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# Toward Regional Low-Carbon Energy Transitions in England: A Relational Perspective

*Ami Crowther*, Saska Petrova and James Evans*

*School of Environment, Education and Development, The University of Manchester, Manchester, United Kingdom*

Re-scaling energy systems and governance to the local level is increasingly necessary to transition to a low-carbon society. City region devolution in England enables city regions to develop their own approaches to low-carbon transitions that reflect the context in which they are situated. The approaches associated with these transitions support the localization of the energy system, the involvement of a diverse range of actors and institutions and the establishment of new supporting infrastructures. This paper considers the interactions between, and influence of, different actors, infrastructures and institutions and how these impact the nature of approaches developed by applying a relational perspective. Relational perspectives are increasingly prevalent in research on low-carbon transitions, although they have not been used to consider how different components of the transition influence the approaches developed—which is the focus of this paper. By understanding the influence of the different components, it supports the establishment of appropriate mechanisms to facilitate low-carbon transitions at the localized scale. This paper analyses the approaches to low-carbon transitions developed by three city regions with devolved powers in England. The approach developed by each of the city regions orientates around a different scale of focus—from the whole city region to strategic hubs to individualized, siloed activity. These different scales of focus reflect the influence held by the actors, institutions and infrastructures located within each city region. The context of the city region itself also influences the actors, institutions, and infrastructures present. By adopting a relational perspective, it unpacks the complex interrelations, the multiple points of interaction and influence, and the multi-scalar nature of low-carbon transitions at the city region level. Although the approaches to low-carbon transitions developed by the different city regions suggest a re-scaling of transition processes, the associated actors, infrastructures and institutions associated with these processes are not isolated from broader contexts and particularities of place. There are multi-scalar interactions and influences which impact the nature of approaches developed, demonstrating the value of relational and heterogeneous perspectives when developing localized approaches to low-carbon transitions.

**Keywords: city regions, decentralization, infrastructure, relational understanding, low-carbon energy transitions, devolution**

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***Edited by:***
*Siddharth Sareen,*
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***Reviewed by:***
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*UMR5593 Laboratoire Aménagement, Économie, Transport (LAET), France*

****Correspondence:***
*Ami Crowther*
*ami.crowther@manchester.ac.uk*

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## INTRODUCTION

Transforming toward a low-carbon energy system is a key contemporary challenge, with the pressures of climate change and energy security enhancing its necessity (Bolton and Foxon, 2015). Establishing a low-carbon energy system requires a transformation of the socio-technical systems that form the basis of our everyday lives; involving shifts in "technical infrastructure, social practices, regulations, institutions, information, cultural meanings and economic networks" (Lennon et al., 2020 p. 184). There is the need to "create different systems or transform existing ones" (Kemp and Loorbach, 2005, p. 125), that incorporate a diversity of actors across different local, national, and international levels of activity. Consequently, energy transitions can be considered the product of dynamic interconnections between multiple scales, including the national, regional, and local, and their respective environmental, social, economic and historical contexts (Lemon et al., 2015). Cities and urban areas are positioned as critical spaces for this transformation as they are the site where the systems of provision that require transformation coalesce, and provide the opportunity to establish and initiate localized visions and strategies of change, at a quicker pace than national and global actions (McCormick et al., 2013).

A range of initiatives have been developed to support low-carbon transitions at the localized scale of cities and urban areas, including Positive Energy Districts (PEDs). PEDs are areas developed within city boundaries that have net zero emissions (SET-Plan TWG, 2018) as a result of optimizing energy efficiency, flexibility and production (Gollner, 2019). Central to PEDs is the interaction and integration of different components including buildings, energy users and regional energy systems—this is facilitated by political vision, governance frameworks, the active involvement of a range of actors, the integration of energy and urban planning, and use of ICT (Gollner, 2019). Through PEDs the city is positioned as a key site for achieving energy and climate targets (Gollner, 2019) as it "can play a unique role as a host, facilitator and incubator of new technologies and solutions" (Build Up, 2020).

Action supporting energy transitions at the city and urban level has been accompanied by a trend of devolution; increasingly sub-national governments globally are being awarded a mix of powers that vary from place to place (Rodríguez-Pose and Wilkie, 2017)—many countries that were previously centralized are becoming more decentralized in nature (Li et al., 2016). The decentralization of energy services to cities and urban regions provides opportunities to establish sustainable energy systems by changing governance structures so that ownership and management of energy systems are more localized (Nolden, 2013). Decentralization enables localities to establish development plans which reflect their local socioeconomic and institutional contexts (Rodríguez-Pose and Wilkie, 2017). Policies developed at the subnational level are contextualized in a way that makes them more pertinent and tangible to the individuals they are aimed at, thus supporting the establishment of more effective policies (Coutard and Rutherford, 2010). This is particularly important in the context of energy policy, as unlike traditional centralized modes of energy generation and distribution whereby energy consumers played a passive role, more localized approaches to energy generation and distribution support the integration of a greater variety of actors that are able to actively engage with the energy system (Lennon et al., 2020). The networks of actors associated with the energy system differ between locations (Lemon et al., 2015) demonstrating the need for context-dependent localized approaches to energy system transformations.

The devolution of power from national government to sub-national governments can be seen in the context of city region devolution in England. Through the "Cities and Local Government Devolution Act 2016" the management of certain governmental responsibilities is devolved to city region combined authorities, alongside additional powers and budgets. A range of responsibilities typically held by national government can be devolved, such as transport, skills and jobs, housing, public services, health and social care, children's services, and offender management. Each devolution deal is bespoke with different responsibilities being devolved reflecting the context of the area and providing opportunities to develop localized strategies (Randall and Casebourne, 2016). Devolution deals are dynamic agreements, with modifications in powers possible. The bespoke nature of devolution deals, and the autonomy given to combined authorities in decision-making and planning, results in a diversity of approaches to transforming the energy system to a low-carbon one. Within the energy strategies developed by the city regions, different actors are assumed to undertake certain roles in order to support the energy transition. Although city region energy strategies are not officially defined as Positive Energy Districts (PEDs) the motivations, intentions and foci of the energy strategies developed by the city regions reflect those of PEDs. Each devolved city region's energy strategy focuses on utilizing local resources, creating opportunities for a range of actors to participate in the energy transition and establishing a cost-effective, sustainable energy system. Actions are developed that reflect the local context, and demonstrate an awareness of the interconnected components that need to be acknowledged. Although, the actions undertaken at this scale also impact and are impacted by other scales of governance, including global, national and sub-regional.

The decentralization of energy can be considered to strengthen democracy and increase participation as a result of the shifting of power from central government to regional and local levels (Ziervogel et al., 2019). The re-scaling of energy actions to the localized level of cities and urban areas results in a greater number and breadth of actors being involved. To ensure the effectiveness of action at this localized level, there is a need for collaborative action between these different actors (McCormick et al., 2013). Consequently, new modes of localized governance have been established in response to the increased complexity of relations within the energy system. However, the decentralization of energy systems has also been critiqued for a number of reasons. There are arguments that decentralization can be considered a move toward a further neoliberalization of the state (Featherstone et al., 2012) through the marketization and privatization of resources and services.

Furthermore decentralization can potentially reinforce existing exclusionary patterns of local power, meaning that democratic and participatory intentions may not be achieved (Brown et al., 2015). Consequently, energy decentralization can foster and reproduce social and spatial inequalities.

The social and spatial aspects of energy systems have been explored in a range of ways—including how space is produced in energy transitions, the processes of re-scaling associated with energy transitions in terms of both governance and actions and the associated cross-scalar interactions, and the spatial materiality of energy transitions in terms of energy landscapes and physical infrastructures (Becker et al., 2016a). A range of lenses have been applied when researching these social and spatial aspects of energy systems, including relational understandings as these enable the consideration of how the "creation and deployment of newer, low carbon energy generation technologies co-evolves with socially, politically, and physically heterogeneous terrain" (Cowell, 2020, p. 73). These relational understandings have also been applied to research on place-based approaches to energy by considering the broader relations associated with these actions. Re-scaling energy approaches to a local scale facilitates the involvement of local decision makers that are able to draw upon local knowledge when designing, implementing, and monitoring energy strategies (Pike et al., 2016), with this bringing both economic and social advantages. Yet, within research there is little acknowledgment of the broader contexts in which these localized practices are embedded, and the consequential cross-scale relationships. Despite a breadth of research engaging with the scale and relativity of energy systems, there is limited research that considers how scale impacts the politics and governance of energy systems (Baka and Vaishnava, 2020). Within the literature there has been little consideration of how different actors and infrastructures are presented in low-carbon transitions re-scaled to the local level, their interrelations and the influence they have on the approaches developed. Transforming to a low-carbon energy system is not as simple as allocating different actors certain roles to undertake; as shown through this paper, there is the need to consider the cross-scalar interrelations between actors, infrastructures and contexts. By developing these understandings, it provides insight to support the establishment of mechanisms that facilitate effective low-carbon transitions as the different components will be accounted for.

This paper focuses on the approaches developed when re-scaling low-carbon transitions to the city region scale, drawing upon relational understandings to unpack the potential factors that have contributed to the approaches taken. Analysis will consider the actors included within these approaches, the roles they are assumed to undertake and the infrastructures that exist to support their completion of these activities. The focus will be on city regions with devolved powers in England, considering their approaches to low-carbon transitions. By adopting a relational understanding of energy transformations it draws attention to the co-constitutive cross-scalar interactions that exist between different actors, contexts, and infrastructures. These relationships are central to energy transitions, influencing and being influenced by the different practices being implemented. Despite focusing upon a specific national context, the global trend of localization and devolution and the focus on the diversity of actors and configurations associated with these processes enables the insights from this research to be applied to strategies of energy transformation globally (Li et al., 2016).

The structure of the paper is as follows: it opens with a literature review that outlines current spatial and relational understandings of energy systems (section Toward Multi-scalar Relations: Spatial and Relational Understandings of Energy Systems) and the relational nature of the infrastructures to support low-carbon transitions (section The Relativity of Infrastructures: How Material and Institutional Infrastructure Influence and Are Influenced by Low-Carbon Transitions). section Methodology outlines the methodology adopted as well as a brief overview of the policy and governance context that the research is situated. The key insights from the existing literature will be used to frame the analysis of the approaches developed by three devolved city regions in England to support low-carbon transitions. The analysis considers the complex relativity associated with low-carbon transitions that are re-scaled to the city region level (section The Role of City Region Governments in Low-Carbon Transitions and the Impact of Multi-scalar Influences), the need to incorporate relational and heterogeneous understandings when developing localized approaches to low-carbon transitions (section Considering the Heterogeneity of Actors—contextualized Actions vs. Blanket Suggestions), and how innovation is facilitated within each city region (section Innovation in City Regions: Who, What, How, and Why?). The paper concludes with reflections on the impact that multi-scalar relations can have on localized approaches to low-carbon transitions, the nature of innovation and the value in the methodology adopted (section Conclusion).

## LITERATURE REVIEW

### Toward Multi-Scalar Relations: Spatial and Relational Understandings of Energy Systems

The recent spatial turn in energy research acknowledges the diversity of energy challenges that emerge as a result of differing geographies, the impact that energy systems have on the practices of everyday life, and the dynamic, uneven and contested spatiality of energy systems (Bridge, 2018). Embedded within this spatial turn is an appreciation of the relational processes associated with the social, political, economic and infrastructural aspects of energy systems. However, within analyses of sustainable energy transitions the importance of spatial, political, and temporal aspects of transitions tend to be underplayed (Roelich et al., 2018). The re-scaling of energy systems to more localized configurations provides the opportunity to unpack the spatial and relational processes that influence this transformation.

The interconnectedness between scales is increasingly considered within urban and energy research (Bulkeley, 2005; Goldthau, 2014; Goh, 2020); scales are understood in relation to other scales and the socio-spatial processes that produce them (Howitt, 1998). This relational perspective means that scale is seen to be produced through the relationships between

actors and the contexts in which they are situated—despite the urban scale being materialized and territorialised in certain ways, it is also made and remade as a result of interactions with other scales (Bouzarovski and Haarstad, 2019). Even when energy policy focuses on making localized changes to infrastructures and practices at the city and municipal scale, the actions implemented are related to and influenced by actions at other scales and levels (García-Sánchez and Prado Lorenzo, 2009); cities and municipalities are not isolated entities.

Furthermore, cities and municipalities are not "rigid and passive physical containers" for change, but are "key nodes within vibrant socio-technical networks that operate across multiple material sites" (Bouzarovski and Haarstad, 2019, p. 257). The networks and information loops within cities facilitate communication between different actors, enabling complex physical and organizational systems to be developed and instituted (Sassen, 2013). There are "multiple scales and diverse socio-physical ecologies" within cities (Sassen, 2013, p. 238), with low-carbon initiatives being increasingly embedded within multi-level governance arrangements as part of a wider political project (van Veelen, 2019). Consequently, these initiatives are often "closely connected to policies, institutions and resources at other scales" (Grandin and Sareen, 2020, p. 74). These relations between scales facilitate change at the urban level, as a range of actors at different levels of governance are able to be drawn upon to support and facilitate the processes of change (Bouzarovski and Haarstad, 2019). There is a need to understand how the politics of scale shapes and is shaped by transitions in particular contexts, and how actors within scales are constructed in the social, political, and economic relations associated with these transitions (Silver and Marvin, 2017).

Actors and initiatives at the global scale influence, and are influenced by, actions at the regional and urban scale. This is encapsulated in the UNFCCC's Paris Agreement, as it acknowledges and advocates for action at the sub-national scale as this can support the achievement of reducing greenhouse gas emissions and the mitigation of climate change impacts (UNFCCC, 2015). However, gaining this recognition was partly the result of actions undertaken by these sub-national actors, with collective groups coming together to demonstrate the value they bring to achieving climate goals, such as the covenant of mayors (Poon, 2016). Individual actors are a core component of the energy transition that significantly influence the outcomes of different initiatives, as it is the cumulative impact of the actions undertaken by these different actors that underpin transition processes (Lennon et al., 2020). Without engaging with individual actors, encouraging and supporting them to shift their behaviors to align with the different strategies developed, evoking change would be difficult. The sustained interconnections between multiple actors at different scales when developing energy transition strategies at the regional and urban scale demonstrates the value of considering these strategies from a relational perspective. By applying a relational perspective it helps unpack the connections between, and influence held by different actors, components and institutional structures.

## The Relativity of Infrastructures: How Material and Institutional Infrastructure Influence and Are Influenced by Low-Carbon Transitions

Energy practices and transition processes within cities and urban areas are facilitated by the infrastructures present. These infrastructures can be both material infrastructures such as technical components of the energy system, or institutional infrastructures relating to the governance of energy systems. Infrastructures influence and are influenced by the contexts in which they are situated; different infrastructural technologies, systems and networks enable different practices, and differ over time and based upon the context they are situated (Shove, 2017). Infrastructures are not a passive entity upon which something operates, rather they become in relation to organized practices. As infrastructures do not exist stripped of use (Star and Ruhleder, 1996) this highlights their inherently relational nature. The practices enabled by infrastructures are the product of cross-scalar interactions and influences, with these practices also influencing the nature of infrastructures developed.

In the context of energy transitions, infrastructures and innovation are products of institutional change, but also produce political pressure for institutional change (Silver and Marvin, 2017). As commented by Bridge et al. (2013, p. 336) "the spatial diffusion of energy technologies is culturally contingent," with multi-scalar systems of signification and cultural routines influencing the integration of these technologies. Introducing new energy technologies and their associated practices highlights the embeddedness of energy systems in the socio-environmental particularities of place (Bouzarovski and Haarstad, 2019). Energy infrastructures dictate human action but also catalyze action in terms of socio-ecological change (Bennett, 2010), thus experiences of energy are shaped by material infrastructures with these material infrastructures being shaped by social processes (Lennon et al., 2020). Urban energy infrastructure is informed by and shaped through multi-scalar governance, with the local context as well as national policies and global institutions contributing (Silver and Marvin, 2017). The socio-political infrastructures that support energy transitions are also important to consider when discussion localized approaches, especially due to the greater range of actors that are involved in the energy system (Hall et al., 2013). New forms and scales of governance are developed in response to, and to facilitate, localized energy transitions. These governance institutions are "multi-layered and interlinked social structures that create, mediate and allow society to be formed" (Becker et al., 2016b, p. 22), with this framing and directing agency and consequently determining the extent to which practices and organizations change (Becker et al., 2016b). Institutions are dynamic and relational, they are "created, maintained and changed through action" (Barley and Tolbert, 1997, p. 112). Alongside formal institutions, intermediary organizations exist within energy governance practices; these organizations intend to mediate between the diversity of actors now present within the energy system (Creamer et al., 2018). Intermediaries support the exchange of knowledge and skills, connect different actors, support innovation, and facilitate

transformational change (van Veelen, 2019). A range of actors can undertake the role of intermediary including individuals, public bodies, non-governmental organizations, consultancies, or trade bodies. Intermediaries are not isolated entities as their capacities and functions are influenced by the wider set of socio-political relations in which they are situated (van Veelen, 2019). These socio-material relations and the associated outputs are also influenced by the practices and approaches of the intermediaries, which further reinforces the relativity embedded within processes of and actors associated with energy transformations.

In considering literature relating to the relativity of energy transitions and their associated infrastructures, a number of key understandings are highlighted:

- The agency of individuals, both independently and collectively, is a key component of the energy system as shown through the increasing number of actors associated with localized energy systems and the approaches to energy transitions (Hall et al., 2013; van Veelen, 2019; Ziervogel et al., 2019; Lennon et al., 2020).
- There is a need for a heterogeneous approach when analyzing the energy system, due to the influence that specific contexts at the urban and individual scale have on energy practices (Bridge et al., 2013; Bridge, 2018; Cowell, 2020).
- Both technical and socio-political infrastructures influence and are influenced by energy practices—transformations are not solely about implementing new technologies, they also require shifts in practices and expectations of energy consumers (Uzzell, 2008; Shove, 2010).
- There are multiple points of interaction and influence within the energy system, between actors, infrastructures and overarching contexts including social, economic, political, technological, and environmental—these are cross-scalar, and include a diversity of actors and energy system components (McFarlane and Rutherford, 2008; Sassen, 2013; Lemon et al., 2015; Bouzarovski and Haarstad, 2019).

Drawing upon these understandings, this paper will now consider the approaches developed when low-carbon transitions are re-scaled to the regional level focusing on the experiences of three English city regions with devolved powers. A relational lens will be applied to help unpack the interactions between and influence held by the different actors, material and institutional infrastructures involved, as well as the impact these interactions and the city region context has on the approaches developed.

## METHODOLOGY

Before outlining the methodology of this paper, we will briefly summarize relevant policies and governance structures relating to city region devolution in England to contextualize the approach undertaken.

In recent years, a range of legislation has been introduced that facilitates the devolution of power within the UK and the creation of more localized governance structures. The "Cities and Local Government Devolution Act 2016" supports the creation of more localized governance structures and localized initiatives, by devolving greater power and resources to combined authorities in England. Through devolution, combined authorities undertake responsibilities typically overseen by national government (Paun et al., 2020). Combined authorities are formed of at least two neighboring local authorities (local government areas), and typically encapsulate city region areas. A total of 10 combined authorities have been established in England, with eight of these being mayoral combined authorities with devolution deals (Paun et al., 2020). A visual representation of the different political entities and scales associated with sub-national devolution to combined authorities in England is provided in **Figure 1**.

Sub-national devolution has influenced low-carbon transitions as combined authorities have developed localized transition strategies; each devolved combined authority (apart from Tees Valley) has declared a climate emergency, and many have outlined ambitions to become zero-carbon ahead of the national government's 2050 target. However, despite processes of devolution appearing to enable the localized re-scaling of low-carbon energy transitions, the practices undertaken by devolved combined authorities need to align with national government spending to receive funding (Paun et al., 2020). Thus, national government is able to maintain overarching control of the activities undertaken within the devolved city regions. This paper focuses on the energy strategies and low-carbon transition approaches developed within the context of this sub-national devolution by using a document review to reflect upon the strategies developed to facilitate a low-carbon transition by three combined authority city regions with devolved powers in England will be explored. The city regions of Greater Manchester, West Midlands and Sheffield have each situated their approach to transition at a different scale, ranging from the whole city region (Greater Manchester) to strategic hubs (West Midlands) to individualized/siloed action (Sheffield) with responsibility being diffused between associated actors in different ways. The location of these combined authority city regions, and the local authorities that they are composed of are shown in **Figure 2**. By focusing on a defined urban context, it enables a more critical reflection of the interactions between actors by acknowledging the particularities of that place (Hodson and Marvin, 2009). The different ways in which localized energy has been operationalised by the different city regions highlights the fluidity of the term "local" within energy systems, and how this can be considered an umbrella term for a range of activities. These different scales influence the institutional and material infrastructures developed within the energy transition. Although this paper discusses experiences within English city regions with devolved powers, it is hoped that the understandings can be drawn upon in other contexts as the focus is on the actors involved with localized energy transitions and the networks that exist to support this.

Within existing literature, document reviews have been used to develop understandings of policies and strategies from a range of perspectives, including the overarching policy itself such as governmental support programmes for community energy (Park, 2012), the impact of policies on behaviors (Doggart et al., 2020), and how the enactment of these policies and approaches can facilitate processes of transition, such as passenger mobility (Geels, 2018). This research undertook a document review to

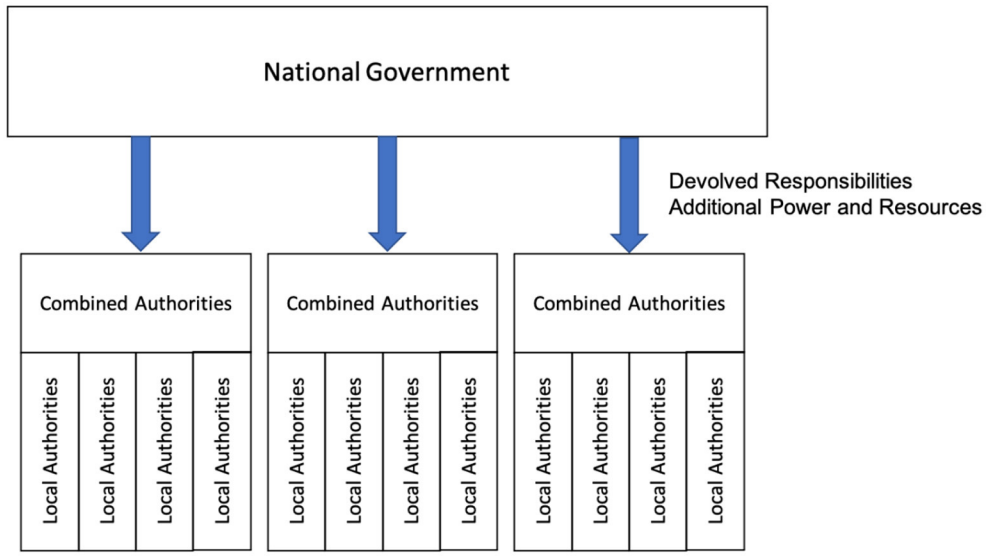


**FIGURE 1 |** A graphical depiction of the key actors associated with sub-regional devolution, showing the shifting of responsibilities, powers, and funding from central government to devolved combined authorities that are comprised of two or more local authorities.

develop understandings of the strategies developed by each of the city regions to support a low-carbon transition, focusing on the scale of action, the actors involved and how responsibility was diffused between these actors.

In order to retrieve documents for the review, three different methods were adopted: (1) Key terms and phrases were entered into a search engine, such as the particular city region (Greater Manchester, West Midlands, or Sheffield City Region) followed by low-carbon transition, low-carbon energy transition, net zero or zero carbon (2) The websites of key actors and organizations (identified through readings and the SNA outlined below) were searched using the key phrases used within the search engine searches or any specific policies identified through other readings, and (3) Relevant documents cited in other documents included within the review were retrieved. These different retrieval methods resulted in documents produced by a range of actors associated with each city region's low-carbon transition being collated for the review, including city region government actors and their strategic partners, public institutions, private companies and national organizations. This variety of actors producing documents relating to each city region's low-carbon transition approach and strategies is reflected in the different types of documents present in the review, including: official strategy and policy documents, press releases, meeting minutes, oral presentations, policy proposals, policy appraisals, promotional documentation, and website sections. The perspectives, motivations, and intentions of these different actors are embedded in the documents they produce, with this bringing an additional dimension to the analysis of the policies and strategies developed to facilitate city region low-carbon transitions. Through the document review, a narrative of the current situation within the city regions, the approaches they have developed to facilitate a low-carbon energy transition, and the actors involved with this was developed by combining the different information and perspectives present in the different documents. However, only documents that are publicly available were included within the review; additional internal documents may exist which could bring additional understanding to the approaches developed or the process of their development. By focusing on documents produced by those involved with each city region's low-carbon energy transition, it highlights the practices and relationships that were intended to be present within the approaches developed, and the imagined impact of the policies without external factors influencing outcomes. This is of interest as it highlights the priorities of the different city regions and how they believe these can best be achieved.

Analysis of the documents was supported by an analytical framework which focused on the scale of the actions within the strategies, the actors that were included, how these actors were understood and presented within strategies, and the roles the different actors were assumed to undertake to support the energy transition (**Table 1**). Having this analytical framework provided structure to the analysis of documents and helped ensure that relevant details were being extracted; the different components of the analytical framework were designed to pick out details relating to the perspectives and interactions that influenced the low-carbon energy transition approaches and strategies developed by the city regions.

Alongside the document review, Social Network Analysis (SNA) was undertaken. SNA is a method for mapping and analyzing the connections between individuals and organizations and provides the opportunity to include diverse voices (Scott, 2015). By mapping these connections and networks it translates messy 'behaviors into things' (Murdoch, 1997, p. 327) providing something that can be analyzed. There is a focus on "the structure of relationships among social entities, as well as

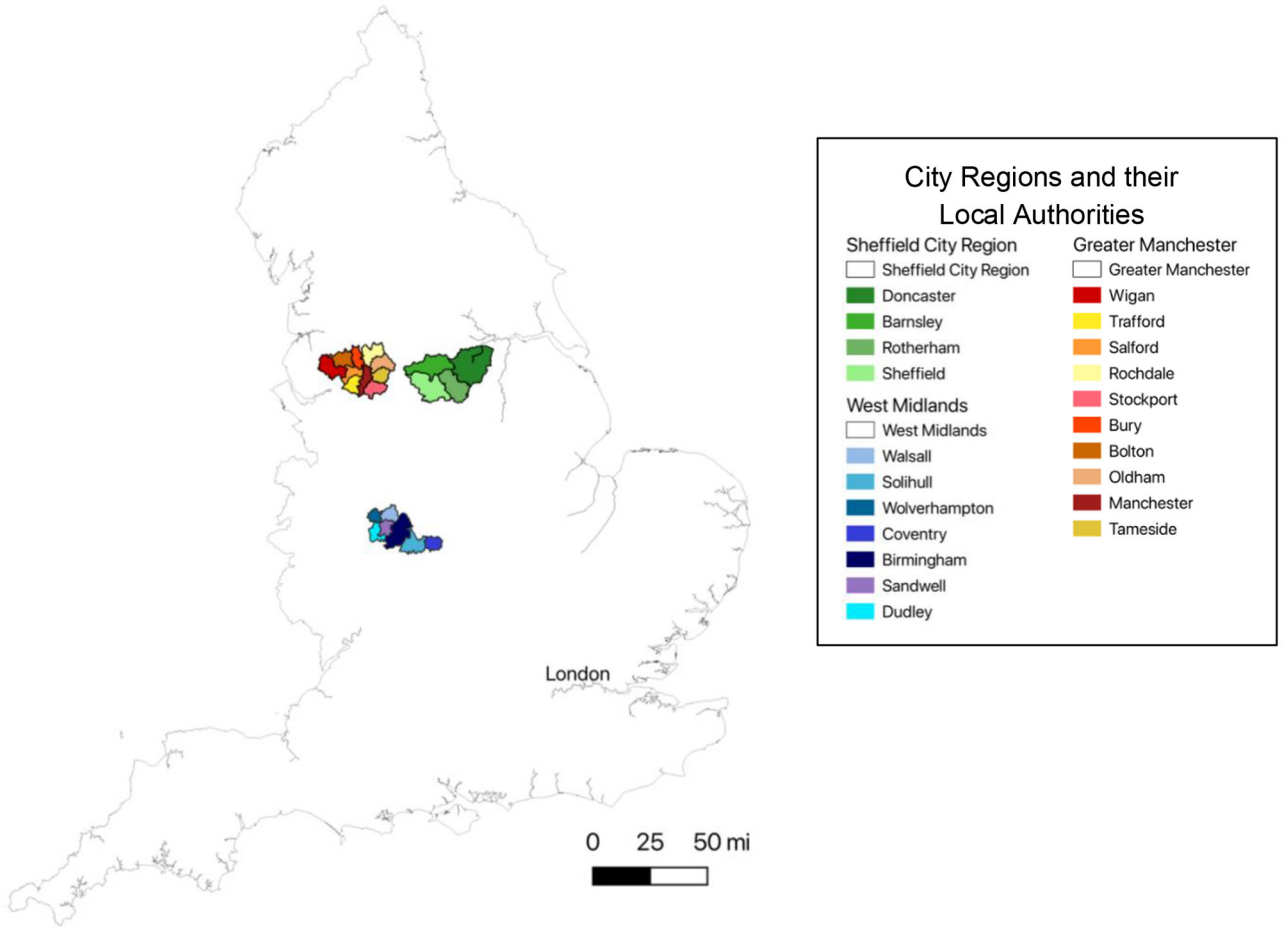


**FIGURE 2 |** A map showing the combined authority city regions of Greater Manchester, West Midlands, and Sheffield including the local authorities that they are comprised of (Authors Own).

the impact of said structure on other social phenomena" (Butts, 2008, p. 13). Developing these understandings can support the achievement of goals or help identify and remove barriers (Mischen and Jackson, 2008). Social Network Analysis has been conducted in a range of research including energy efficiency projects (Zedan and Miller, 2017), multi-scalar energy networks (Martinus et al., 2015), actors and technologies associated with innovation (Van Der Valk and Gijsbers, 2010), social movements (Saunders, 2007) and natural resource management (Prell et al., 2009). Within this research, SNA was conducted to highlight the different actors associated with the city region's approaches to low-carbon transitions, the scales at which these actors were situated, and the relations that existed between actors. The SNA was conducted by drawing upon the document review, picking out the key actors mentioned within these documents and the relationships presented. By mapping the actors in this way it complements the relational approach taken in the analysis, as a visual representation of these interactions and associated influence is provided.

The insights obtained through the document review and stakeholder analysis were combined, with overarching themes relating to the scale of activity, the actors involved and the infrastructure to support them being highlighted. Relational understandings were applied to these themes to further unpack the processes and relationships embedded within the energy strategies developed by city regions. The themes highlighted provide the structure for the analysis section which follows—there is a discussion of the role undertaken by the city region's municipal government, the extent to which actors are considered heterogeneous, and how innovation is incorporated into the low-carbon transition approaches.

## ANALYSIS

The analysis of the paper will focus on the different approaches undertaken by the three case study city regions when re-scaling action on energy transitions to the city/urban scale. Relational understandings will be drawn upon to unpack the

**TABLE 1 |** A breakdown of the analytical framework used to support the analysis of each city region's approach to a city region low-carbon transition, developed by the authors.

| CITY REGION CODING FRAMEWORK | |
|---|---|
| **Who?** | |
| What actors are present within the City Region and associated with implementing energy strategies | |
| **What Capacity?** | |
| ***Component in System*** | ***Knowledge Holder*** |
| The actors are viewed as being part of the system and process, but are not drawn upon for insight or information when developing the plans—this doesn't undermine their legitimacy | The actors are able to provide information and insight that will facilitate the development/establishment/maintenance of energy strategies and the transition to low-carbon society—able to break down into the different types of knowledge held by actors (Experiential, technical, bureaucratic etc.) |
| **How are they presented?** | |
| ***Heterogeneous*** | ***Homogeneous*** |
| There is an understanding of the diversities, subtleties and complexities within the group, with an acknowledgment that referring to the group as a single entity doesn't capture this | Actors are presented as a homogenous group, there is not distinction between the different actors within the group or the different experiences/knowledge bases/ |
| ***Active*** | ***Passive*** |
| Actors actively engage with the planning, development and establishment of different elements of the energy strategy, they are shown to have agency and the ability to influence outcomes for themselves and/or the actions undertaken | Actors are involved in the activities associated with the energy strategy/plan but don't influence the direction or really contribute to decision-making processes—they are guided by the decisions of others |
| **What is understood about them and when?** | |
| ***Experiences*** | ***Viewpoints*** |
| There is engagement and interest in the everyday, embodied and/or historic experiences that actors have had in relation to energy and/or the approaches adopted Consider at what point throughout the project's lifecycle this is drawn upon i.e., planning, developing, implementing, functioning, maintaining | There is interest in what actors think about the situation or the proposals for action to be implemented = Consider at what point throughout the project's lifecycle this is drawn upon i.e., planning, developing, implementing, functioning, maintaining |
| **How is knowledge obtained?** | |
| ***Assumptions*** | ***Engagement*** |
| Actors are not directly consulted about their understandings, perceptions, and/or views, rather external actors make assumptions of these based upon the data and evidence available to them | Actors are directly asked or given the opportunity to share their views, understandings are presented by the actors in their own words |

potential factors that have contributed to the approaches taken, considering the actors involved, the roles they are assumed to undertake and the infrastructures that exist to support their completion of these activities. **Table 2** provides a brief overview of the approach developed by each of the city regions, outlining the vision, scale of action, the institutional vehicles developed, governance and main actors involved.

## The Role of City Region Governments in Low-Carbon Transitions and the Impact of Multi-Scalar Influences

Each city region's municipal government is positioned as a key actor in, and co-ordinator of, the local low-carbon transitions, with institutional infrastructures being established to facilitate the actions required.

For both Greater Manchester and Sheffield City Region, existing governance configurations at the city region level have been expanded to incorporate responsibility for the city region's low-carbon transition. Greater Manchester has established the GM Green City Region Board to support the city region's low-carbon transition, with challenge groups being established to oversee particular action including "Sustainable Consumption and Production," "Low Carbon Buildings," "Energy Innovation," and "Natural Capital." Greater Manchester's vision of an Energy Transition Region (ETR) comes under the Energy Innovation Challenge Group. The ETR focuses on a place-based approach to low-carbon transitions at the scale of the city region by developing appropriate infrastructures and shifting practices—there is the intention to establish a smart energy system that draws upon local assets and innovative approaches (Owen, 2019). Sheffield City Region's Energy Strategy, which outlines actions related to low-carbon transitions, is part of the Mayor's Climate Response Framework. The documents that comprise the Mayor's Climate Response Framework outline how the city region intends to achieve environmental sustainability and address the climate emergency (SCR Mayoral Combined Authority, 2020). There is an emphasis that the intended approach requires strong leadership from the public sector (SCR Mayoral Combined Authority, 2020), in order to facilitate and support the involvement of local residents and businesses (SCR, 2019). By drawing upon existing governance structures it helps integrate the low-carbon ambitions with existing priorities across the city regions, brings it to the consciousness of key decision-makers and helps ensure relevant actors are involved by drawing upon existing networks. Unlike Greater Manchester and Sheffield City Region who allocated responsibility for facilitating low-carbon transitions to existing entities, the West Midlands established a new body called Energy Capital to support the city region's low-carbon transitions. Energy Capital is responsible for the coordination of changes in the West Midlands' energy system, with the intended outcome being a modem, clean competitive and secure energy system (Climate-KIC, 2020). Energy Capital is embedded within the city region's governance structure and is accountable to the municipal government (WMCA, 2018). The main outputs that Energy Capital are utilizing to support the low-carbon transition are Energy Innovation Zones (EIZs). EIZs

**TABLE 2 |** A table outlining the approaches developed by each of the city regions, summarizing the overarching vision, the scale of action, the governance structure and key actors/actions.

| | Greater Manchester City Region | West Midlands City Region | Sheffield City Region |
|---|---|---|---|
| Vision | To develop a city-region energy system that is smart, fit for the future, low-carbon and sustainable<br>Become a zero carbon city region by 2038 | To become Zero carbon by 2041 through a range of actions across multiple sectors | To have a clean, efficient and resilient energy system, which supports a healthier environment for people to live, work and visit, and which drives our transition to a low carbon economy<br>Become zero-carbon by 2040 |
| Scale | City region—Whole Systems Approach | Strategic Hubs | Individualized/Siloed Activity |
| Vehicle | Energy Transition Region (ETR) and Energy Innovation Agency (EIA) | Energy Innovation Zones (EIZs) | Mayor's Climate Emergency Response Framework |
| Governance | Building upon and extending existing governance structures within Greater Manchester | Developed Energy Capital, a body responsible for overseeing energy transition in the city region that is embedded in regional governance structure | Action lead and initiated by regional government |
| Main Actors | Greater Manchester Combined Authority (GMCA), Local Authorities (Bolton, Bury, Oldham, Manchester, Tameside, Wigan, Trafford, Salford, Rochdale and Stockport), Energy Innovation Agency (EIA), Businesses, Academia, Communities | West Midlands Combined Authority (WMCA), Local Authorities (Walsall, Solihull, Wolverhampton, Coventry, Birmingham, Sandwell, and Dudley), Energy Capital, Local Enterprise Partnerships, EIZ Partnership Boards, Businesses | Sheffield City Region Mayoral Combined Authority, Local Authorities (Doncaster, Barnsley, Rotherham, and Sheffield), Local Enterprise Partnerships, Businesses, Communities |
| Main Actions | Innovative projects to energy challenges in the city region are supported through the ETR, the cumulative impact of these considered to support transition | Strategic hubs of activity within the city region are established through EIZs—action dependent upon the context, motivations, priorities and actors present within the area | Range of actions to be taken by individual actors and groups with cumulative impact on the transition to a low-carbon city region |

are geographically-bounded hubs within the city region that aim to stimulate local and democratically accountable clean energy innovation (Energy Capital, 2018). EIZs are also embedded within the regional governance structure—Energy Capital and WMCA provide regulatory support, funding and expertise to the EIZ, whilst the local authority in which the EIZ is considered responsible for the coordination and management of these strategic hubs (WMCA, 2018). The creation of a new body to coordinate progress to a low-carbon energy transition provides the opportunity to focus attention on the actions that need to be undertaken, and develop internal processes and mechanisms that are tailored to these actions specifically. The approach taken by each city region—whether that be integrating responsibility for the low-carbon transition into existing governance structures or establishing new bodies to facilitate progress—reflects the context of the city region, its existing structures, its resource and its perceptions of how best to support change.

The different approaches developed by the city regions to support low-carbon transitions, and the institutional infrastructures accountable for their implementation, not only influence the actions that will be undertaken within the city region but are also influenced by the city region's context. The nature of the approaches and associated institutional infrastructures are a reflection of the context of the city region itself, its ambitions, resources and priorities. The context in which strategies are to be implemented impacts decision-making processes, determines the feasibility of actions and the likelihood of their success; each city region has different networks of actors engaged in low-carbon activities and different resources available to them (Lemon et al., 2015). Not only does the context of the city region influence the approaches taken, but the approaches themselves have an impact on the configuration of the city with regards to both material infrastructures and non-material circumstances. The embedded social and cultural dimensions of the approaches developed, such as power, politics, and entrenched inequalities influence the dynamics of transitions and impact the contextual setting (Lawhon and Murphy, 2012). The West Midlands region is an industrial and manufacturing hub reflecting its geographical location and historical legacy (HM Government, 2019). These factors contribute to the nature

of innovations being implemented through the city region's EIZs—there is a bias toward manufacturing and supporting these industries. The Sheffield City Region approach to a low-carbon transition predominantly focuses on demand side action with this reflecting the city region's current lack of localized generation assets (SCR, 2020). A range of action is outlined including making better use of infrastructure for energy efficiency, low carbon energy generation, or sustainability, accelerating the uptake of Ultra-Low Emission Vehicles by developing the required infrastructure and upskilling the workforce to support future energy systems (SCR, 2020). Local energy generation is to be supported through community energy schemes (SCR, 2020). Greater Manchester's Energy Transition Region concept intends to support the testing of innovative energy approaches at scale by "bringing together academia, industry, community energy and the public sector" (GMCA, 2019). This collaboration-focused mechanism included in the city region's approach to the low-carbon transition is only possible due to the diversity of resources and knowledge situated within Greater Manchester.

Furthermore, the approaches developed by the different city regions are a product of broader contexts and cross-scalar relationships. Actions situated at the city-region level that intend to support low-carbon transitions are influenced and constrained by actors and infrastructures at other scales, including national government and individuals within the city region (García-Sánchez and Prado Lorenzo, 2009; Silver and Marvin, 2017; Bouzarovski and Haarstad, 2019). For each city Region, receipt of funding is dependent upon aligning with central government spending (Paun et al., 2020) demonstrating the influence the central government is able to exert despite having devolved powers to the city region. Low-carbon transitions are also dependent upon individual actors engaging with the approaches developed in order to make progress; a diversity of actors are embedded within these approaches including industrial actors, local communities, businesses, academic institutions and non-governmental organizations. When considering these multi-scalar influences it highlights the complexity embedded within localized low-carbon transitions; there is a need to establish a narrative and supporting infrastructures that engage individuals at the sub-regional level but also align with broader national intentions.

## Considering the Heterogeneity of Actors—Contextualized Actions vs. Blanket Suggestions

Despite the municipal governments of the devolved city regions coordinating the localized approaches toward a low-carbon transitions, they emphasize that they are not solely responsible. As outlined in the Sheffield City Region Energy Strategy "collective change requires collective action" (SCR, 2020). The low-carbon transition approaches developed by each of the city regions are dependent upon the engagement of a range of actors, with these actors being assumed to undertake specific roles and support the energy transition in particular ways. There is an expectation that a range of actors will engage with initiatives, shift their behaviors and adapt their practices. Re-scaling low-carbon transitions to the local scale supports the engagement of a range of actors (Ziervogel et al., 2019), with the opportunity to draw upon local knowledge being considered an advantage of localized energy approaches (Pike et al., 2016). The interaction with a range of individuals, understanding their situation, contexts and priorities is considered a benefit of localized approaches to energy transitions (Lennon et al., 2019). Being able to situate low-carbon transition initiatives in the specific context of the city region supports place-based approaches that reflect the diversity of actors present and aligns with their contexts. However, within the city region's approaches to low-carbon transitions, only the Energy Innovation Zones (EIZs) developed by the West Midlands appear to acknowledge the diversity of needs, priorities and capabilities of different actors. Both Greater Manchester and Sheffield City Region appear to take a more "blanket" approach to actions providing high-level outlines of what is to be done by actors, and not acknowledging the specificities of individual actors' contexts.

Each of the EIZs developed in the West Midlands is a product of the context in which it is situated, with this influencing the priorities and configuration of the EIZ; they are portrayed as reflecting "the local needs and perceptions of energy system opportunities and challenges" (King, 2018). The EIZs provide the opportunity to implement activities that align to specific local goals (Climate-KIC, 2020), with local market and customer needs driving the approaches developed (King, 2018). Currently there are four pilot EIZs underway—Black Country, UK Central, Birmingham Central and Tyseley, and Coventry—with each EIZ focusing on developing strategies that reflect the context and the actors present. The influence context has on the actions undertaken within an EIZ is shown in the case of Black Country EIZ. Black Country EIZ encompasses an industrial area that has the motivation to attract further advanced manufacturing companies to the area, particularly aerospace, automotive and high added value engineering (Energy Capital, 2018). These industrial actors require an affordable, reliable and high-quality supply of energy to power their manufacturing processes. Consequently the EIZ is focusing on developing a modern, clean energy system that can deliver energy at globally competitive costs (Energy Capital, 2018) demonstrating how the socio-economic context of an area can influence the nature of energy projects undertaken. Tyseley and Birmingham Central EIZ provides another insight into how context can influence the nature of energy developments. The geographical location of Tyseley and Birmingham Central EIZ has influenced the energy innovations being scaled-up. As the EIZ is located in close proximity to the city center which is attempting to tackle its air pollution problem through a "Clean Air Zone" and the electrification of transport vehicles including buses and taxis (Energy Capital, 2018), the innovative technologies being developed through the EIZ focus on supporting this. Thus, as part of Tyseley and Birmingham Central EIZ a low-carbon refueling station powered by a waste to energy plant are being developed (TEP, 2019).

Although each of the 4 pilot EIZs have been developed in consideration of the local context, there remains a focus

on manufacturing and industrial actors across the four pilots with this reflecting the broader context of the West Midlands. The West Midlands is a manufacturing and industrial hub as a result of geographical location, good transport links and historical legacy (HM Government, 2019). However, the reason for focusing on manufacturing and industrial actors may extend beyond this geographical context to include the influence of broader actors and institutions on plans developed—EIZs are not isolated entities within city regions, rather they are part of a multi-scalar political ecology that makes up the city (Sassen, 2013), and are influenced by actions at other scales as well. Energy Capital, the body established by the devolved West Midlands government to coordinate the city region's low-carbon transition, supports the development of EIZs and depends upon these strategic hubs to achieve the low-carbon ambitions (Energy Capital, 2018). Consequently, the understandings, preferences and priorities of Energy Capital feed into the EIZ plans. The Energy Capital Board is composed of range of actors including local government, local academic institutions, BEIS, and Energy Systems Catapult (WMCA, 2018). An Industrial Advisory Board supports Energy Capital and includes representatives from Jaguar Land Rover, Liberty Group, Western Power Distribution and the National Grid (King, 2018). The priorities of Energy Capital are likely to reflect the actors that are associated with the body, which include large industrial actors, manufacturers and innovators, with the views of these actors reflecting the nature of EIZ approaches. This highlights the impact that the institutional infrastructures can have on approaches to low-carbon transitions—if Energy Capital were to also have an Advisory Board made up of actors focused on more socio-political issues then perhaps different approaches would be present in the EIZs. Thus, ensuring advisory groups and institutional boards are representative of the interests of a range of actors and organizations within the city region could be considered a critical component of ensuring an equitable low-carbon energy transition that reflects the needs of a range of different groups. The focus of EIZs are not only influenced by institutions at the city region level but also national incentives. The UK Industrial Strategy intends to support economic growth by encouraging investment in skills, industries, and infrastructure (HM Government, 2017). As part of this, emphasis is placed on the potential for UK manufacturing industries to increase their share of the global market as a result of shifting to clean energy sources and efficient new materials (HM Government, 2017). This shows how EIZs align with the national focus and as previously mentioned, aligning with National priorities is critical for city regions as this ensures they receive their funding.

The approaches developed by Greater Manchester and Sheffield City Region to support low-carbon transitions appear to show less consideration of the heterogeneity of the actors involved. Theoretically, by re-scaling transitions to the city region level it means approaches can be adapted to reflect the particular context in which they are to be implemented. However, the approaches developed by Greater Manchester and Sheffield City Region do not appear to consider the diverse contexts and relationships that different actors have with the energy system as both city regions provide blanket suggestions for the actions different actors are to undertake. There is little consideration of issues relating to "unequal access to energy, limited financial resources, educational privilege and expertise, or differential levels of control over one's environment and practices" (Lennon et al., 2020, p. 189). Consequently, these issues could manifest as barriers to the achievement of low-carbon ambitions; if the differential abilities of actors engage with low-carbon transitions is not acknowledged with appropriate mechanisms being implemented to support these individuals then equitable low-carbon transitions will not be achieved. As the approaches developed by each of the city regions to achieve a low-carbon transition emphasize the importance of collective action, there is a need to ensure that this diversity is appreciated.

The lack of consideration given to the different contexts of actors can be seen in Sheffield City Region's intention to double the number of community energy organizations in South Yorkshire by 2040 (SCR, 2020). There are multiple factors that affect a communities' ability to participate in local energy schemes including varying interests and knowledge about local energy technologies, different financial situations, different priorities and different renewable energy potential as a result of geographical location (Eadson et al., 2019). Within Sheffield City Region, 11.5% of residents live in flats and 34% live in rented accommodation (ONS, 2016), with these housing types and tenures potentially restricting the ways in which individuals can contribute to community energy projects, especially if there is the intention to install Solar PV on individual properties. This highlights how the built environment can constrain action that supports low-carbon transitions—there is a need to consider the context in which energy technologies are being implemented, including the renewable potential, building type and building tenure (Pehnt, 2006). Thus, despite community energy theoretically empowering individuals through the localization of energy, by not adapting these suggested actions to reflect the different contexts of actors, it can have the inverse effect and leave individuals feeling disempowered and disenfranchised (Lennon et al., 2019). Furthermore, despite actions being undertaken by individual actors, the driving force behind these actions is ultimately the municipal government; there is a top-down implementation of actions that are normally established through bottom-up approaches. The driving forces behind community energy in Sheffield City Region highlight the relationship between the broader regional scale and individual actions—and demonstrate that it is the cumulative impact of sub-regional actions that is intended to underpin the low-carbon transition of the entire city region. To support the achievement of these individualized actions, there is the need for effective communication between the different actors involved in Sheffield City Region's energy sector. This need for communication could be facilitated by intermediary organizations who work "in-between" the different actors, supporting interactions, and illuminating areas where practices could be changed to better reflect the situation (Moss, 2009; Creamer et al., 2018; van Veelen, 2019). In doing so, it offers the potential to have more bespoke approaches to the low-carbon transition that better reflects the contexts of

the actors involved and acknowledges the heterogeneity of these actors.

Similarly in Greater Manchester, Demand Side Management (DSM) is advocated within the city region's approach to the low-carbon transition. Within this, there is the assumption that all energy consumers within the city region will be able to make the required shifts in their energy practices, and become a "more responsible consumer" (GMCA, 2019), yet the different contexts of individuals may mean that engaging with DSM practices may not be possible for some. An individual's energy practices cannot be separated from the broader temporalities of their daily life and their specific context (Blue et al., 2020). As discussed by Shove and Walker (2017), energy demand is a product of the daily rhythms of life—for some, these rhythms and the contexts in which they are situated offer greater flexibility in energy practices, whilst for others they are constrained by them. Daily rhythms are the product of multi-scalar influences such as occupation and working hours, housing type, and household composition (Powells et al., 2014). There is a need to acknowledge and accommodate for the diverging daily rhythms of different groups within society, and how this impacts their flexibility in energy practices.

As shown here, the heterogeneity of different actors associated with low-carbon transitions is considered to varying extents in the approaches developed by each of the city regions. Understanding the contexts and characteristics of the different actors associated with low-carbon transitions is important as it enables appropriate support mechanisms to be developed. Applying relational understandings can help appreciate the diversity of characteristics held by actors supporting low-carbon transitions, as this theoretical lens draws attention to the different aspects that influence actors including geographical factors, institutions, and existing infrastructures.

## Innovation in City Regions: Who, What, How and Why?

Within the low-carbon transition approaches developed by the city regions particular emphasis is placed on innovation. Each city region has developed different infrastructures, both material and institutional, in order to facilitate innovation that will support its low-carbon transition. This focus on innovation could be seen as a product of the scale at which the approaches are developed, as often experimentation and living labs are conducted at sub-national scales. Through experimentation and living labs it is possible to test out new approaches within a defined context (Frantzeskaki et al., 2017; von Wirth et al., 2019). The notion of experimentation and living labs are implicitly present in the approaches developed—for the West Midlands the EIZs provide the space to scale-up innovations (Energy Capital, 2018) whilst the Energy Innovation Agency (EIA) developed in Greater Manchester intends to provide a mechanism to bring together research and act as a resource to different actors within the city region (Owen, 2019). In the approach developed by Sheffield City Region innovation is woven throughout the different individualized actions outlined (SCR, 2020). The way in which each City Region supports innovation reflects its context, motivations and resource.

The establishment of EIZs demonstrates the centrality of innovation to the West Midlands' low-carbon transition. EIZs are a product of the context in which they are situated, resulting in a range of actors being involved across the different EIZs (King, 2018). This diversity of actors has implications on governance and management as it is not possible to establish an one-size-fits-all approach to designing, implementing and maintaining EIZs. This is particularly evident when considering the different ways in which actors embedded within the context of the EIZs can influence the outcome of the EIZs—the businesses and industries present, local residents, the city region government actors and national government can impact the nature of the EIZs, as is shown in the examples of Black Country EIZ and Birmingham Central and Tyseley EIZ discussed in the previous section. The diversity of actors present and the influence they can have demonstrates the importance of ensuring there are appropriate mechanisms in place to help ensure these influences are channeled constructively into the project. As part of this, the Local Authorities (LAs) and Local Economic Partnerships (LEPs) in which the EIZs are situated undertake a myriad of roles to support the innovation processes (King, 2018; WMCA, 2018). The LAs and LEPs interact with a diversity of actors associated with the EIZs who are situated at different scales and influence the innovation process in different ways. The LAs and LEPs coordinate and facilitate the interaction between the industries and organizations that are undertaking the innovation in the EIZ, they also collate and communicate the viewpoints of local residents through their local government role and liaise with the city region government over the EIZ development (WMCA, 2018). Thus, the LAs and LEPs could be considered as key intermediaries that facilitate communication, support collaboration and help share the experiences of different actors (van Veelen, 2019). Having the LAs and LEPs as intermediaries within the EIZs is advantageous for a number of reasons. Firstly they are established and recognized components of the local government framework meaning that individuals are likely to draw upon them as a resource. Secondly they will have an established network and communication methods that they can draw upon when undertaking this intermediary role—LAs are able to interact with their constituencies, and the LEPs have established links with local business. Finally, as they are situated in the context of the EIZ they have a contextual awareness that will facilitate interactions. The range of actors associated with, and able to influence, the innovation process of EIZs demonstrates the benefits of rescaling this action to a local scale as this enables the context and associated actors to be considered when developing the required support mechanisms. The roles undertaken by the LAs and LEPs demonstrates the importance of having key intermediaries that are able to work in-between the other actors, and bring together the different actors associated in constructive ways.

The role of the LAs and LEPs in the West Midlands is comparable to that of the Energy Innovation Agency (EIA) in Greater Manchester. The intention of the EIA is to support collaboration and engagement between different actors associated within Greater Manchester's energy sector to foster innovation that supports the transition to a low-carbon city

region (GMCA, 2020). Similarly to the LAs and LEPs, the EIA is embedded within the city regional governance structure—it is a collaborative endeavor between the local universities, local government and industry (GMCA, 2020). By having these different actors engage with Greater Manchester's low-carbon energy transition through a formal mechanism it could increase the efficiency of innovative developments due to the high levels of resource and knowledge held, as well as the range of networks they are a part of. However, the actions undertaken and innovative approaches developed through the EIA, are likely to reflect the priorities and interests of these academic, governmental and industrial actors as these priorities and interests will be embedded within the resources they are able to provide. Unlike the EIZs, which focus on a defined strategic zone within the city region, the EIA is to be an overarching resource for the entirety of Greater Manchester (Owen, 2019). The broad city region focus of the EIA could foster greater collaboration amongst a wider range of actors to further innovative approaches across a range of contexts—by covering a greater geographical area there is the possibility to interact with a greater range of actors that can influence support the low-carbon transition. However, there is the potential that by having the EIA operate at the city-region level, despite providing support on a case-by-case basis, the heterogeneity of the actors embedded in different contexts may not be fully captured if adequate resources are not allocated to support.

Both the West Midlands and Greater Manchester established formal mechanisms that intend to support innovation by providing a space to scale-up technologies and facilitate collaboration between different actors. For Sheffield City Region, innovation is included as a goal in the city region's energy strategy—"Promote investment and innovation in low carbon energy generation, distribution and storage technologies" (SCR, 2020) but unlike Greater Manchester and the West Midlands there is no formal vehicle to support this. Rather innovation is woven throughout the different areas outlined in the strategy. For example, one area of focus is to "Encourage clean and efficient growth in local businesses and increase the number of jobs in the low carbon energy sector," although on the surface this appears to be economically focused, activities considered to support the achievement of this include "supporting SMEs to become aware of, and apply for, low carbon innovation funding provided from the UK Government and elsewhere" and "establishing South Yorkshire as an innovation incubator where energy innovations can be taken from concept, to prototype, to trial, through to full-scale production" (SCR, 2020, p. 10) thus demonstrating the intention for innovation to occur. The lack of formal innovation mechanism is not to say that there is no collaboration between different knowledge holders within the city region. Sheffield City Region has developed a strategic partnership with the University of Sheffield, Sheffield Hallam University and a range of experts called SCR:NZ which focuses on identifying ways to progress toward net zero (SCR, 2019). As with both West Midlands and Greater Manchester, the actors involved within these partnerships, their interests, motivations and priorities are likely to influence the innovation that occurs.

By considering how innovation is presented and facilitated within the different city regions, it highlights the different influences that act upon approaches to low-carbon transitions—the actors involved, institutional configurations and broader socio-economic context of the city region can influence the actions undertaken.

## CONCLUSION

Re-scaling low-carbon energy transitions to the city region level enables a greater diversity of actors to participate in the energy system and provides the opportunity for different infrastructures and institutions to be developed. This paper has applied relational understandings to the approaches developed by three devolved English city regions to support their low-carbon transition—focus was placed on the actors, infrastructures and institutions involved, the networks of interactions they are embedded in and the influence they have on the approaches developed. Each of the approaches developed by the city regions reflects the different motivations, priorities and resources within the area. Consequently, the different energy strategies are situated at different scales within the city region—within Greater Manchester there is a focus on a whole systems approach, the West Midlands identify strategic hubs within the city region, and for Sheffield City Region the focus appears to be on individualized and siloed activity—highlighting how the "local" scale of energy systems is an umbrella term for a range of activities. The relational lens adopted throughout this paper demonstrates the complexity associated with low-carbon transitions, the inability to develop one-size-fits all approaches to low-carbon transitions, and the importance of considering and accounting for context when developing approaches.

By undertaking a document review and SNA to understand the low-carbon energy transition approaches developed by the different city regions, it provided insight into what the authors producing the documents believed the intended outcomes to be; the strategies are presented in the author's own words, reflecting their perspectives, motivation and intentions without any external influence. By combining insights obtained from different documents it enables areas of consensus and contestation to be highlighted, as well as potential gaps in understanding or where strategies may not be as effective when implemented in the real world compared to devised in a policy document. Also, by considering who is not producing documents relating to these issues it can illuminate actors that are not necessarily as involved. The document review methodology could be drawn upon in a range of research contexts, not only those relating to energy transitions or devolution, as it provides rich insight into the motivations, intentions, priorities and perspectives of different actors embedded within processes. Through the document review it possible to identify how policy is understood by different actors within the system, and by unpacking the interlinks between different actors' understandings it illuminates underlying motivations, intentions, priorities and perspectives.

The approaches developed within each city region are both enabled and constrained by actors, infrastructures and

institutions situated at scales both above and below the region. Despite having devolved powers, the city regions need to align their overarching priorities with that of the national government in order to receive funding, which could either hinder their ability to undertake certain actions as they are not considered a priority or provide additional support and funding to undertake actions. This demonstrates the impact that national government priorities can have on the approaches developed to achieve a low-carbon energy transition—a shift in priorities would lead to different outcomes. Furthermore, individual actors within the city region need to be incentivised and supported to undertake the actions required from them. Appreciating this complexity that emerges through multi-scalar interactions is critical when developing approaches to low-carbon energy transitions as they are an external influence which can impact the outcomes of strategies developed. Re-scaling governance to the city region scale and developing localized initiatives has the potential to enable consideration of how these interactions manifest at the city region level and develop appropriate strategies. The strategies developed would reflect the context of the city region, including its actors and infrastructures, and in doing so would support the achievement of a more equitable low-carbon energy transition. Yet, this potential is not being fully captured in existing approaches, as shown through the blanket suggestions provided by Greater Manchester and Sheffield City Region, as well as the industrial focus of the West Midlands' EIZs; there is a need to greater acknowledge the diversity within city regions and dedicate enough support/develop appropriate mechanisms to ensure an equitable change occurs. When developing city region approaches to low-carbon energy transitions, there is a need to appreciate the diversity of contexts at the sub-regional scale and incorporate these understandings into tangible actions so that the needs of different actors are recognized—particularly as there is an emphasis on everyone playing a role in the transition.

Within each of the low-carbon transition approaches developed by the city regions, emphasis has been placed on the role of innovation. This again can be considered to be a product of re-scaling low-carbon transitions to the city region level as there is the opportunity for experimentation and living labs. The mechanisms established to support innovation can be considered institutional infrastructures that facilitate the collaboration between actors—the nature of these institutional arrangements is a product of the context they are situated, and the institutions themselves influence the innovative activities undertaken. Each of the city regions support collaboration within their approaches to innovation, with the nature of this collaboration, the priorities, and actors involved being a product of the local context whilst also being influenced by international, national, and sub-national contexts. The actors involved with the collaboration also influences the outcomes and action undertaken demonstrated the complexity of relations associated with low-carbon transitions. However, it is critical that everyone is able to participate in the innovation process or engage with the innovations developed, otherwise there is the risk that innovation could become a vehicle of exclusion. The range of actors and resources associated with transitions has the potential to help overcome this exclusion but appropriate structures are required to co-ordinate efforts. This further emphasizes the critical role of infrastructure in low-carbon energy transitions, not only in terms of facilitating progress but also as a mechanism to support an equitable transition being developed. Situating infrastructures, particularly those which are institutional, at the regional scale helps ensure that they reflect the needs of the actors within that context, and can adapt if the context changes.

The localization narrative, reinforced through processes of devolution, highlights the benefits of developing approaches to low-carbon transitions that consider the context in which they are situated. Consequently, different geographical, economic and socio-material contexts mean that a one-size-fits-all approach to low-carbon transitions is not feasible. The different low-carbon transition approaches developed by the city regions discussed in this paper have started to engage with the need to develop bespoke contextually-situated approaches, but additional resources and infrastructures are required to implement strategies that enable an equitable low-carbon transition. The context within which city region low-carbon transitions occur, and the actors involved are not isolated from broader contexts and particularities of place—there is interaction between these different scales, with each scale influencing and being influenced by other scales. This highlights the complexity embedded within low-carbon transitions, and the need to develop further understandings of the different components involved in order to develop appropriate mechanisms to facilitate transitions. Reflecting upon how these multi-scalar relationships and influences have impacted existing approaches provides insight that can be drawn upon when developing future iterations of approaches to facilitate low-carbon energy transitions.

## AUTHOR CONTRIBUTIONS

AC, SP, and JE developed initial concept of paper. AC conducted the research analysis and wrote first draft and final draft based upon comments from co-authors. SP and JE supported continued development of paper concept, highlighted theoretical perspectives, supported editing, and helped refine paper. All authors contributed to the article and approved the submitted version.

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## REFERENCES


Baka, J., and Vaishnava, S. (2020). The evolving borderland of energy geographies. *Geogr. Compass* 14:e12493. doi: 10.1111/gec3.12493

Barley, S. R., and Tolbert, P. S. (1997). Institutionalization and structuration: studying the links between action and institution. *Organ. Stud.* 18, 93–117. doi: 10.1177/017084069701800106

Becker, S., Beveridge, R., and Röhring, A. (2016b). "Energy transitions and institutional change: between structure and agency," in *Conceptualizing Germany's Energy Transition: Institutions, Materiality, Power, Space,* eds L. Gailing and T. Moss (London: Palgrave Macmillan UK), 21–41.

Becker, S., Moss, T., and Naumann, M. (2016a). "The importance of space: towards a socio-material and political geography of energy transitions," in *Conceptualizing Germany's Energy Transition: Institutions, Materiality, Power, Space*, eds L. Gailing and T. Moss (London: Palgrave Macmillan UK), 93–108.

Bennett, J. (2010). *Vibrant Matter: A Political Ecology of Things*. Durham: Duke University Press.

Blue, S., Shove, E., and Forman, P. (2020). Conceptualising flexibility: challenging representations of time and society in the energy sector. *Time Soc*. 29, 923–944. doi: 10.1177/0961463X20905479

Bolton, R., and Foxon, T. J. (2015). Infrastructure transformation as a socio-technical process — implications for the governance of energy distribution networks in the UK. *Technol. Forecast. Soc. Change* 90, 538–550. doi: 10.1016/j.techfore.2014.02.017

Bouzarovski, S., and Haarstad, H. (2019). Rescaling low-carbon transformations: towards a relational ontology. *Transac. Inst. Br. Geogr.* 44, 256–269. doi: 10.1111/tran.12275

Bridge, G. (2018). The map is not the territory: a sympathetic critique of energy research's spatial turn. *Energy Res. Soc. Sci. Spatial Advent. Energy Stud.* 36, 11–20. doi: 10.1016/j.erss.2017.09.033

Bridge, G., Bouzarovski, S., and Eyre, N. (2013). Geographies of energy transition: space, place and the low-carbon economy. *Energy Policy* 53, 331–340. doi: 10.1016/j.enpol.2012.10.066

Brown, E., Cloke, J., and Harrison, J. (2015). *Governance, Decentralisation and Energy: A Critical Review of the Key Issues* (Working Paper 1). Loughborough: Renewable Energy and Decentralization (READ).

Build Up (2020). *Annex 83: Positive Energy Districts [WWW Document]*. Build Up. Available online at: https://www.buildup.eu/en/explore/links/iea-ebc-annex-83-positive-energy-districts (accessed September 25, 2020).

Bulkeley, H. (2005). Reconfiguring environmental governance: towards a politics of scales and networks. *Polit. Geogr.* 24, 875–902. doi: 10.1016/j.polgeo.2005.07.002

Butts, C. T. (2008). Social network analysis: a methodological introduction. *Asian J. Soc. Psychol.* 11, 13–41. doi: 10.1111/j.1467-839X.2007.00241.x

Climate-KIC (2020). *Birmingham and The West Midlands [WWW Document]*. Climate-KIC in the UK and Ireland. Available online at: https://uki.climate-kic.org/who-we-are/climate-kic-in-the-uk/birmingham-and-the-west-midlands/ (accessed September 25, 2020).

Coutard, O., and Rutherford, J. (2010). Energy transition and city–region planning: understanding the spatial politics of systemic change. *Technol. Anal. Strateg. Manag.* 22, 711–727. doi: 10.1080/09537325.2010.496284

Cowell, R. (2020). The role of place in energy transitions: siting gas-fired power stations and the reproduction of high-carbon energy systems. *Geoforum* 112, 73–84. doi: 10.1016/j.geoforum.2020.03.009

Creamer, E., Eadson, W., Veelen, B., van, Pinker, A., Tingey, M., Braunholtz-Speight, T., et al. (2018). Community energy: entanglements of community, state, and private sector. *Geogr. Compass* 12:e12378. doi: 10.1111/gec3.12378

Doggart, N., Ruhinduka, R., Meshack, C. K., Ishengoma, R. C., Morgan-Brown, T., Abdallah, J. M., et al. (2020). The influence of energy policy on charcoal consumption in urban households in Tanzania. *Energy Sustain. Dev.* 57, 200–213. doi: 10.1016/j.esd.2020.06.002

Eadson, W., Dobson, J., Shepherd, J., Bridge, E., and Hall, J. (2019). *Catalysing People-Powered Energy in Yorkshire and the Humber*. Centre for Regional Economic and Social Research, Sheffield, MA.

Energy Capital (2018). *EIZs Across the West Midlands [WWW Document]*. Energy Capital. Available online at: https://www.energycapital.org.uk/eizs-across-the-west-midlands/ (accessed September 25, 2020).

Featherstone, D., Ince, A., Mackinnon, D., Strauss, K., and Cumbers, A. (2012). Progressive localism and the construction od political alternatives. *Transac. Inst. Br. Geogr.* 37, 177–182. doi: 10.1111/j.1475-5661.2011.00493.x

Frantzeskaki, N., Broto, V. C., and Coenen, L. (Eds.). (2017). *Urban Sustainability Transitions*, 1st Edn. ed. *Routledge Studies in Sustainability Transitions*. New York, NY: Routledge, Taylor and Francis Group.

García-Sánchez, I.-M., and Prado Lorenzo, J.-M. (2009). Decisive factors in the creation and execution of municipal action plans in the field of sustainable development in the European Union. *J. Clean. Prod.* 17, 1039–1051. doi: 10.1016/j.jclepro.2009.01.008

Geels, F. W. (2018). Low-carbon transition via system reconfiguration? A socio-technical whole system analysis of passenger mobility in Great Britain (1990–2016). *Energy Res. Soc. Sci.* 46, 86–102. doi: 10.1016/j.erss.2018.07.008

GMCA (2019). *5-Year Environment Plan for Greater Manchester: Executive Summary*.

GMCA (2020). *New University-Led Energy Agency to Turn Greater Manchester Green [WWW Document]*. Greater Manchester Combined Authority. Available online at: https://www.greatermanchester-ca.gov.uk/news/new-university-led-energy-agency-to-turn-greater-manchester-green/ (accessed November 30, 2020).

Goh, K. (2020). Urbanising climate justice: constructing scales and politicising difference. *Cambridge J. Regions Econ. Soc.* 13, 559–574. doi: 10.1093/cjres/rsaa010

Goldthau, A. (2014). Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism. *Energy Res. Soc. Sci.* 1, 134–140. doi: 10.1016/j.erss.2014.02.009

Gollner, C. (2019). "Positive Energy Districts and Neighbourhoods for Sustainable Urbanisation. Policies and models for the energy transition: from barriers to breakthroughs," in *EUSEW*.

Grandin, J., and Sareen, S. (2020). What sticks? Ephemerality, permanence and local transition pathways. *Environ. Innov. Soc. Trans.* 36, 72–82. doi: 10.1016/j.eist.2020.04.008

Hall, D., Lobina, E., and Terhorst, P. (2013). Re-municipalisation in the early twenty-first century: water in France and energy in Germany. *Int. Rev. Appl. Econ.* 27, 193–214. doi: 10.1080/02692171.2012.754844

HM Government (2017). *Industrial Strategy: Building a Britain Fit for the* Future.

HM Government (2019). *West Midlands Local Industrial* Strategy.

Hodson, M., and Marvin, S. (2009). Cities mediating technological transitions: understanding visions, intermediation and consequences. *Technol. Anal. Strateg. Manage.* 21, 515–534. doi: 10.1080/09537320902819213

Howitt, R. (1998). Scale as relation: musical metaphors of geographical scale. *Area* 30, 49–58. doi: 10.1111/j.1475-4762.1998.tb00047.x

Kemp, R., and Loorbach, D. (2005). "Dutch policies to manage the transition to sustainable energy," in *Jahrbuch Ökologische Ökonomik: Innovationen und Nachhaltigkeit*, Band 4, eds F. Beckenbach, U. Hampicke, and C. Leipertet (Metropolis: Marburg).

King, D. (2018). *Powering West Midlands Growth: A Regional Approach to Clean Energy Innovation*. Energy Capital.

Lawhon, M., and Murphy, J. T. (2012). Socio-technical regimes and sustainability transitions: insights from political ecology. *Prog. Hum. Geogr.* 36, 354–378. doi: 10.1177/0309132511427960

Lemon, M., Pollitt, M. G., and Steer, S. (2015). Local energy policy and managing low carbon transition: the case of Leicester, UK. *Energy Strat. Rev.* 6, 57–63. doi: 10.1016/j.esr.2015.02.001

Lennon, B., Dunphy, N., Gaffney, C., Revez, A., Mullally, G., and O'Connor, P. (2020). Citizen or consumer? Reconsidering energy citizenship. *J. Environ. Policy Plann.* 22, 184–197. doi: 10.1080/1523908X.2019.1680277

Lennon, B., Dunphy, N. P., and Sanvicente, E. (2019). Community acceptability and the energy transition: a citizens' perspective. *Energ Sustain. Soc.* 9:35. doi: 10.1186/s13705-019-0218-z

Li, F. G. N., Pye, S., and Strachan, N. (2016). Regional winners and losers in future UK energy system transitions. *Energy Strat. Rev.* 13–14, 11–31. doi: 10.1016/j.esr.2016.08.002

Martinus, K., Sigler, T. J., Searle, G., and Tonts, M. (2015). Strategic globalizing centers and sub-network geometries: a social network analysis of multi-scalar energy networks. *Geoforum* 64, 78–89. doi: 10.1016/j.geoforum.2015.06.006

McCormick, K., Anderberg, S., Coenen, L., and Neij, L. (2013). Advancing sustainable urban transformation. *J. Clean. Prod.* 50, 1–11. doi: 10.1016/j.jclepro.2013.01.003

McFarlane, C., and Rutherford, J. (2008). Political Infrastructures: governing and experiencing the fabric of the city. *Int. J. Urban Reg. Res.* 32, 363–374. doi: 10.1111/j.1468-2427.2008.00792.x

Mischen, P. A., and Jackson, S. K. (2008). Connecting the dots: applying complexity theory, knowledge management and social network analysis to policy implementation. *Public Administr. Q.* 32, 314–338. Retrieved from: https://www.jstor.org/stable/41288320

Moss, T. (2009). Intermediaries and the governance of sociotechnical networks in transition. *Environ. Plan. A* 41, 1480–1495. doi: 10.1068/a4116

Murdoch, J. (1997). Towards a geography of heterogeneous associations. *Prog. Hum. Geogr.* 21, 321–337. doi: 10.1191/030913297668007261

Nolden, C. (2013). Governing community energy—feed-in tariffs and the development of community wind energy schemes in the United Kingdom and Germany. *Energy Policy* 63, 543–552. doi: 10.1016/j.enpol.2013.08.050

ONS (2016). *2011 Census Aggregate Data*.

Owen, S. (2019). *Whole System Smart Energy Plan - Greater Manchester*. Energy Systems Catapult, Birmingham, AL.

Park, J. J. (2012). Fostering community energy and equal opportunities between communities. *Local Environ.* 17, 387–408. doi: 10.1080/13549839.2012.678321

Paun, A., Wilson, J., and Nicholson, E. (2020). *English Devolution: Combined Authorities and Metro Mayors [WWW Document]*. The Institute for Government. Available online at: https://www.instituteforgovernment.org.uk/explainers/english-devolution-combined-authorities-and-metro-mayors (accessed September 24, 2020).

Pehnt, M. (2006). Dynamic life cycle assessment (LCA) of renewable energy technologies. *Renew. Energy* 31, 55–71. doi: 10.1016/j.renene.2005.03.002

Pike, A., Rodriguez-Pose, A., and Tomaney, J. (2016). *Local and Regional Development*. London: Routledge.

Poon, L. (2016). *The Paradox of a Global Urban Agenda Led by Nations, Not Cities*. Bloomberg City Lab. Available online at: https://www.bloomberg.com/news/articles/2016-10-18/at-habitat-iii-cities-call-for-a-seat-at-the-table-in-un-talks (accessed March 15, 2021).

Powells, G., Bulkeley, H., Bell, S., and Judson, E. (2014). Peak electricity demand and the flexibility of everyday life. *Geoforum* 55, 43–52. doi: 10.1016/j.geoforum.2014.04.014

Prell, C., Hubacek, K., and Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. *Soc. Nat. Resour.* 22, 501–518. doi: 10.1080/08941920802199202

Randall, J., and Casebourne, J. (2016). *Making Devolution Deals Work*. Institute for Government, London.

Rodríguez-Pose, A., and Wilkie, C. (2017). Revamping local and regional development through place-based strategies. *Cityscape*. 19, 151–170. Available online at: https://www.jstor.org/stable/26328304

Roelich, K., Bale, C. S. E., Turner, B., and Neall, R. (2018). Institutional pathways to municipal energy companies in the UK: realising co-benefits to mitigate climate change in cities. *J. Clean. Prod.* 182, 727–736. doi: 10.1016/j.jclepro.2018.02.002

Sassen, S. (2013). Cities are at the center of our environmental future. *S. A. P. I. E. N. S* 2, 72–83.

Saunders, C. (2007). Using social network analysis to explore social movements: a relational approach. *Soc. Mov. Stud.* 6, 227–243. doi: 10.1080/14742830701777769

Scott, M. (2015). Re-theorizing social network analysis and environmental governance: insights from human geography - Michael Scott, 2015. *Prog. Hum. Geogr.* 39, 449–463. doi: 10.1177/0309132514554322

SCR (2019). *The Mayors Climate Emergency Response*.

SCR (2020). *Sheffield City Region Energy Strategy*.

SCR Mayoral Combined Authority (2020). "SCR mayoral combined authority board minutes of the meeting held on Monday 27th July," in *Virtual Meeting* (Sheffield).

SET-Plan TWG (2018). *SET-Plan Action No3.2 Implementation Plan: Europe to Become a Global Role Model in Integrated, Innovative Solutions for the Planning, Deployment and Replication of Positive Energy Districts*.

Shove, E. (2010). Beyond the ABC: climate change policy and theories of social change. *Environ. Plann. A Econ. Space* 42, 1273–1285. doi: 10.1068/a42282

Shove, E. (2017). "Matters of practice," in *The Nexus of Practices: Connections, Constellations, Practitioners*, eds A. Hui, T. Schatzki, and E. Shove (London: Routledge), 155–168.

Shove, E., and Walker, G. (2017). "Fuelling culture: demand," in *Fuelling Culture: 101 Words for Energy and Environment*, eds I. Szeman, J. Wenzel, and P. Yaeger (New York, NY: Fordham University Press), 107–109.

Silver, J., and Marvin, S. (2017). Powering sub-Saharan Africa's urban revolution: an energy transitions approach. *Urban Stud.* 54, 847–861. doi: 10.1177/0042098016668105

Star, S. L., and Ruhleder, K. (1996). Steps toward an ecology of infrastructure: design and access for large information spaces. *Inform. Syst. Res.* 7, 111–134. doi: 10.1287/isre.7.1.111

TEP (2019). *Tyseley Energy Park: Powering Clean Energy Growth*.

UNFCCC (2015). *Paris Agreement*. United Nations, Paris.

Uzzell, D. (2008). "The challenge of climate change; the challenge for psychology," in *Presented at the 43 Australian Psychological Association Annual Conference* (Hobart, TAS).

Van Der Valk, T., and Gijsbers, G. (2010). The use of social network analysis in innovation studies: mapping actors and technologies. *Innovation* 12, 5–17. doi: 10.5172/impp.12.1.5

van Veelen, B. (2019). Caught in the middle? Creating and contesting intermediary spaces in low-carbon transitions. *Environ. Plann. C Politics Space* 38, 116–133. doi: 10.1177/2399654419856020

von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., and Coenen, L. (2019). Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation. *Eur. Plann. Stud.* 27, 229–257. doi: 10.1080/09654313.2018.1504895

WMCA (2018). *A Regional Energy Strategy for the West Midlands*. WMCA, Birmingham, AL.

Zedan, S., and Miller, W. (2017). Using social network analysis to identify stakeholders' influence on energy efficiency of housing. *Int. J. Eng. Bus. Manage.* 9, 1–11. doi: 10.1177/1847979017712629

Ziervogel, G., Satyal, P., Basu, R., Mensah, A., Singh, C., Hegga, S., et al. (2019). Vertical integration for climate change adaptation in the water sector: lessons from decentralisation in Africa and India. *Reg. Environ. Change* 19, 2729–2743. doi: 10.1007/s10113-019-01571-y

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