to be on recommending future policy strategies, rather than analysis of policy impacts.

3.3 Health policy

According to the most recent official figures available, the health sector accounts for 12% of service sector energy consumption in the UK (BEIS, 2017), so the potential for health policies to impact energy use is high. Insights into impacts of health policy on energy demand have been provided by a small number of dedicated analyses: Blue (2018) shows how policies on treatment targets (among other things) have shifted practice in hospital care, with energy implications: for example, energy-intensive services such as pathology

and radiology are now often provided immediately at the start of patients' treatment pathways.

Meanwhile, Hand et al. (2005) show how government-run health campaigns influenced public perceptions of cleanliness which led to the now-common practice of showering every day; and Nicholls and Strengers (2018) analyse the impact of official infant health advice in Australia on increasing energy demand for air conditioning. (The topic of air conditioning, whilst less relevant for the UK, is generalisable to many parts of the world; meanwhile in the UK, we hypothesise that health advice on keeping infants warm in winter could lead to increased heating demand.) Overall however, a far greater proportion of the literature we found looks at the impact of energy policies on health (for example, the impact of transport policy on air pollution), rather than the other way round.

A common theme in this sector is the idea of promoting physical activity (e.g. walking and cycling) for health reasons. However, the impact on transport systems and behaviours is often only mentioned in passing (for example, Kahn et al., 2002; King, 1998; Morandi, 2009; Nordh et al., 2017; Pretty, 2006; Task Force on Community Preventative Services, 2002). An analysis by Lawlor et al. (2003) looks at policies to promote cycling for health reasons, such as creating cycle paths and networks; yet though they mention the potential impacts of this on demand for motorised transport, this is only in passing. Similarly, an analysis by Sallis et al. (1998) into the effectiveness of various policy strategies for improving activity levels only mentions transport impacts in passing. De Meester et al. (2014) draw a link between the health and education sectors in an analysis of activity levels in children; they argue that improvements in physical activity can follow from health education policies in schools. This article is an interesting one to highlight, because it again illustrates our earlier point about looking across sectors: in this case, changes to education policy could result in health and transport co-benefits.

Similarly to the education sector, we found a number of documents on the energy demands of large institutions – in this case hospitals which, like universities, have high energy demand. Brown et al. (2012) and the Department of Health (2015) both look at the energy consumption of the NHS, which has an active policy for energy demand reduction (unlike the vast majority of public health institutions around the

world). Like many of the documents from the sector, however, these seek to generate policy recommendations but do not attempt to analyse the impact of policies. It is important to note that carrying out a search using the keyword 'carbon' may have identified more literature on this particular topic, therefore it is worth being cautious about the gap identified here. Nevertheless, the literature we did find generates an important insight: the main reason why institutions such as hospitals seek to reduce their energy consumption is to reduce expenditure, driven by economic priorities and budgetary constraints. As discussed in the 'communications' section, this illustrates the importance of looking not just at linkages between single-sector policies and energy, but more broadly at the nexus of interdependent policy decisions, processes and dynamics across multiple sectors.

3.4 Work and welfare policy

There is little available information on the estimated energy impacts of the work and welfare sector, but it is clear that this sector has a significant impact on energy, both directly (for example, because the type and location of people's work influences their energy demand), and indirectly (because this sector influences multiple other sectors). Butler et al. (2016) point out that welfare policy can impact energy consumption in diverse ways, including demand reduction (e.g. through improvements in housing standards) and the reproduction of certain demand patterns (e.g. from employment policies). Building on that work, Butler et al. (2018) conduct dedicated analysis of the impact of welfare policies on energy demand in the UK, arguing that energy vulnerabilities are affected in direct ways by contemporary welfare and employment policies, and that the connections between fuel poverty and poverty more generally are not being addressed in the necessary cross-departmental manner. Importantly, they also emphasise that there are multiple wider governance agendas with important implications for energy demand that become visible when looking at other areas of policy: for example, welfare policy plays a role in digitalisation, by generating new digital requirements for accessing welfare services.

Despite the relatively large volume of literature on this sector, most of it is dedicated to a small set of specific themes. The main one of these is the impact of UK welfare reform, particularly benefits payments,

on fuel poverty. Grey and non-peer-reviewed literature dominates this topic, and only a small proportion of the articles we found carry out dedicated analysis (Guertler and Jansz, 2012; Lambie-Mumford et al., 2016; Snell et al., 2015). A recent paper by Mould and Baker (2017) looks at a number of issues including this one, and argues that welfare policy is currently not well-aligned with fuel poverty policy (which tends to be rooted in the energy sector); they argue that seeking better policy alignment might be more effective than the current strategy of focusing on improving energy efficiency. The second theme in this category relates to transport access, and the impact of welfare and equality policies; in particular, we found a body of literature on the impact of disability and gender policies on access to public transport (Cole, 2006; Darcy and Burke, 2018; Hamilton et al., 2005; Lowe et al., 2015; Roberts et al., 2006; Vanhala, 2006; Wilson, 2003). In addition, there are also a number of studies examining the energy system impacts of the transport sector, but these lie outside the scope of our analysis.

It is likely that policies around the liberalisation of labour markets will affect workers' transport demand, yet we did not find any analyses of this, despite the fact that there is evidence suggesting links between labour market trends and commuting patterns (Department for Transport, 2017; Ozkul, 2014) and extensive work on liberalisation of labour markets (e.g. Peck, 1996). Also, in theory, policies that increase wages or decrease unemployment may lead to an increase in people's spending power, which in turn increases energy consumption, but we did not find any analysis of this. (See also the discussion of earnings, taxation and energy demand in section 3.5). We did find several quantitative analyses of rebound effects relating to energy efficiency, all of which point out that assumptions relating to labour market structure can have a significant impact on the results from economic models; however, these papers do not draw links with labour market policies, because changes to the labour market are represented as the result of market mechanisms rather than actual policies (e.g. Allan et al., 2007; Hanley et al., 2006; Turner, 2009). This reflects a recurring pattern throughout the literature, in which phenomena such as labour market structure are presented independent of any policies, despite the fact that governments clearly have a hand in producing and reproducing them.

3.5 Economic policy

'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,' writes Solow (2005: 511). The energy impacts of fiscal, monetary and other economic policies on energy systems are clearly extremely large, partly because economic policy is of paramount importance for governments, but also because of the overlaps and interdependencies between the economic policy sector and all other sectors. These interdependencies also create complexities which made this a challenging category to analyse. Nevertheless, the prevailing topic within this category relates to energy commodities, with a substantial body of literature on the impacts of exchange rate and interest rate policies on the costs of energy goods, particularly oil (e.g. Adewuyi, 2016; Darby and Phillips, 2007; El-Erian, 2012; Frankel, 2006; Halkos and Paizanos, 2016; Hasanov et al., 2017; Hussain et al., 2017; Rosa, 2014; Tokic, 2015; Yoshino and Taghizadeh-Hesary, 2016). There is also a substantial body of literature on the links between economic growth and energy, but with generally little mention of the policies which may be driving this growth.

We also found a body of literature on the privatisation and liberalisation of energy utilities. There is literature on this from multiple national and cross-national contexts; articles focusing on the UK case include Eikeland (1998); Jamasb and Pollitt (2008, 2015, 2011); Joskow (2008); Kishimoto et al. (2017); and Newbery (2005, 1997). Regarding other impacts of liberalisation, our review only identified one Working Paper, which argues that a shift towards liberalisation in sectors such as the aviation industry has increased air travel, and thus increased energy demand from the aviation sector (Reardon and Marsden 2016). Work in this area is mostly framed as contributing to analysis of liberalisation as a whole, with the energy sector being analysed alongside examples from other sectors, such as railways and communications networks. Importantly, the approach taken in this body of literature tends to view liberalisation as an overarching long-term, large-scale process with ramifications for various sectors (including the energy sector), rather than as a particular agenda implemented through specific policies at specific sites and scales.

We anticipated that taxation policy would have received attention in the literature, because of the significant impacts that taxes can have on the supply and demand of any commodity. One example of this is in the exchange rates and interest rates discussed previously; but beyond this, the literature mainly refers to specific energy taxes (for instance, oil and gas taxes or transportation tax) and does not explore the broader tax regime within which these sit. There appears to exist a significant gap in the literature on the impacts of income, property and other personal taxes on energy demand. Research has shown a correlation between high earnings and high energy consumption/carbon footprints (Preston et al., 2013; Sommer and Kratena, 2017), and given the impacts of taxation on expendable income, it follows that taxation likely has significant impacts on energy consumption. Yet the only reference we found to this was tangential, in articles which discuss attempts to create a (real or hypothetical) revenue-neutral carbon tax, in which the regressiveness of the carbon tax would in theory be reduced via corresponding reductions in income tax (e.g. Bandyopadhyay et al., 2007; Dresner and Ekins, 2006).

3.6 International trade policy

International trade creates energy impacts via demand for global transport, in particular within industries such as shipping. Global energy consumption for freight is projected to grow from 40 quadrillion Btu in 2012 to 60 quadrillion Btu in 2040, with marine vessels accounting for nearly a third of the total (EIA, 2016), and maritime transport is responsible for around 2.5% of global greenhouse gas emissions (IMO, 2014).

Many articles address the fact that changes in international trade policy could have major energy impacts, including through global freight demand (e.g. Cadarso et al., 2010; Cristea et al., 2013; Hecht and Andrew, 1997; Kosmas and Acciaro, 2017; Levinson, 2009; Shannina et al., 2017; Vöhringer et al., 2013). However, most analyses of international trade and energy consumption discuss ways in which transportation changes can impact trade rather than vice versa, or they discuss trade dynamics without discussing policy. This issue is connected to agricultural policy, because a significant proportion of global freight relates to food consumption and policies relating to the sourcing of food internationally (cf. Cox et al., 2016). There is not scope to cover the agricultural sector in detail within this article, but this constitutes another example of

the importance of looking at cross-cutting and interconnected impacts across a nexus of policies from multiple sectors.

Elsewhere in the trade policy literature, some articles examine the ways in which shifts in trade policy could contribute to clean energy objectives or emissions reduction targets, for example by setting export tax rates to discourage energy-intensive exports (Eisenbarth, 2017), addressing obstacles to clean energy trade (Fu et al., 2017; Hughes and Meckling, 2017; Melendez-Ortiz and Sugathan, 2017; Zhao et al., 2017), or formulating trade strategies to address climate goals (Mathews, 2017). We found a substantial body of analysis, all peer-reviewed, on the impacts of trade ‘openness’ on energy consumption; these articles focus on a range of national and international contexts, and come to divergent conclusions about the energy consumption consequences of international trade (e.g. Ben Jebli and Ben Youssef, 2015; Isik et al., 2017; Lean and Smyth, 2010; Machado et al., 2001; Sadorsky, 2012, 2011; Shahbaz et al., 2014; Suri and Chapman, 1998). In an emerging theme common to many of the sectors in this paper (and which shall be discussed further in section 4), these papers tend not to mention specific policies or to analyse the impacts of policies in any detail, but rather discuss a general process of trade openness. There is also some emerging literature on the energy impacts of e-commerce; however, like the literature on communications, these tend to view e-commerce as driven by technology rather than policy (e.g. Ding et al., 2017; Palsson et al., 2017). Finally, we also found a body of analysis which seeks to quantify national consumption-based greenhouse gas emissions, in an attempt to account for the emissions embodied in traded goods; work exploring this in the UK context includes Baker (2018), Barrett et al. (2013, 2011), DEFRA (2016), Scott et al. (2013) and Wiedmann et al. (2008). Again, this literature does not tend to refer to policies *per se*, focusing instead on quantitative analysis of emissions (though it is worth noting that, as much of this literature concerns carbon emissions, it is possible that a search strategy including the term ‘carbon’ would have identified further literature). In general, this sector illustrates a prevailing pattern, which is that analyses tend to focus on the links between general phenomena (globalisation, liberalisation, digitalisation etc.) and energy supply or demand, rather than on the impacts of specific non-energy policies.

4 Discussion

4.1 The 'invisibility' of non-energy policy impacts on energy systems

At its simplest, the relationship between non-energy policies and energy systems can be represented as follows:

Non-energy policies → Non-energy sectors/phenomena → Energy systems

Several qualifications to this schematic are undoubtedly required. First, while non-energy policies clearly affect non-energy sectors/phenomena, they are not their sole determinants; there are many other causal influences on non-energy sectors/phenomena and neither this article, nor any of the literature reviewed, seeks to suggest otherwise. Second, neither non-energy policies nor non-energy sectors/phenomena operate in isolation: non-energy sectors/phenomena are typically affected by multiple, and sometimes contradictory, policy objectives and processes, while patterns of energy demand are shaped by interactions between various non-energy sectors/phenomena (e.g. labour markets and broadband provision). A recent paper on the energy demand implications of the Sustainable Development Goals provides a particularly good illustration of this: see Santika et al. (2019). Third, neither this schematic nor any of the foregoing analysis mean to imply that analysing or calculating the impacts of non-energy policies on energy systems is straightforward; quite the contrary, the analytical challenges involved are clearly huge. Still, this highly simplified schematic both identifies an important causal pathway, and provides a simple framework for review and evaluation of the existing literature.

In one sense, the fact that we have identified such a large number of documents (600) which at least mention connections between non-energy policies and energy systems demonstrates both the significance of this issue, and its partial visibility within the literature. Moreover, as shown in section 3, a number of studies do provide dedicated analyses of the impact of non-energy policies on energy systems, and examine these connections in an explicit, focused and detailed way. However, these studies are from a range of disciplines and do not constitute a coherent body of literature, there being virtually no cross-referencing between them. A large proportion of the 73 dedicated analyses we found belong to bodies of similar

literature on a very small number of specific topics (for example, the impact of school choice policy on mobility patterns, or the impact of exchange rate policies on the cost of energy commodities). Beyond these topics, the connections between non-energy policies and energy systems are usually just tacitly implied, or treated as tangential to the papers' central arguments. For whatever reason, it is also far more common for studies to analyse the impacts of energy policies on non-energy outcomes (e.g. health, GDP or air quality) than the impacts of non-energy policies on energy systems.

Indeed, most research on this topic falls into two categories, with two different limitations. On the one hand, research on the effects of non-energy sectors/phenomena on energy systems very rarely considers how these sectors/phenomena have themselves been shaped by non-energy policies. Thus papers may explore how energy systems are affected by urbanisation, trade expansion or GDP growth, but fail to consider how policies have influenced the growth of cities, market shifts or economic development. As an example, liberalisation is frequently discussed in research on energy systems: there exists discussion of the impacts of liberalisation on energy supply and demand in literatures on industrial policy, trade policy, foreign aid policy, education policy, agricultural policy, and media policy (and a review directly focusing on this topic would likely add to the list). But liberalisation is generally represented in these studies as a contextual factor – as a long-term, large-scale process with ramifications for various sectors, including the energy sector – rather than as a specific policy agenda implemented through particular policies at particular sites and scales. In truth, of course, policymakers clearly have a hand in processes of liberalisation. By passing over this and instead presenting liberalisation as an inexorable process, analysts effectively reproduce depoliticised and naturalised understandings of the causes of energy system change (Kuzemko, 2016).

Relatedly, while numerous papers seek to model or quantify the causes of energy system change, very few consider the impacts of policies *per se*. Instead, such studies generally focus on a non-energy variable such as GDP or population growth and analyse its relationship with a variable such as energy price or energy consumption. There may be some reflection on policy, but this is usually in the form of policy

recommendations, or at the level of hypotheticals. The issue of integrated or joined-up policy-making was not the subject of much dedicated analysis in the work we considered, although many papers touched on it in their policy recommendations.

On the other hand, and at the other end of our schematic, research on the impacts of non-energy policies on non-energy sectors/phenomena – for instance on how communications policies affect digitalisation, how education policies affect school choice, and how health policies affect hospital practice – rarely discusses energy. We therefore have a lacuna. There exists research exploring the relationship represented by the first arrow of the schematic above, and other work focused on the second, but very little which takes a holistic view of the overall relationship between non-energy policies and energy systems. This fragmentation is significant, because it makes it all the more difficult to see, and in turn ameliorate, the impacts of non-energy policies on energy systems. This fragmentation thus contributes to rendering non-energy policy impacts on energy supply and demand invisible.

4.2 Towards a future research agenda

In view of this, we recommend that future work should aim to make non-energy policies more visible within energy research, specifically by taking an integrative approach that encompasses both parts of the above causal chain. As part of this, there is a role for empirical studies of the implications of policies in individual sectors, similar to the work by Royston (2016) on higher education and Butler et al. (2018, 2016) on welfare. This also, however, requires work which analyses the interactions, feedbacks, synergies and so on between the policies of different sectors. For example, it was noted above that a policy for roll-out of high-speed broadband may appear relatively intractable, thus making it challenging to mitigate its impacts on energy demand, but that if policies guiding working practices are factored in, avenues for change may become more readily apparent. As noted by Butler et al. (2018: 71), ‘by examining policy and governance only in terms of the categories, classifications, and distinctions of existing government institutions, analysis can obscure these non-linear outcomes and wider forms of influence,’ including the ways in which the very framing of issues has major implications for what is considered feasible within energy policy.

In addition to making the linkages between non-energy policies and energy systems more visible, there is urgent need for research on the significance of these linkages, and on their tractability. For example, it is one thing to show that there exist connections between the liberalisation of education services or labour markets and rising transport demand; it is quite another to specify the precise contribution of such policy agendas to rising demand, or to calculate the energy demand consequences of alternative policies, or to suggest how energy demand concerns might be better integrated into non-energy policy objectives. The major research challenge in this area is not so much to establish that causal linkages exist – since, as noted, this is in one sense quite obvious – but to establish their significance and, by extension, the potential for policy-supported and politically-inspired change.

5 Conclusion and Policy implications

Energy systems are affected by a plethora of policies from outside the energy sector. Yet because of existing silos in research and policymaking, energy matters tend to be understood from a narrowly energy-centric basis, without much consideration of these wider influences. To draw attention to and encourage reflection on this problem, this paper has reported the findings of a systematic literature search and review (carried out in 2016 and updated in 2018) into existing research on the impact of non-energy policies on energy systems including transport. It has focused on six sectors where, despite the existence of some research on the links between non-energy policies and energy systems, there exist noteworthy research gaps. Overall, we have argued that non-energy policy impacts on energy systems are not sufficiently visible, and their significance and tractability are not sufficiently understood, within either research or policy. By neglecting the role of policy, much of the existing literature obscures the role of assorted political objectives, processes and decisions in the constitution of energy systems.

The main policy implication of our analysis follows directly from this. The near-invisibility of the role of non-energy policies in the constitution of energy systems, and the prevalence of depoliticised understandings of the causes of energy systems change, inevitably make ‘joined-up’ policymaking across the energy/non-

energy divide more difficult and less likely. In particular, the widespread inattention to the role of non-energy policies – and by extension governments and other governing institutions – in creating, maintaining and reproducing patterns of energy demand helps to naturalise this demand, to place it beyond question, and to impede efforts to manage and reduce it (Royston et al., 2018; Shove, 2014). By no means do we mean to suggest that such joined-up policymaking would be straightforward, or that energy-related priorities could be easily integrated into or ‘mainstreamed’ within non-energy domains. But this is a challenge for elsewhere. Here, we simply wish to stress that improving knowledge and understanding of the complex and multi-faceted connections between non-energy policies and energy systems is a vital task for researchers and policymakers alike.

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Appendix A: Keywords used in literature search

Each sectoral term was searched alongside each policy term and each energy term. So for example, the sectoral term 'agriculture' was searched 18 times in total (3 policy terms multiplied by 6 energy terms).

Each search was carried out in full using the following databases: Web of Science, Scopus, Google Scholar, the University of Sussex Library catalogue, and google.co.uk.

Sectoral terms	Policy terms	Energy terms
Agricultur(e/al)	Judicial	Energy
Air quality	Justice	Electricity
Art	Land use	Fuel
Brexit	Law	Gas
Building	Manufactur(e/ing)	Oil
Business	Marine	Transport
Commerce	Media	
Communication	Military	
Competition	Monetary	
Construction	Music	
Culture	NOX	
Cyber	Overseas	
Decentralisation	Particulate	
Defence	Pension fund	
Devolution	Pensions	
Economic	Planning	
Education	Pollution	
Enterprise	Population	
Equality	Prisons	
EU exit	River	
EU referendum	Security	
Families	Sport	
Finance	Tax	
Fiscal	Telecoms	
Flood	Water	
Food	Welfare	
Foreign	Work	
Freight		
Health		
Housing		
Industr(y/ial)		
Innovation		
International aid		
International trade		
ICT		