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The role of knowledge exchange in energy demand policy innovation

Authors

Clare Downing[1], Email: clare.downing@ouce.ox.ac.uk, Sarah Higginson[1], Email: sarah.higginson@ouce.ox.ac.uk, Tanya Wilkins , Email: tanya.wilkins@anu.edu.au, Rose Kobusinge[1], Email: nrosekobusinge@gmail.com, Hannah Simon[1], Email: hannah.r.simon@gmail.com, Kay Jenkinson[1], Email: kay.jenkinson@ouce.ox.ac.uk,

Affiliations: (1) Environmental Change Institute, University of Oxford, Address: OUCE, South Parks Road, Oxford OX1 3QY, (2) National Centre for the Public Awareness of Science, Australian National University. Address: Peter Baume Building, #42A Linnaeus Way, Canberra, ACT, 2601.

Abstract

The purpose of this paper is to draw together lessons from a systematic review of academic knowledge exchange (KE) literature with the aim of informing the energy demand field, especially with regards to policy development. The exchange of knowledge between researchers and stakeholders such as policymakers is an essential part of ensuring that energy demand policy is evidence-based. At its most engaged, two-way KE involves researchers and policymakers both participating in, and sometimes even co-creating policy, in a long-term relationship. KE (and the tools, processes, skills, engagement methods and knowledge involved) is therefore critical to maximising the impact of research.

This paper is based on a systematic review of the KE literature across eight thematic areas, taking ten papers from each area, resulting in a review of 80 papers. Analysis of these papers synthesised the factors necessary for effective KE. CREDS https://www.creds.ac.uk/ (Centre for Research into Energy Demand Solutions), is a major UK-based energy demand research programme, that is presented as a case study demonstrating the use of KE, in particular in relation to policy impact and innovation. The paper ends with combined lessons from the literature and the empirical evidence from CREDS.

Key words

Knowledge exchange, literature review, energy demand, research-informed policy innovation

Introduction

The aim of this study was to conduct a systematic review of the literature on knowledge exchange (KE) and related concepts across eight subject areas (Education, Health, Marketing and Communications, Environment, Climate, Sustainability and Energy, Business, IT, Political Science and International Development) in order to draw out the factors applicable to KE in energy demand (ED) research.

Systematic literature reviews pose "a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review" (Cochrane, 2016). As the volume of literature expands, so the usefulness of such reviews, to bring together, synthesise, and critique the literature has increased (Siddaway, 2018). A primary benefit of these reviews is that they provide a single point of reference by means of which to 'achieve robust and broad conclusions and implications' (Baumeister, 2013).

The audience for this paper is energy demand researchers and policymakers interested in evidence-based policy.

Paper structure

This paper is developed in the following sections: the **introduction**; the **methodology** employed in the literature review; the **results** of the review from across the eight disciplines; the discussion of CREDS as a **case study**, applying the literature review results to an energy demand research programme; the **lessons** for the wider energy demand research and policy community on how to use KE as a tool in energy demand policy innovation; and the **conclusion**.

What is Knowledge Exchange?

Questions have been raised about the strategic purpose, value for money and impact of research beyond academia considering the substantial the amount that is being invested (Walshe & Davies, 2013). Many authors consider KE a positive way to achieve impact, make connections between stakeholders and share research for use in policy making (Provvidenza et al. 2013; Zahedi et al. 2016; Sá et al. 2011; Jansen, et al. 2012; Freebairn et al. 2017; Cummings et al. 2018; Quinn, 2014; Kitagawa & Lightowler, 2013; Cooper, 2014; Böcher, 2014; Rossi & Rosli, 2015 and Reed et al. 2014).

In defining KE, it is helpful to separate the two terms, 'knowledge' and 'exchange'. Knowledge is both explicit and tacit. Explicit knowledge exists in symbolic or written forms (i.e. reports, proposals), whereas tacit knowledge is more implicit (i.e. experience, know-how, know-whom, know-where) (Arpaci, 2016). 'Exchange', in this context, is harder to define in that it includes many different activities, such as sharing, generation, co-production, co-management, and brokerage of knowledge (Fazey et al. 2013). Table 1 indicates a range of terms that may be used as synonymous with knowledge exchange.

Table 1: Synonyms for knowledge exchange (KE) (derived from Zahedi et al., 2016)

knowledge exchange	knowledge sharing	knowledge transfer	knowledge management
knowledge mobilisation	knowledge creation	knowledge engineering	knowledge integration
knowledge transfer process	knowledge distribution	knowledge shift	knowledge acquisition
knowledge flow	knowledge discovery	knowledge valuation	knowledge use
knowledge application	knowledge theory	experience transfer	technology transfer
knowledge generation	knowledge co-production	knowledge co-management	brokerage of knowledge

What is considered to be KE has evolved from a 'deficit model' – imparting wisdom from an expert to a layperson or user in a one-way process (Collins, 2012) – to the two-way exchange of knowledge between parties, a more iterative rather than linear process, and involving stakeholders, joint ownership and valuing of different kinds of knowledge (Ali, 2015). Schultze et al. (2014) distinguished KE from communication: not just the sender/receiver model from a source to a destination via a communication channel but rather an organisational-level construct. Similarly, Reed et al. (2014) outlined the recent shift of "knowledge as a thing" (which can be given and received) towards "knowledge as a process" (which evolves over time and is context-specific).

Establishing KE as a spectrum of processes over time allows it to be understood as the generation, sharing and use of knowledge that is appropriate to the context, purpose and participants involved (Wilkins and Cooper 2019). The investment of time in the process also distinguishes the different ends of the spectrum: a short-term exchange, or a more active, longer-term engagement seeking a connecting solution (Lannon & Walsh, 2020). For more complex KE, brokers are required to work at the interface (Hoeijmakers, 2013), who understand the motivations of those involved and can design beneficial outcomes (Ankrah et al. 2013). The characteristics of KE brokers include: inquisitiveness; a belief in the value of evidence; and a commitment to identifying assumptions, posing thoughtful questions, reflection and perspective taking (Archibald et al. 2018).

For the purposes of this paper, KE is defined as a spectrum: at one end, the simple, unidirectional act of passing on information, such as through an email, presentation or noticeboard (Nidhra et al., 2012); at the other, co-produced explicit and tacit knowledge emerging from relationships between engaged stakeholders (Fazey et al. 2013). Such knowledge networks involve collections of institutions varying in scale, goals, reach and geography, but connected through flows of resources, rhetoric and ideas (Fouksman 2017).

The energy demand research context and CREDS

Energy demand (ED) is the term used to describe the consumption of energy by human activity. It drives the whole energy system, influencing the total amount of energy used; the location of, and types of fuel utilised in the energy supply system; and the characteristics of the end-use technologies that consume energy. Reducing our energy use is a critical but often-overlooked part of achieving net zero emissions. As described on the [CREDS website](https://www.creds.ac.uk/), https://www.creds.ac.uk/ the reduction of ED covers all uses of energy and is a multi-disciplinary endeavour covering energy efficiency, reducing demand, and improving demand side flexibility, and hence needs to engage numerous, diverse stakeholders in order to succeed.

As such, lowering ED and reaching net zero emissions will depend on sharing knowledge between those conducting research and those whose work has a direct impact in the field, including policymakers. KE studies have highlighted the need for a central point of coordination and sharing of information at the system level, in order to facilitate effective knowledge exchange beyond the individual or institutional level. The CREDS knowledge exchange team was set up with this remit in mind: to work across the nine CREDS research themes to help share knowledge between them, and to work with external stakeholders. The programme has three audiences: researchers, policymakers and business. Until now, KE has not been an explicit focus of ED research; in fact, the CREDS programme model is seen as something of a case study by its funders, and so is presented here as such.

Methodology: A systematic literature review

This review was undertaken by an interdisciplinary team, both with and without academic backgrounds, which in itself became an exercise in knowledge exchange. Our methodology was based on Kitchenham & Charters (2007) and consisted of three iterative phases.

Phase 1: Planning (definition of research questions, search terms[i], data source, study selection, definition of inclusion and exclusion criteria),

This study was designed to answer the following research questions:

- What KE lessons can be extracted from across a broad range of disciplines?
- How are these lessons applicable to researchers in the energy demand field?

A balance between sensitivity (finding as many articles as possible) and specificity (finding relevant articles) is important in determining search terms (Siddaway, 2018). The approach adopted was to firstly select the search terms. The search terms selected that related to knowledge were:

"knowledge exchange" OR "knowledge transfer" OR "knowledge mobilisation" OR "knowledge sharing"

The search terms selected for the eight disciplines (searching in the paper title only) were added to the knowledge search terms:

"education", "health", "communication" OR "marketing", "**environment**" OR "sustainability" OR "climate change" OR "energy", "business" OR "industry" OR "SME" OR "small to medium enterprise", "information technology" OR "software development", "politics" OR "political science" OR "international

relations" OR "policy development" OR "policy influence", and "knowledge*" AND "international development"[ii].

The eight search strings were run on the Scopus and Web of Science peer-reviewed literature databases, and the top ten papers in each discipline were selected according to the number of citations. A second-tier selection process to ensure the relevance of the ten papers in each discipline was undertaken by a sub-group who collectively read the abstract and selected papers based on the criteria in Table 2 below. This resulted in 80 papers[iii] for the literature review and analysis.

Table 2: Inclusion and exclusion criteria for systematic literature review

Inclusion criteria	Exclusion criteria
• Relevant to business, policymakers and researchers • Must include KE lessons • Peer-reviewed journal article • Published in the last ten years (2010-2020) • English language only	• Relevant to communities or the general public • Mostly covering theoretical concepts rather than practical application of KE • Book chapters

Phase 2: Analysis and synthesis (data extraction, synthesis, coding)

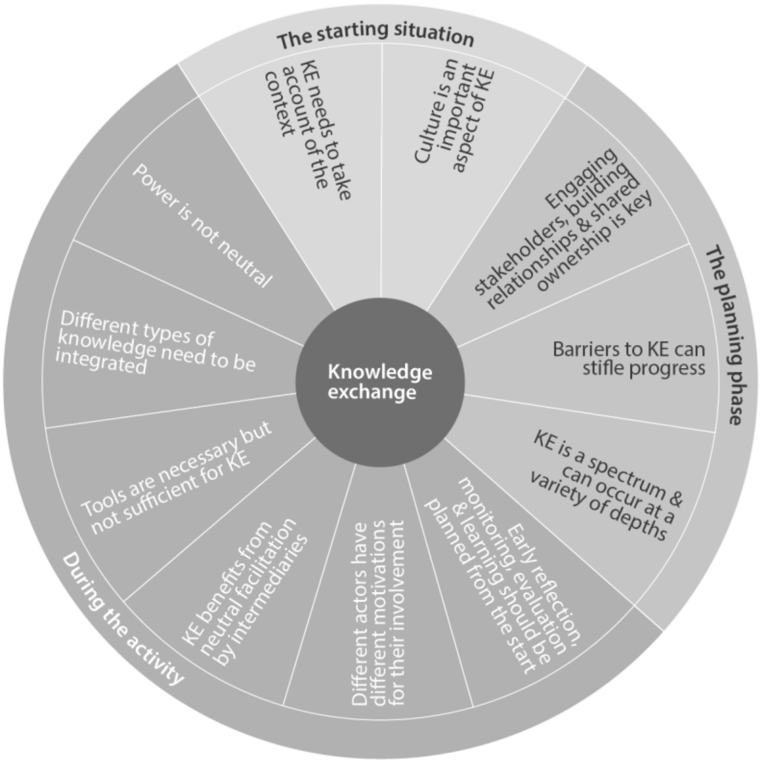
A summary spreadsheet was developed to record the findings from the papers. The spreadsheet was analysed in NVivo[iv], creating initial and child nodes, which were synthesised into the 11 factors of KE.

Phase 3: The final part of the review was to write up the paper.

Results: The eleven factors of KE found in the literature

This section describes the results of the literature review. The results have been synthesised into 11 factors that need to be considered for effective KE. Initial word frequency analysis indicated that the factors did not appear to alter significantly between the disciplines, but the terminology varied and further work is needed to analyse this in more detail. These factors are provided in Figure 1. They are organised according to the chronological process that KE activities typically follow, namely: 'the starting situation', 'the planning phase' and 'during the activity'. However, since KE is an iterative process, the factors could be considered in any order.

Figure 1: KE factors revealed by the literature arranged according to the KE process



The starting situation

KE needs to take account of the context:

KE is context-specific and about the environment within which KE happens. The context includes both the internal organisational setting, as well as the external circumstances within which the KE is being carried out. KE cannot be an 'off the shelf' solution, it needs to be tailor-made to fit the context. How the knowledge is created and experienced (Davison et al. 2012), the usability of the knowledge (Cooper, 2014) and attitudes towards KE, e.g. knowledge as conferring competitive advantage (Charband & Navimipour, 2018; Ghobadi & D'Ambra, 2013) vs. knowledge as co-created for social good are all influenced by the context. The level at which KE is happening is also important, e.g. does it involve individuals, institutions or systems, is it local or (inter)national, and is it human or technology-centric? (Cooper, 2014).

Culture is an important aspect of KE

Culture was mentioned in around a third of the papers reviewed. Culture concerns people: their ethos, values, ways of operating, and attitudes towards knowledge. The literature suggests that KE is supported by organisational cultures that will accept change, or are prepared to make mistakes (Eze et al. 2013; Jack et al. 2010; Oyemomi et al. 2016; Santos et al. 2015). 'Proximity' (cultural and geographical) between organisations (de Zubielqui et al. 2015) and a 'learning culture' (Eid & Nuhu, 2011) are also helpful. Conversely, differences in culture are challenging, e.g. different attitudes between researchers and stakeholders, or disagreement about key research findings (Cvitanovic et al. 2016; Sá et al. 2011; Thomas, 2012). It is important to recognise that best practice and knowledge created in one culture does not automatically translate to another culture (Yuan et al. 2013), and that people from different cultures have different cognitive styles and responses to particular forms of communication (Michailova & Sidarova 2011).

Organisational culture depends on many factors including size, management, commitment towards KE, and reward and incentive schemes (Sá et al. 2011; Cvitanovic et al. 2016). To improve KE, a number of formal mechanisms were suggested, such as Knowledge Exchange Portals (KEPs) to link silos and promote knowledge management (Quinn, 2014), and knowledge sharing visibility (KSV) targets as a way to recognise KE and incentivise staff (Zhang, 2012). A lot of valuable KE happens informally and remains uncodified (Davison et al. 2012). To improve KE, the aim is to inspire employees to contribute individual, tacit, and informal knowledge and organizational memory (Oyemomi et al. 2016).

KE requires leadership and management to deliberately alter the existing culture to better support KE. Certain features are commonly mentioned: the balance between technical drivers (use of technology for knowledge management, such as databases) and social drivers (such as empowering leadership, or effective reward systems) (Eze et al. 2013); communication and leadership styles (human-oriented being better for KE than task-oriented (de Vries et al. 2010)); valuing tacit knowledge exchange via social networks (Arnett & Wittmann, 2014); and encouraging team work, cohesion, and decision-making that unlocks trust, respect, and mutuality (Eze et al. 2013). In contrast, KE is damaged by employee rulebooks (Eze et al. 2013), verbal aggressiveness, lack of support due to being task-oriented (de Vries et al. 2010), and vertical competition (Palacios-Marqués et al. 2015).

The planning phase

Engaging stakeholders, building relationships and shared ownership is key

Engaging stakeholders was mentioned in around 40 percent of papers as the most important enabler of KE. Stakeholders include all actors – knowledge producers, intermediaries, knowledge users, and third parties who may influence or be affected by the work. Some of the benefits of effective stakeholder involvement are: to improve the study question (make it more relevant); improve recruitment (a better sample); to improve the quality of the data by having a wider set of perspectives to draw on; to check that the analysis seems appropriate (face validity); and to understand all views so that appropriate (inclusive) solutions can be found that do not exclude those affected (Abma et al. 2017). For full engagement, participants need equal status. Stakeholder networks (social or professional) and communities of practice (smaller, more focused and drawn together by an issue or interest), both within and between organisations, evolve over time and need to be 'actively facilitated' (Connell, 2014).

KE relies on building trusted relationships. Ghobadi (2015) defines trust as 'the willingness of a person to relate to another, believing that the other's action will be beneficial rather than detrimental'. It influences willingness to share knowledge and learn, and depends on social interaction and co-operation. One of the main ways of creating trust is open, equal dialogue in a transparent process based on respectful relationships, being truthful about likely outcomes, and dealing with conflict fairly. Trustworthiness of leaders, intermediaries or brokers is key, and can only be built through time, patience, humility, and empathy (Reed et al. 2014). This is so important that 'institutional reputations do not matter as much as the personal profile or, the perceived gravitas of the individual' (Thomas, 2012). Trust is damaged by competition for scarce resources, such as funding, clients, new ideas/knowledge, or reputation (Huang, 2014). Lack of trust in an institution can be due to poor management, job insecurity, and inappropriate procedures.

The result of strong engagement and building lasting relationships where stakeholders are motivated to participate is the shared ownership of knowledge.

KE is a spectrum and can occur at a variety of depths

Researchers have tended to be more interested in knowledge production rather than mobilisation, but this does not result in KE (Walshe & Davies, 2013). Focusing only on the dissemination of written 'products', such as reports, briefings or, academic papers, should not be expected to yield a significant long-term impact (Dagenais et al. 2013; van den Driessen Mareeuw et al. 2015). Although written 'products' and online sites can act as vehicles to link researchers to practitioners, policymakers and consumers (Mairs et al. 2013), processes (joint activities and relationships) are generally considered to be more in-depth and result in greater impact (MacKillop & Sheard 2019). Both are of value, however, and Cummings et al. (2018) describe the future of KE as a mixture of practice-based activities (focused on social media, people-centric approaches, and embedded in organisational processes), and societal perspectives on knowledge (focused on cross-domain knowledge integration, different sources and types of knowledge, multi-stakeholder processes, and complex/emergent forms of knowledge).

Long-term KE tends to be iterative and evolving, involving participants in continuous reflection and learning (Archibald et al. 2018) as research, practice, and policy develop alongside one another to address knowledge gaps (Fazey et al. 2013). Jansen et al. (2012) advise integrating policy, practice, and research into a three-way triangle of collaboration and learning. KE is a complex, dynamic process (Archibald et al. 2018) which needs to incorporate scientific state of the art research, orient it towards public goals and practical problems, and involve stakeholders in a transparent process for its use (Belausteguigoitia & De Clercq, 2018; Böcher et al. 2014). Provvidenza et al. (2013) lists the steps of the process as: identifying knowledge needs; adapting knowledge for the context; assessing barriers and selecting facilitators; developing interventions; monitoring knowledge use; and evaluating impact and implementing a plan to sustain knowledge over time. This non-linear, iterative process includes all the steps between the creation of new knowledge and its application, and is not the focus of this paper.

Barriers to KE can stifle progress

The literature highlights significant barriers for KE. In a higher education context, restricted individual and organisational capacity and fear of knowledge revelation (Khalil & Shea, 2012) were commonly cited barriers. Knowledge revelation covered a number of areas: plagiarism, misuse, and that the 'public good' of knowledge could be used for economic gain (Kitagawa & Lightowler, 2013), political gain, or misunderstood by the public. Securing the time, money, and trained personnel to ensure regular, high-quality stakeholder engagement with serious implications for policy engagement was another strong barrier. Once funded, there are tensions between implementation and reporting, i.e. the needs of the work vs. the requirements of the funders (Lannon & Walsh, 2020). The timing of engagement was further challenged by the varied needs of different audiences, be they policy cycles, or news cycles, for example, and may conflict with research outputs, e.g. timing of publishing academic papers.

Solutions to these barriers described in the literature included: capacity building and skills development to enhance KE capabilities (Cvitanovic et al. 2016; Khalil et al., 2012) and promote KE within an organisation (Eid & Nuhu, 2011; Kelly, 2018; van den Driessen Mareeuw et al. 2015; Oyemomi et al. 2016); improving teamworking and interactions between researchers and users, recording KE monitoring data so that impact can be demonstrated (Eid & Nuhu, 2011; Kelly, 2018; van den Driessen Mareeuw et al. 2015) and the use of role models to share KE values (Jansen et al. 2012). Zahedi et al. (2016) stress the importance of 'temporary co-location' (e.g. visits, secondments, and internships), emphasising improved social relations, effective team learning and the dissemination of knowledge.

During the activity

Early reflection, monitoring, evaluation and learning should be planned in from the start

Learning by doing can be beneficial in KE (Mosse, 2014) but KE is often conducted on an ad-hoc basis, based on 'what seems to work' with little theoretical, methodological, or empirical grounding, or systematic evaluation (Reed et al. 2014). KE activities should be part of the grant application, planned in from the beginning of a research project or programme, include strategic KE aims that have been negotiated and agreed by all parties (Ali, 2015; Böcher & Krott, 2014; Cvitanovic et al. 2016) and focus on both short-term dissemination and long-term impact. The strategy should include how momentum will be maintained (Oyemomi, 2016), flexibility built in, and skilled staff and financial resources allocated for KE activities (Reed et al. 2014). It needs to define: how collaboration will happen through which communication channels (Böcher & Krott, 2014; Michailova & Sidorova, 2011), how monitoring and feedback will be captured, and how knowledge will be shared and lessons learned (Cooper, 2014; Cvitanovic et al. 2016; Dagenais et al. 2013; Jack et al. 2010; Kitagawa & Lightowler, 2013; Mairs et al. 2013; Miković et al. 2020). For their part, researchers should plan what gap they aim to fill with what knowledge (Reed et al. 2014), understand their stakeholder group (Mosse, 2014), and select appropriate KE strategies and communications tools (Provvidenza et al. 2013; Böcher & Krott, 2014; Michailova & Sidorova, 2011).

Understanding overall project performance includes an evaluation of the KE strategy (Peltokorpi, 2014). Monitoring and evaluation (M&E) should focus on both the process and impact of the KE (Provvidenza et al. 2013), starting at project initiation and continuing throughout. There is also evidence that quality and environmental management systems that include M&E, such as ISO 9001/14001, are strongly related to knowledge transfer, which fosters innovation (Hamdoun et al. 2018). Monitoring provides the evidence base for the evaluation (Dagenais et al. 2013) and should take account of intended/unintended and positive/negative impacts as well as external factors to understand why things happened (Archibald et al. 2018). It should ideally be both quantitative and qualitative (measuring non-monetary factors such as power, skills, equality and social position (Kelly, 2018; Peltokorpi, 2014). M&E of KE in an academic context should take into account that traditional academic indicators (e.g. citations) do not encourage KE; that the costs and effort involved can be a strain for smaller projects (Lannon & Walsh, 2020); that there is a time lag between the engagement and impact; and many of its impacts are qualitative in nature which makes KE difficult to measure.

The focus of M&E is improvement, not criticism: the results can be used to make adjustments/adaptations (Mairs et al. 2013; Provvidenza et al. 2013), should help refine practices, foster learning, share good practice, and consider the legacy of the project (Reed et al. 2014).

Different actors have different motivations for their involvement

Individual and institutional motivations for engaging in KE were explored by around a third of the papers reviewed. They may be primarily transactional (e.g. based on business outcomes), humanitarian (to achieve some social good), or academic (focused on the accumulation and promotion of knowledge). Di Gangi et al. (2012), for example, suggests individuals who share knowledge might gain status and reputation.

Like businesses, which see knowledge as a significant resource for competitive advantage, access to knowledge plays a key role in universities' innovation enhancement (Charband & Navimipour, 2018; de Zubielqui et al. 2015). Being seen as a neutral broker could be an advantage, something universities might achieve if they are not seeking a profit or attempting to promote an agenda (Collins, 2012). Academia's traditional function, to produce 'tradeable [academic] "goods", such as theories, concepts, methods, and empirical data' (Aris, 2020) leads some to distrust in KE as being associated with the commodification of research (Bates, 2012)[v]. However, others suggest that universities should engage different stakeholders in a 'third mission' (Rossi & Rosli, 2015) to help transform knowledge into better environmental and economic performance (Ryszko, 2016).

To enable KE to work effectively, the motivations of all participants should be understood and addressed, and shared goals communicated effectively (Archibald et al. 2018; Reed et al. 2014; Yuan et al. 2013). These are wide-ranging and may include a desire to increase engagement, connect with communities of practice, share information, recruit participants, crowdsource new ideas, conduct, discuss and challenge emerging research, pursue professional development, keep up to date, expand networks around specialised topics, support peer review, share values and skills, and provide moral support to colleagues (Choo et al. 2015). Ghobadi (2015) bundles his 44 motivations for KE into seven areas: people-related, capability-related, team-related, structure-related, organisational-related, task-related, and technology-related. Miković et al. (2020) suggests the two major reasons why organisations engage in KE are to 'enhance their influence on decision-making processes and to improve the outcomes and power of beneficiaries'. Organisational motivations may also be linked to team or, business objectives, such as competitive advantage or the achievement of team goals (Abma et al. 2017; Ankrah et al. 2013; Arnett & Wittmann, 2014; Cummings et al. 2019; de Zubielqui et al. 2015; Freebairn et al. 2017; Hamdoun et al. 2018; Huang, 2014; Provvidenza et al. 2013).

Importantly, KE is not always positive. It can also be the case that those involved in KE suffer from information overload, that inaccurate information is propagated, or that productivity is harmed through diversion into non-critical tasks (Choo et al. 2015).

KE benefits from neutral facilitation by intermediaries

KE typically takes place between three groups: knowledge producers, intermediaries, and knowledge users (Reed et al. 2014). Intermediaries have many labels, including knowledge brokers, boundary spanners, or technology translators. Their role is to provide a bridging, brokering or facilitation function, but exact definitions are scarce. So-called 'honest brokers' (i.e. declaring any conflicts of interests), intermediaries tend to specialise in a particular domain, such as research, industry or policy, or in a particular type of organisation (Cooper 2014). Intermediaries create social networks both within and between organisations but are likely to have missing network connections due to their areas of specialisation (Arnett & Wittmann, 2014) that may affect their effectiveness.

Collins (2012) highlights eight key knowledge brokering functions: linkage and partnerships, awareness raising, accessibility, engagement, capacity building, implementation support, organisational development, and policy influence. In other words, intermediaries are not just 'conduits' of knowledge but also generate their own knowledge: they must "absorb complex ambivalent messages from diverse sources" and "translate them into terms that can be understood and acted upon" (Fazey et al. 2013). They work across different dimensions, creating broad linkages between organisations, building at several interfaces (researcher, principal investigator, and management levels), supporting active exchange and networking, co-producing knowledge, facilitating multi-actor networks, and working across 'knowledge platforms'.

Intermediaries have been successfully used in university-industry relationships (UIRs) for knowledge transfer since it is believed that collaborative research by academia with industry can be a powerful source of innovation, and governments' concerns that academic research should be relevant to, and accessible by, industry (Ankrah et al. 2013). Funders may also have a role "as connectors and matchmakers in fragmented knowledge infrastructures overseeing other intermediaries and have a presence at many innovation system levels" (van den Driessen Mareeuw, 2015).

Tools are necessary but not sufficient for KE

The technical tools required for KE were mentioned in around a third of papers. The majority of tools mentioned in the literature were 'collaborative technology' (e.g. Ghobadi, 2015) – mainly IT-based systems to encourage information sharing and network building, but also 'phone calls, newsletters and social media'. Alongside this, more social 'tools' such as face-to-face meetings, hackathons, conferences, retreats, and use of shared languages (disciplinary, IT programming or geographic) were also identified as encouraging KE within and between organisations.

As well as providing a repository for information (i.e. for knowledge management), tools support KE by promoting relationships, and building and extending networks. However, the use of interactive technologies does not guarantee KE (Zhang, 2012; Davison et al. 2012) and needs to consider employees' technology preferences (Michailova & Sidorova, 2011). Information technology can support resilient and effective KE communities, but traditional strategies (e.g. meetings, workshops) are even more valuable routes to KE as they support stakeholder engagement and building relationships. In this context, Di Gangi et al. (2012) points out the need to balance the high codification costs of tacit knowledge (which make small, face-to-face interactions preferable), against the need to engage a wider, larger audience.

Different types of knowledge need to be integrated

There are different types of knowledge, which effective KE needs to engage with through respectful dialogue and an open process. Historically, *expert* knowledge has been the most influential (Collins, 2012), particularly in a policy context. However, Fazey et al. (2013) argues that *discipline-specific knowledge* is becoming less distinct, with a shift from the natural sciences towards viewing subject areas as processes involving 'complex and dynamic relationships between people' as part of the way that knowledge is created. KE is therefore a necessarily interdisciplinary endeavour, which partly informed the choice to cover multiple disciplines within this review. As views of what constitutes knowledge change (Ali, 2015; Lannon & Walsh, 2020) researchers have started to recognise the value of *local knowledge*, which better appreciates realities on the ground and lived experiences, resulting in more appropriate recommendations (Mosse 2014). *Tacit knowledge* (gained through experience) is also increasingly seen as important but is typically hard to track, evaluate (Nidhra, 2012), and even articulate, given its very specific, individual nature (De Gangi et al. 2012).

Charband & Navimipour (2018) and Miković et al. (2020) note the life cycle of knowledge as moving through the following phases: creation (or innovation); acquisition (or collection, transformation, and accumulation or storage of tacit into explicit knowledge); dissemination (or transfer of explicit knowledge and sharing of tacit knowledge); and usage (or application, use of knowledge management tools, standardisation of knowledge, storage of data and prevention of data loss, simplicity of knowledge usage).

Power is not neutral

Consistent with the old maxim 'knowledge is inseparable from power' (Fazey et al. 2013), this has profound implications for KE. The relative position and status of those generating and using knowledge significantly affects who has access, how it is transformed and used, and whose voices get heard in decision-making, raising important ethical questions for the design and implementation of KE[vi] – hence the need for an iterative process that values different sources of knowledge, and facilitates discussion to negotiate power and reach a common understanding Freebairn, 2017; Mosse, 2014). Indeed, the emergence of less distinct boundaries between science and society has led to recognition of the need to integrate knowledge from a wider set of perspectives (Fazey et al. 2013).

As above, in academia theoretical knowledge has traditionally been considered more valid than empirical, local or tacit knowledge (Aris, 2020) and debates rage on the relative merits of the physical and social sciences (Ali, 2015; Böcher & Krott, 2014). Power is also embedded in impact evaluation and knowledge management practices, which tend to undervalue local knowledge and lived experience, both spaces in which the most impactful KE often occurs. Such power inequalities are subtle, and they are usually ignored (Kelly, 2018). Fortunately, there are increasing attempts to address some of these issues, particularly in the international development domain, by moving away from colonial models of development, with local or indigenous knowledge, practices, and solutions being recognised as valuable (Collins, 2012). There are lessons here for KE.

Surprisingly perhaps, equality, diversity. and inclusion (EDI) issues hardly emerge in the KE literature. Yet gender, seniority (Thomas, 2012), age, race, sexuality, neurodiversity, and other protected characteristics are all relevant, both in terms of who carries out KE and whose knowledge is shared. Mosse (2014) suggests that adopting highly participative methods of engagement might help. It is therefore concerning that, as Phillipson et al. 2012 report, while stakeholders are involved as research subjects, fewer have influential roles (e.g. event participants, members of advisory groups), or are involved in research dissemination. Moss (2013) points out that the impact of knowledge on stakeholders who were passively engaged is limited[vii].

Despite mainstream acceptance of evidence-informed decision-making, researchers with relevant expertise are often not engaged when policy decisions are made and, similarly, practitioners (considered the 'end users') are often not included in the research process (Ghobadi & D'Ambra, 2013). Thomas (2012) reports that relatively little KE is taking place between academics and the private/ public sectors, and so research councils have begun to fund follow-on projects (Impact Acceleration Awards) for the creation of networks, hosting seminars, or writing non-technical publications, thus helping to support business development and innovation in the future. The literature cautions that KE funding must be applied carefully. Incentives should be carefully designed so as not to preference certain KE activities over others (Rossi & Rosli, 2015). Walshe & Davies (2013) point out the two conflicting positions – while funding has increased markedly, its focus on applied, competitive performance-based research results in increasing 'contractualisation', where research is seen as an income stream of consultancy, patents, and intellectual property, rather than serving knowledge. In contrast, they state that research should be more applied, and should be 'pulled' from practice to ensure transferability.

The social nature of KE provides further issues for discussion in relation to power. Moss (2013) discusses the structural inequalities in the construction of knowledge, and argues that recognising and acting to reduce the impact of power dynamics is important – knowledge should be a 'tool of democracy'. In this context, "people's ability to access, generate, and leverage specialised knowledge" is becoming an important indicator of welfare (Maphosa & Bayat, 2018). Within the public policy sphere, evidence is often judged as trustworthy on the basis of its source (Reed et al. 2014). A critical approach to KE must acknowledge the social nature of knowledge, especially as decision-makers do not often have the resources for critical interrogation of knowledge (Reed et al. 2014).

There is a complicated gap to straddle here. On the one hand, KE is simplified by a shared culture and trusted relationships. On the other, a diversity of knowledge, stakeholders, and tools deepens the process. Intermediaries and all those involved in KE must reflect on their role in KE power structures. They risk becoming gatekeepers to the flow of information and material resources (Taylor & Bhasme, 2018), but can also choose to support and stand in solidarity with particular communities (Ali, 2015) and the kinds of knowledge they own.

Case study: Using KE in CREDS for energy demand research impact

The paper now examines KE in action by presenting a case study featuring an energy demand research programme trying to influence policy. The Centre for Research into Energy Demand Solutions (CREDS) is a large (£19.5M/~23MEuros) research centre established in 2018 with a five year programme, with a vision to make the UK a leader in understanding the changes in energy demand required for the transition to a secure and affordable, low carbon energy system. The research focuses on energy efficiency, reducing demand, and improving demand-side flexibility. Most of the authors of this paper are employed by CREDS.

How CREDS does KE

The energy demand policy and research *context* in the UK: Historically, energy demand research has received significantly less funding and attention than energy supply, and previous UK programmes typically comprised disconnected individual projects. Government funding for energy efficiency policy initiatives has been intermittent, and negligible since 2013. Despite this, since 1970, energy use in the UK has fallen eight percent, while gross domestic product (GDP) has trebled. Taken by its broadest measure (the ratio of GDP to energy use), energy efficiency has improved by a factor of three. The CREDS research proposal was written in 2017, when the UK had a Clean Growth Strategy https://www.gov.uk/government/publications/clean-growth-strategy but before it legally committed itself to the net zero emissions targets https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law .

To ensure that KE was embedded in CREDS from the beginning, the proposal included an impact plan, in which two of the three aims were to: 1) generate impact in research, businesses and policymaking, and 2) to champion the importance of energy demand. Fourteen percent of the budget (£2.8M/~3.1MEuros) was set aside for programme management and KE, significantly more than normal for a research programme in the UK. The programme was set up as one large, interdisciplinary centre, with multiple themes to encourage coordination and integration across the different research areas. The programme included a large flexible fund to support impact and other activities.

The *culture* of supporting KE within CREDS began immediately – an external strategy consultant was commissioned to work with the Executive Committee to develop the mission, vision, branding and values, which guide every activity. All 24 organisations involved in the centre participate in the KE, impact, and championing aims of the centre, a culture actively promoted by the KE team, whole centre meetings (WCMs), training activities, early career researcher events and internal e-newsletter where knowledge is shared and continuous learning is encouraged.

The expectation for KE in the programme was set out within the first six months of the centre in the CREDS Communication and Engagement Strategy and Plan (November 2018). It is also led from the top through the Director and Executive Committee who are engaged and experienced academics and KE practitioners. Members of *the KE team act as intermediaries*, providing a critical mass of specialist expertise, leading innovative practices and catalysing KE activities. CREDS also has a networking role, linking energy demand researchers through its Energy Demand Research Network (EDRN) events and by providing online resources.

From the proposal writing stage, CREDS was committed to *engagement* and building relationships with policy stakeholders. Most research programmes have limited engagement with civil servants and, consequently, reduced policy impact. CREDS has actively built these relationships, such as with the Department for Business, Energy and Industrial Strategy (BEIS), and has an active and ongoing programme of engagement through events, meetings, webinars, invitations to speak, secondments and so on. For example, using the flexible fund, a researcher worked with BEIS on an activity which complemented their own research to identify five projects in the area of non-domestic buildings, successfully discovering research gaps for policy and leading to a facilitated cross-departmental workshop that has improved the programme's understanding of policy priorities across different departments (https://www.creds.ac.uk/publications/engaging-with-civil-servants-to-improve-impact/).

CREDS uses different tools for different levels and types of engagement, engaging *across the KE spectrum*. On the one hand is the website, mostly an example of dissemination but providing a comprehensive showcase of all the research findings in a range of formats, from detailed academic papers and technical reports to short briefings and blogs written in lay-language. Material is promoted via social media, an external e-newsletter and (where of interest to the general public) the mainstream media, and has resulted in engagement with policymakers and other stakeholders.

As well as external audiences, CREDS also focuses on KE within the consortium of around 160 staff. The *tools* are traditional but effective, and include whole centre meetings every six months, a bi-weekly e-newsletter, online meetings and file sharing, and regular 'theme liaison' contact with a dedicated person in the KE team. All of these tools focus at least in part on improving the KE capacity of the consortium, particularly with regard to engaging stakeholders like policymakers. Meanwhile, bi-annual meetings with the advisory board, which includes policymakers, provide an opportunity for an ongoing, two-way engagement that benefits both parties.

On the other hand, *deeper levels of engagement* are evident, such as the long-term and close relationship between the CREDS Materials & Products theme and the UK Climate Change Committee (CCC)[viii] . The relationship involves weekly interactions, and directly shaped and influenced UK climate policy, as evidenced by CCC's citations. It has benefited researchers, enabling them to develop their research through interaction with policymakers and benefits CCC, giving them access to technical expertise (policy analysis, modelling support and a secondment https://www.creds.ac.uk/publications/supporting-the-climate-change-committee/).

Early *monitoring and evaluation* has helped to capture the positive (if immature) impact of CREDS and identify areas for improvement. Both the centre overall, as outlined above, and individual themes or occasionally projects have developed engagement and promotion plans against which progress is measured. The CREDS M&E process monitors impact and progress against these sorts of plans. Again, the tools used are fairly traditional but our feedback suggests that they are working effectively: quarterly and annual reports (see https://www.creds.ac.uk/publications/creds-annual-report-october-2019-to-september-2020/ for an example); feedback forms, an event report and a wash-up meeting for all major events; and a thorough evaluation of whether the programme is achieving its aims was carried out by an external panel of academics, policymakers and industry experts (February 2021).

Different actors have different motivations for their involvement, but knowledge producers (research teams), intermediaries (KE team), and knowledge users (policymakers or other stakeholders) are drawn together to maximise the impact of the work. For example, just as the pandemic began, an interactive online workshop was held with an academic and third sector audience, drawing together their *different types of knowledge* and reflecting on how their research might have greater real-world impact in the context of net zero. The report https://www.creds.ac.uk/event-report-how-might-our-research-have-greater-real-world-impact/ that emerged from this event identified multiple ways in which policymakers, third sector, researchers, academic institutions, and funders need to work together to aid the emergence of a more impact-based research and KE culture in academia.

Finally, CREDS has an active Equality, Diversity and Inclusion (EDI) programme https://www.creds.ac.uk/publications/we-are-the-ones-that-we-seek-equality-diversity-and-inclusion-in-creds/ in *recognition of the power issues in research and KE*. It has a significant focus on promoting early career researchers (ECRs) https://www.creds.ac.uk/publications/evaluation-report-creds-early-career-researcher-flexible-fund-call/ who were allocated a million pounds https://www.creds.ac.uk/eight-exciting-new-projects-from-the-creds-flexible-fund/ (1.1MEuros) of the flexible fund. It also focuses on inclusivity, language, and process to ensure that everyone can participate as fully as possible in this challenging research agenda. This work has attracted widespread interest from other consortia, funders, and policy audiences that are interested in transforming the research landscape into a more equitable space.

How this way of working influences policy

There are many examples of KE within CREDS, but this section focuses on three that had particular and ongoing policy impact. It should be borne in mind that these impacts are immature in that they are beginning to change thinking, but there is still work to do in terms of system transformation. In addition, the researchers and stakeholders involved have existing relationships that were developed over many years before CREDS, and this work would not be possible without that experience.

- **Working with the Local Government Association on transport:** Around 230 councils in England have declared a climate emergency. To help local authorities plan the delivery of these targets, the Local Government Association (LGA) commissioned CREDS Transport and Mobility theme researchers to write a series of 4-page guidance notes on transport decarbonisation. The DecarboN8 research network+ matched the LGA funding and also received an Impact Acceleration Award (IAA) from CREDS. This funding was used to involve a range of experts in two planning workshops, during which the LGA officers co-designed the selection of seven topics, and were kept involved during the writing process to ensure they had insight into the evidence that was being presented. The publication of the briefings was accompanied by publicity on social media and a series of webinars. It is hoped this relationship will lead to future collaborations (see https://www.creds.ac.uk/publications/lga-guidance-on-actions-for-transport-in-the-climate-emergency/).
- **Working with central government on energy in buildings:** Energy Performance Certificates (EPCs) are designed to measure the energy efficiency of domestic and non-domestic buildings, but have long been recognised as being inaccurate, as they are based on *estimated* energy use assessed in relation to the heating system, appliances, heating losses, property size, and insulation of a building. Instead, CREDS researchers are developing a cheaper, more accurate, digitally generated *in-use* building efficiency certificate[ix] that would address the gap between designed and actual energy performance. A close relationship has built up over time between these researchers and the Department for Business, Energy and Industrial Strategy (BEIS), leading to data sharing agreements, further funding, and requests for tailor-made evidence for use in the revision of policy. (see https://www.creds.ac.uk/energy-performance-certificates-in-buildings-consultation-response/).

- **Working with multiple policy stakeholders on industry:** The industrial sector has historically focused on energy efficiency, with much success, but further opportunities in this area are limited. CREDS researchers have been researching how to improve the efficient use of materials through process changes, such as substitution and light-weighting[x]. To help promote this work, they have established an ongoing relationship with a multi-departmental group that discusses the inter-relationships between energy, resources, and the economy, as well as the policy implications. Taken together over many years, these activities have had a transformative impact on understanding what policy options are available to deliver global reductions in energy demand, and has helped shape the resource agenda by providing three indicators – carbon footprint (consumption-based emissions), material footprint (in raw material equivalents), and resource productivity. (see https://www.creds.ac.uk/publications/transforming-uk-government-energy-and-resources-policy/).

Gaps within CREDS

There are a number of areas where CREDS has further work to do on KE. The examples above are considered two-way exchange on the spectrum of KE, but not all staff are equally knowledgeable and able to practice KE: CREDS is working to build capacity of their researchers to conduct engagement through individual support and tailored group training activities. Monitoring began with quarterly reporting, but this was found to provide insufficient depth to assess how effective the KE activities were in some cases, so an additional step to capture in-depth impact related data is being developed.

The recommendations from the evaluation are that CREDS needs to take stock and reflect, engage deeper and wider with policymakers, and consider how it might establish a lasting legacy. CREDS plans to investigate the Knowledge Exchange Framework that has recently been published by UK Research and Innovation (see https://re.ukri.org/knowledge-exchange/knowledge-exchange-framework/) in its reflection process, however, there are concerns that this framework has too strong a focus on the commercialisation aspect of KE.

Lessons from research and practice

The key findings from each of the eleven factors from the literature have been summarised as lessons from the research. In addition, the case study from CREDS has reflected on factors from the literature, and illustrates through empirical evidence how some of these factors are being applied and where there gaps remain. This section shows how these factors have been operationalised (or will be operationalised in future) and suggests that these lessons could be applicable for other energy research programmes and the policy community in order to enhance KE as a tool for improving energy demand policy innovation.

1. **KE needs to take account of the context:** At this point in ED research, at least in the UK, KE is not standard practice and is certainly not well funded. Hence, dedicated budgets are required with clear plans for KE activities and how they will be monitored at the design or proposal stage. Researchers need to know what they want to achieve with the knowledge exchange of their research from the outset and include this as a KE plan. CREDS KE team is working to improve this process within the programme by helping individual researchers to develop KE plans that analyse the context of their research, and selects appropriate stakeholders so that they develop the right messages for the right people, at the right time, in the right way. The right time is not when the research is complete, but when the stakeholder needs the information. The right way is about choosing the right communications tool.
2. **Culture is an important aspect of KE:** Senior management/research leaders need to actively supportive KE and lead by example. There also needs to be a critical mass of KE expertise within the research programme to manage KE of the research results that are generated. While sharing common cultural values and norms can forge strong links that support KE, care should be taken to remain inclusive, addressing cultural differences through a transparent process. Following the

evaluation, CREDS is looking to take stock of its culture with respect to KE to see how this can be improved in the future.

3. **Engaging stakeholders, building relationships and shared ownership is key:** It is clear that thinking needs to start early, in the planning and proposal development stage. Where possible, proposals and research questions should be co-developed with end-users and stakeholders, or at least in consultation with them. This diversifies the research, engages stakeholders early, and helps to address power relationships. CREDS new project on 'System Shock to System Change: Learnings from Covid for energy use in a net zero UK' is being planned, and the KE team is currently developing the stakeholder engagement element in the proposal.
4. **KE can occur at a variety of depths:** KE is a spectrum, with different interventions being appropriate at different times. Long-term, trusting, respectful relationships are important and begin with stakeholder engagement based on mutual benefit. It takes patience, and involves managing and meeting expectations, which can be challenging. CREDS is hoping to continue its ongoing relationships with its main policy links within BEIS and CCC but, is conscious that relationships with other governments departments could be improved, and this is a priority for the future.
5. **Barriers to KE can stifle progress:** There are pros and cons of carrying out KE, and careful thought should be given to whether a particular intervention will support policy impact and innovation. CREDS is planning a training course within each research theme to enhance capacity building and skills in KE, in order to help overcome the barriers, either real or perceived, of the researchers. KE activities need to be recognised, valued, and rewarded within research institutions and, ideally, within the institutions with which engagement takes place. Further funding for impact accelerator award work will be made available within CREDS to support and reward future KE activities.
6. **Early reflection, monitoring, evaluation and learning should be planned in from the start:** It is important to include M&E of the KE process and outcomes from the beginning, and throughout the project. Reflecting with stakeholders on how best to meet their needs can be powerful and facilitate policy innovation. CREDS routinely writes up notes of meetings to clarify actions and assess progress. The programme is also in the process of developing an impact log to monitor progress, so that when impact happens in the future it can provide evidence that proves the influence.
7. **Different actors have different motivations for their involvement:** Ideally, KE requires a clear strategic direction that reflects the reasons that different actors wish to participate, such as competitive advantage, social good, or reputation. Such networks of actors need time and space to develop, and must be proactively managed. CREDS has tried to be proactive by asking their network what they need and why, but it has been a challenge to balance the many different requests with the resources available.
8. **KE benefits from neutral facilitation via intermediaries:** Intermediaries can facilitate KE. Where larger programmes are envisaged, it is advisable to recruit a critical mass of dedicated KE experts, as well as specialists in communication, design, strategic website content management, and programme management to enhance the impact of research, develop and sustain networks, support relationships and the co-production of knowledge, and build the capacity of researchers and stakeholders to engage with each other. CREDS has a team of around eight specialist staff, and budget for facilitating meetings, managing the website, creating materials, etc. but resources are still limited and have to be carefully prioritised.
9. **Tools are necessary but not sufficient for KE:** Information technology (online meetings, webinars and events, social media, websites, etc.) can support KE activity but they are not a substitute for it. CREDS has found that one-to-one engagement via phone calls and subsequent meetings with specific teams have been essential elements for long-term, in-depth KE.

10. **Different types of knowledge need to be integrated:** A commitment to including diverse people and equally valuing all forms and sources of knowledge (expert, local, indigenous, multiple disciplines, policy, practice, and tacit) is important. Finding ways to include tacit knowledge is an ongoing challenge. CREDS holds whole centre meetings so that all members of staff at all levels can interact and share experiences, but the lack of opportunities for socialising in the online WCMs during the COVID-19 pandemic has made sharing of experiences difficult.
11. **Power is not neutral:** It is worth remembering that knowledge is power, and KE is political. Power politics needs to be explicitly addressed within KE processes, both taking account of how the knowledge is produced, shared and used, and paying attention to the differing status and diversity of individuals and organisations in the process. CREDS has started to encourage early career researchers to join Executive Board meetings, so that they can learn more about the governance of a large research programme to help their career development, to demonstrate that the management systems are transparent and open, and that junior staff can have a voice.

Conclusion

The literature review revealed 11 factors for effective KE. These were viewed through the lens of an energy demand programme in the UK as an example of how KE can impact energy demand policy innovation and lessons were drawn out. KE is not standard in energy research but this paper has argued for its inclusion in large research programmes which aim to impact policy. In the effort to meet net zero targets, KE provides an important tool in promoting evidence-based energy demand policy with engagement from multiple stakeholders.

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Endnotes

[i] Search terms might also be called key words and represent the main concepts of the researc topic. They help to organise and make sense of the data.

[ii] This proved to be a more complicated search as the consistent combination of KE terms returned minimal results. A range of combinations were trialled to cover international development, including: "*development*" (returned too many irrelevant results), "developing world", "global south", "majority world", "overseas development aid", "overseas development", "global development", before deciding to change our terms to international development, which finally returned ten papers to read.

[iii] The 80 papers can be found here: https://www.creds.ac.uk/wp-content/uploads/References-KE-literature-review-2021.pdf

[iv] NVivo is a qualitative, data analysis, computer software package that helps researchers to organize, analyse and find insights in unstructured or qualitative data

[v] [v] Indeed, the Knowledge Exchange Framework (KEF) being piloted in the UK for universities would suggest that this critique is not far from the mark: https://re.ukri.org/knowledge-exchange/knowledge-exchange-framework/

[vi] For example, intellectual property rights, the ethical issues of including or excluding marginalized groups, and how power is used to influence what is considered by some to be 'valid' knowledge"

[vii] There was a statistically significant link ($p<0.05$) found between the relationship of stakeholders to projects and their perceived impact.

[viii] The Climate Change Committee (CCC) is an independent non-departmental public body, formed under the Climate Change Act to advise the United Kingdom and devolved Governments and Parliaments on tackling and preparing for climate change.

[ix] Smart Meter Enabled Thermal Efficiency Rating (SMETER)

[x] Substitution of a material with a higher greenhouse gas (GHG) emission with one of a lower GHG emission. Lightweighting involves using fewer materials or making them less heavy to achieve efficiency.

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