Investigating energy infrastructure through the low carbon challenge: technologies, governance, and socio-spatial effects

Editorial

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1.0 Rationale –the intellectual and policy agenda

In its 2022 report, the Intergovernmental Panel on Climate Change reiterated the increasingly severe, interconnected and often irreversible impacts of climate change, emphasising the urgency of immediate action, with particular focus on rapid transformation of energy infrastructure (IPCC, 2022). Such calls for new, expanded and environmentally sustainable energy infrastructure exemplify what Bridge et al labelled as our contemporary 'infrastructural moment' (Bridge et al., 2018: 9). Political, economic and environmental voices have exhorted the considerable scale of the infrastructural investment required, with climate emergency narratives intertwining with earlier positioning of infrastructure spending as a response to the 2008 financial crises (Feindt and Cowell, 2010) and, more recently, to the coronavirus pandemic (Johnson, 2020). Rhetorics of speed, scale and necessity inform policy discourses dominated – at least in national and corporate arenas - by delivery.

Yet, transitioning to a net zero-emissions energy system is a hugely complex task requiring a holistic appraisal of how energy is generated, transferred, and utilized across all forms of infrastructure. The importance of examining and better understanding infrastructures, their obduracy, renewal, and change, across the globe, has never been more acute. It is estimated that around 70% of global greenhouse gas emissions stem from infrastructure (Crouch, 2021). What is more, infrastructure has to be resilient to the climate change that is already happening and still to come. This 'infrastructural moment' has produced much interest across the social sciences, keen to grasp how energy infrastructure co-evolves with socio-economic institutions, actors and social norms (Calvert, 2015). Such perspectives are vital, since infrastructure is not just an entity to be delivered, or an 'asset class 'to be packaged neatly for economic gain. Infrastructural systems deeply infuse patterns of production and consumption; they require governance and simultaneously configure how governing might

be undertaken; and infrastructure provides an analytical window - an ontology - through which societal struggles to achieve energy transitions can be observed and appraised (Sovacool et al., 2020).

Several broad themes have attracted the attention of researchers. The first centres on issues of technology and technology choice. Debate about the respective merits of 'centralized' versus 'decentralized' energy pathways are well established (Lovins 1977), and analysts have escaped these dualistic oppositions to engage with the myriad hybrid permutations of scalar form. However, disputes about the merits of alternative future technological pathways for energy decarbonisation play out in the context of extant infrastructural systems. Infrastructures, and their constitutive networks of actors, facilities and institutions, are both the subject and battleground of future technological choices: consequently, new challenges emerge in reconciling 'decentralised' regimes of provision with energy infrastructures that are spatially integrated and interconnected at wider scales (Goldthau, 2014). Equally important, though less studied, is how dominant, centralized infrastructural systems accommodate new technologies, and re-shape or attenuate any decentralising potential.

The second theme concerns the socio-spatial effects of infrastructure. There is a rich seam of social science research that understands energy infrastructure as simultaneously socio-material and technical systems - deeply intertwined with the structure of society - with the capacity therefore to organise social as well as ecological relations. Various analysts have charted how energy infrastructures shape social and spatial differentials in economic and environmental outcomes (Graham and Marvin, 2001). The particular agentic effects of infrastructures arise from shifting norms of social organisation, but also from their material obduracy. Current configurations of energy infrastructure have deep historical roots and are closely entwined with the overall development trajectory of territories. This history and associated path dependence mean that efforts to accelerate the sustainable transition to greener energy systems need to start from an appreciation of these contextual particularities (Meadowcroft, 2016; Wiig et al 2022). Yet, energy infrastructure transition is not only shaped by spatial contexts but can be configured as a 'space-making process' (Bridge and Gailing, 2020), influenced by interacting processes of accumulation, innovation, competition and social mobilisation, that are constituted spatially. Indeed, dominant infrastructural space-making in the energy field displays near-inherent cross-scalar qualities, linking across territory, connecting sites of production and consumption, yet also creating inclusion and exclusion. How does decarbonisation affect these dynamics? New concerns include the spatially uneven distribution of smaller-scale low carbon electricity, heat and storage infrastructure across cities and regions and the geographical reach, access arrangements, and forms of ownership for infrastructure systems that influence energy availability and engagement in low carbon energy deployment (O'Sullivan et al., 2020, Creamer et al., 2018, Oteman et al., 2014).

In order to understand how these new socio-spatial arrangements emerging around energy infrastructure and decarbonisation are shaped, steered and contested, further attention needs to be paid to issues of governance: the third theme (Brisbois, 2020: 49). Social scientists have given careful attention to the complex architectures of political power and spaces of governance that have emerged as governments and other agents, at all levels, seek to orchestrate energy infrastructure development (Muinzer and Ellis, 2017). Energy infrastructure governance has been shown to configure the politics of decarbonisation, in

shaping the scope of democratic steering (Chilvers and Longhurst, 2016) and the integration of novel actors with objectives that diverge from dominant systems. Understanding energy transitions will therefore require a discussion and acknowledgement of the capacity for agency and the type of relations through which agents can bring about change (Partzsch, 2017). Researchers have also observed how the highly technical, complex nature of energy infrastructures and their associated regulatory processes can render them opaque to non-incumbent actors (Lockwood et al., 2017, Palm, 2021), begging questions about how citizens engage with high-consequence issues.

Energy infrastructures are undeniably vital - politically, economically and materially - in the struggle to achieve decarbonisation, and social scientists have done much to reposition infrastructures from a 'largely passive backdrop' (Wiig et al 2021, p.3) to an active component of change, rendering their contours visible and open to critical analysis. Yet the socio-spatial patterns of interactions surrounding an infrastructural moment such as this – and their environmental, social and political implications - are still only partly understood. Against this backdrop, the papers contributing to this special issue explore the intersection between energy infrastructures and the low carbon challenge, taking forward our understanding of the interactions between technologies, social-spatial effects and governance. We use the remainder of this editorial to preview the papers in this special issue and to identify cross cutting themes and areas for future research.

2.0 The special issue and constituent papers

The contributions for this special issue were selected from a call for papers to contribute a session at the Royal Geographical Society-IBG Annual Conference, London, 1-4 September 2020. The idea for the conference session and the special issue was sparked by the almost exponentially increasing political, economic and intellectual interest in infrastructure as a constituent ingredient of energy systems, and as an element that greatly conditions how any transition to decarbonised, sustainable energy systems will be achieved. While the conference did not go ahead as planned due to the Covid 19 pandemic, we organised an 'interactive discussion event', in an asynchronous way. Authors were invited to post their papers online and for a week, starting from the 7th of September 2020, with the event providing an opportunity to receive feedback and develop ideas.

This special issue brings together scholars from different disciplinary backgrounds that are researching issues of energy infrastructure in the context of the low carbon challenge and investigating infrastructural dimensions of energy transition governance and environmental policy more widely. Energy infrastructure has long provided fertile material for cross-national theory-building, as scholars examine how commonly occurring categories of infrastructure, such as mega-projects or 'community energy', unfold in and impact on different geographical settings (Sovacool and Cooper, 2013, Oteman et al., 2014). The work presented here continues in this tradition, bringing together studies undertaken in Ethiopia, India, Italy, Mexico, North Macedonia, the UK and Spain, but drawing out wider insights for our understanding of decarbonisation, scale and governance.

We group the contributions in line with the broad themes of the research identified above:

1. Technology choices: alternative pathways meet challenging social contexts

Two of the contributors examine the governance challenges arising where new energy infrastructures - both large-scale projects and 'local energy systems' - interface with different social contexts.

In her analysis of social justice and environmental sustainability in new energy infrastructure projects in the Mayan region of Yucatan in Mexico, Barragan-Contreras (2021) presents the dilemmas of energy infrastructure implementation on the ground. Stressing the procedural injustices found in decision-making processes, the paper shows how a just approach to renewable energy expansion requires changes to normative top-down approaches to procedural justice and questions current power dynamics, to encourage greater decision-making power for indigenous communities. Barragan-Contreras concludes that promoting rights to indigenous communities' energy sovereignty can support renewable energy implementation, through reducing the opposition and promoting alternative, decentralised ways to expand renewable energy infrastructure.

Nathan et al (2022) examine the implementation of solar micro-grids in the Komna Block of Nuapada District in the state of Odisha, India. While microgrids have the potential to provide electricity in rural areas, success to date has been limited in the region because, the authors argue, they exhibit characteristics of a common resource that it is overexploited by individuals for personal, short-term gain. Nathan et al suggest that the successful sustenance of micro-grids can be supported by promoting key elements of common-pool resources management theory, which include institutional arrangements that are simple and comprehensible, coupled with systems of enforcement and regular monitoring.

These contributions not only highlight how energy infrastructure transition is shaped by spatial contexts but stress how the cultural and social-environmental conditions and local and non-incumbent actors have a role to play in defining the decentralising potential of energy infrastructure systems.

2. Socio-material and technical effects of infrastructure systems

Two of the papers present in-depth analyses of how citizens respond to dominant energy infrastructural regimes, the discourses that surround them, and their socio-spatial effects.

Moles-Grueso and Stojilovska (2021) explore the divide between official and everyday framings of consumer energy sustainability, drawing from two case studies promoting energy conservation in commercial buildings in Barcelona (Spain) and programmes to address household energy poverty in North Macedonia. The paper reveals spatial inconsistencies in official policy and practice that highlights the existence of systemic unequal participation, inequalities, and injustice. In the two cases, proponents gave insufficient consideration to the role of citizens and their everyday epistemologies. This ignored *inter alia* citizens' limited capacities for replicating innovative solutions, their mistrust of official 'messengers', and – in North Macedonia - the affordability, versatility and autonomy afforded to publics by fuelwood systems. The resulting alienation created by official practices, in turn, affects citizens' propensity to act accordance with them.

Tesfamichael (2022) revisits the narratives and socio-technical imaginaries developed around the Grand Ethiopian Renaissance Dam (GERD) hydropower plant, and how they interact with everyday energy practices in Ethiopia's capital, Addis Ababa. The paper highlights the gaps between public narratives about desirable energy futures and the elite-dominated imaginaries. Tesfamichael reveals that although dominant narratives equating the GERD with nation-building have been persuasive, there is a disparity with public concerns about growing private sector involvement in energy, and a pervasive sense of precarity in energy provision. Moreover, the GERD exemplifies a centralised political system in which public dissatisfactions with energy provision struggle to translate into effective change.

These two contributions take various energy infrastructures as starting points exploring the importance of recognising and understanding everyday practices alongside dominant narratives of low carbon infrastructural change. They stress the importance of understanding citizens as co-producers of meaning if we are to overcome conflict around dominant material interests, and address risks of 'backsliding' to higher carbon, more polluting energy sources.

3. Energy infrastructure governance and the distribution of agency

The final two papers examine how energy infrastructures, their organisation and governance, configure the scope and distribution of agency for shaping energy transitions.

De Laurentis and Cowell (2021) analyse the challenges associated with the restructuring of electricity grid networks to accommodate the expansion of renewable energy in Italy and two of its regions, Apulia and Sardinia. The authors use the regional level as an entry point to examine the often difficult relations between territorially-bounded government bodies and the steering of spatially-extensive infrastructures. The regional case studies investigated examine how electricity network infrastructures, and their governance, can affect renewable energy deployment and shape the opportunities that emerge for participation in infrastructure renewal. However, the capacity of regional actors is partial in scope and reach, being confined largely to streamlining consenting and helping to find sites- and channel resources- for infrastructural investment to mediate potential material constraints.

Britton et al. (2022), use a discursive institutionalist approach to analyse the emergence of heat networks in England, and show how ideas and their ability to influence a wider range of actors are shaping the development of heat networks in England. Examining heat network developments in Bristol, Birmingham and Sheffield, the paper highlights how local actors can mobilise ideas, from within and beyond energy, to challenge national institutions and norms. Although local actors lack both agency and structural advantage, they have sought to create the discursive space to resist the power of dominant institutional norms that see heat network developments as a techno-economic problem albeit with limited success.

These final contributions of the special issue highlight the complex interactions between different governance scales in meditating material change to energy systems, showing that the spatial embeddedness of energy infrastructures can present opportunities to challenge dominant development trajectories. However, in both cases, the agency of sub-national government actors - being local or regional - is often limited. The case of Italy shows that such

agency can often be restricted to measures that render regional territory more readily available for incumbent industry actions, as much as facilitating greater local control. In the case of England, the lack of institutional structures to engage sub-national actors in energy policy is evident and hampers the ability of local actors to influence national policy debates.

3.0 Cross-cutting issues and directions for further research

The papers in this special issue have provided a range of insights on how energy infrastructures - as simultaneously socio-material, political and technical systems –can shape the dynamics of decarbonisation. Together, the work is likely to attract an audience from scholars of sustainability transitions, energy decarbonisation, materiality and 'techno-politics', as well as environment and development. Looking across the papers, a number of cross-cutting themes emerge that represent new ways of integrating the broad themes that have characterised energy, infrastructure and decarbonisation research to date.

Social and spatial unevenness in the accessibility and affordability of energy have long since been observed, and the papers further delineate how infrastructures are implicated in this - in their uneven territorial extension, and in their relative imperviousness to host community and resident populations' concerns and priorities. This links across to governance. Infrastructure is integral to the path dependencies that affect the scope for different communities and social groups to participate, beneficially, in the opportunities of energy decarbonisation (O'Sullivan et al., 2020). These issues become very important as we look forward to further stages in decarbonisation transitions and contemplate the distributive effects of expanding smaller-scale low carbon electricity, heat and storage infrastructure across cities and regions and their geographical reach, terms of access, and forms of ownership (Baker and Phillips, 2019, While & Eadson, 2019).

Tesfamichael (2022) and Moles Grueso and Stojilovska (2021) have given intriguing perspectives on how infrastructures exert *social effects* beyond the notionally instrumental and material relations that they enable, or their (sometimes considerable) environmental impacts. Infrastructures are shown to exert effects in the symbolic realm, through meaning, by promulgating particular national and technological imaginaries. Contradictions between 'official' narratives and the everyday energy experiences of citizens can foster mistrust and disconnection rather than engagement in wider decarbonisation agendas. While energy infrastructures - and their developments - are often woven into discourses and debates about identity, image, and significance (Perreault and Valdivia, 2010), such imagineries can become normative and might influence and co-produce social and political orders (Longhurst and Chilvers, 2019, Rudek, 2021). The way in which citizens interpret and respond to dominant energy infrastructure imaginaries becomes important, highlighting the scope for infrastructure analysts to engage with the work of social psychologists looking at 'behavioural spillovers', where interventions in one realm of social life exert effects on behaviours in other realms (Nash et al., 2017).

Many of the papers presented in this special issue show that struggles around energy infrastructure expansion are not just about the distribution of costs and benefits, or between different goals - important though those are. Also present are tensions between universalising and situated discourses of the common good, with important moral and political dimensions,

highlighting the relevance of investigating the *spatial reach of infrastructural systems, their values and agency*. Barragan-Contreras observed how renewable energy developer consultation practices, rooted in certain notions of justice, foundered in the face of alternative conceptions of justice that challenged their reach, emphasising instead the reallocation of resources and control to local communities. Moles-Grueso and Stojilovska (2021)'s analysis asserts the importance of 'rights to energy', and the need to bridge 'universal' and 'particular' conceptions of energy justice. However, both De Laurentis and Cowell and Britton et al. highlight some of the difficulties in expecting more localised territorial actors to accrue significant agency to steer the development of energy systems. Indeed, developing and maintaining infrastructural systems can serve to both entrench and challenge the existing structures of governance; where system-maintaining principles of universality, standardisation and integration confront problematising notions of local, regional or national energy 'sovereignty'.

Social scientists have been interested in theorising in general about energy, infrastructures, and transitions, yet there are many ways in which the material particularities of different energy vectors can affect how social, environmental and governance processes work out. The collection of papers presented highlight how e*nergy materialities can make a difference*. Thus, a material lens helps drawing out more explicitly the mutual constitution of the social and physical nodes of energy infrastructure (De Laurentis and Pearson, 2018, Svensson, 2021). Moreover, many analysts focus mainly on electricity networks, yet the complexity and integrated nature of electrical systems may make them particularly challenging subjects for local agency. Other vectors, such as heat, have been described as more inherently local - being less transportable, more embedded in local, contextual features of the built environment, and less encompassed (in many countries, so far) by standardised markets or technologies (Wesche et al 2019). This may entail more space for local action, albeit not always towards decarbonisation.

The special issue papers also highlight a whole number of avenues for future research on energy infrastructures and decarbonisation.

Firstly, energy infrastructure research requires a *broadening in its infrastructural focus.* As noted above, electricity in general, and renewably generated electricity in particular, has dominated energy infrastructure research to date but, in many countries, 'net zero' goals are multiplying the technological fronts in which transition is being pursued. The production of hydrogen as a means of storing 'surplus' renewable electricity production and/or substituting for hydrocarbon vehicle fuels and natural gas raises a whole series of questions about the politics of pathway choice ('green' or 'blue' hydrogen?); the influence of extant hydrocarbon and petrochemical infrastructures, and the actors around them, on pathway choice; and the socio-spatial effects of hydrogen, its production facilities and as a fuel, on society and communities. Similar types of issues arise around carbon-capture and storage technologies, widely identified as pivotal to net zero energy systems, but with numerous unresolved challenges. At the more localised end, long-standing interest in local energy generation could usefully expand to more closely investigate who designs, develops, and controls the 'integration infrastructure', by which demand management and different energy vectors might be integrated (Hvelplund and Djørup, 2017).

Secondly, research on energy infrastructure requires *a broadening of focus from building to maintaining.* As low carbon energy infrastructure moves from novelty to an established presence, so researchers might supplement the prevailing emphasis on the dynamics of new project development with closer attention to infrastructural maintenance. Analysts have already begun to examine what happens when ageing wind turbine installed capacity reaches 'end of life' decisions (Windemer, 2019). And, as papers in this special issue have observed, locally-gathered firewood remains an expedient (affordable and controllable) default option in many countries, to which populations quickly 'backslide' where national electricity regimes prove unreliable or expensive, injecting considerable contingency into electricity-driven decarbonisation efforts. Poor and deteriorating infrastructure performance is by no means a problem wholly of the Global south (Baker and Phillips, 2019, Silver 2019).

Thirdly, while analysts are familiar with the 'space making' effects of energy infrastructure development (Bridge and Gailing 2020), there is more to learn from the interface between energy infrastructures, decarbonisation agendas, and *wider processes of political and governance re-scalin*g. Differences of value and priority can become starkly apparent where infrastructures become entangled in scalar governance shifts and resulting border tensions. Whether these are moves towards market integration, secession (as with Brexit, or devolution [Cowell et al., 2017]) localisation, or responses to geopolitical situations – the move to disarticulate European energy systems from Russian hydrocarbons sparked by the invasion of Ukraine is a major case in point. At the same time, dealing with infrastructures and the supra-local flows that they enable can restrict agency at lower spatial levels, raising under-explored questions for the meaning of 'sovereignty' and its distribution.

Last but not least, more effective approaches to energy decarbonisation, which steer towards net zero with greater justice, urgently require more policy and analytical attention to *reflexive governance*, in a number of respects. Reflexivity is required to construct transition pathways that are sensitive to, and supportive of diverse social and spatial contexts, expert and everyday meanings, and allow effective co-evolution between local agendas and wider systemic changes. There is also a need for better societal deliberation of key energy pathway choices too rarely brought into explicit comparison, notably between supply-based approaches to energy decarbonisation, underpinned by large-scale infrastructures and consumption-centred pathways that emphasise energy efficiency, demand reduction, and lifestyle and cultural change, the extent of which may reduce the requirement for infrastructure-heavy supply-based systems. The two options are obviously connected, even contending, and citizens regularly see the links. However, we need to think through how deliberative arenas might better connect and interrogate these alternatives and understand and challenge the institutional arrangements that tend to compartmentalise them.

References

BAKER, L. & PHILLIPS, J. 2019. Tensions in the transition: The politics of electricity distribution in South Africa. *Environment and Planning C: Politics and Space,* 37**,** 177-196.

BARRAGAN-CONTRERAS, S. J. 2021. Procedural injustices in large-scale solar energy: a case study in the Mayan region of Yucatan, Mexico. Journal of Environmental Policy & Planning, 1-16.

BARRY, A. 2013. *Material Politics: Disputes Along the Pipeline,* West Sussex, Wiley Blackwell.
BRIDGE, G. & GAILING, L. 2020. New energy spaces: Towards a geographical political economy of energy transition. *Environment and Planning A: Economy and Space,* 52**,** 1037-1050.
BRIDGE, G., ÖZKAYNAK, B. & TURHAN, E. 2018. Energy infrastructure and the fate of the nation: Introduction to special issue. *Energy Research & Social Science,* 41**,** 1-11.
BRISBOIS, M. C. 2020. Shifting political power in an era of electricity decentralization: Rescaling, reorganization and battles for influence. *Environmental Innovation and Societal Transitions,* 36**,** 49-69.
BRITTON, J., WOODMANM B. & WEBB, J. 2022. Ideational bricolage as a route to transforming local institutions for heat decarbonisation: heat networks and local government in England. Journal of Environmental Policy and Planning
CHILVERS, J. & LONGHURST, N. 2016. Participation in Transition(s): Reconceiving Public Engagements in Energy Transitions as Co-Produced, Emergent and Diverse. *Journal of Environmental Policy & Planning,* 18**,** 585-607.
COWELL, R., ELLIS, G., SHERRY-BRENNAN, F., STRACHAN, P. A. & TOKE, D. 2017. Energy transitions, sub-national government and regime flexibility: How has devolution in the United Kingdom affected renewable energy development? *Energy Research & Social Science,* 23**,** 169-181.
CREAMER, E., EADSON, W., VAN VEELEN, B., PINKER, A., TINGEY, M., BRAUNHOLTZ-SPEIGHT, T., MARKANTONI, M., FODEN, M. & LACEY-BARNACLE, M. 2018. Community energy: Entanglements of community, state, and private sector. *Geography Compass,* 12**,** e12378.
CROUCH, M. 2021. COP26 is crunch time for net-zero infrastructure. Mott Macdonald.
DE LAURENTIS, C. & PEARSON, P. J. G. 2018. Understanding the material dimensions of the uneven deployment of renewable energy in two Italian regions. *Energy Research & Social Science,* 36**,** 106-119.
DE LAURENTIS, C. & COWELL, R. 2021. Reconfiguring energy flows: energy grid-lock and the role of regions in shaping electricity infrastructure networks. *Journal of Environmental Policy & Planning***,** 1-16.
FEINDT, P. H. & COWELL, R. 2010. The Recession, Environmental Policy and Ecological Modernization – What's New about the Green New Deal? *International Planning Studies,* 15**,** 191-211.
GOLDTHAU, A. 2014. Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research & Social Science,* 1**,** 134-140.
GRAHAM, S. & MARVIN, S. 2001. *Splintering Urbanism: Networked Infrastructures, Technological Mobilites and the Urban Condition,* New York, Routledge.
HVELPLUND, F. & DJØRUP, S. 2017. Multilevel policies for radical transition: Governance for a 100% renewable energy system. *Environment and Planning C: Politics and Space,* 35**,** 1218-1241.
IPCC 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability: Summary for Policymakers. Switzerland: Intergovernmental Panel on Climate Change.
JOHNSON, B. 2020. Prime Minister Economy Speech, 30th June 2020. Dudley.
LOVINS, A. 1977 Soft Energy Paths: Toward a Durable Peace. Penguin: Harmondsworth
LOCKWOOD, M., MITCHELL, C., HOGGETT, R. & KUZEMKO, C. 2017. The governance of industry rules and energy system innovation: The case of codes in Great Britain. *Utilities Policy,* 47**,** 41-49.
LONGHURST, N. & CHILVERS, J. 2019. Mapping diverse visions of energy transitions: co-producing sociotechnical imaginaries. *Sustainability Science,* 14**,** 973-990.
MEADOWCROFT, J. 2016. Let's Get This Transition Moving! *Canadian Public Policy,* 42**,** S10-S17.
MOLES-GRUESO, S. & STOJILOVSKA, A. 2021. Towards spatializing consumer energy sustainability. Empirical findings about the policy and practice of energy conservation and poverty in Barcelona and North Macedonia. Journal of Environmental Policy & Planning, 1-14.
MUINZER, T & ELLIS, G. 2017 'Subnational governance for the low carbon energy transition: mapping the UK's "energy constitution"', *Environment and Planning C* 35(7) 1176-1197

NASH, N., WHITMARSH, L., CAPSTICK, S., HARGREAVES, T., POORTINGA, W., THOMAS, G., SAUTKINA, E. & XENIAS, D. 2017. Climate-relevant behavioral spillover and the potential contribution of social practice theory. *WIREs Climate Change,* 8**,** e481.

NATHAN, H. S. K., DAS, S. D. & PS, A. P. 2022. Rural microgrids – 'Tragedy of commons' or 'community collective action'. Journal of Environmental Policy & Planning, 1-16

O'SULLIVAN, K., GOLUBCHIKOV, O. & MEHMOOD, A. 2020. Uneven energy transitions: Understanding continued energy peripheralization in rural communities. *Energy Policy,* 138**,** 111288.

OTEMAN, M., WIERING, M. & HELDERMAN, J.-K. 2014. The institutional space of community initiatives for renewable energy: a comparative case study of the Netherlands, Germany and Denmark. *Energy, Sustainability and Society,* 4**,** 11.

PALM, J. 2021. Exploring Limited Capacity in the Grid: Actors, Problems, and Solutions. *Frontiers in Energy Research,* 9.

PARTZSCH, L. 2017. 'Power with' and 'power to' in environmental politics and the transition to sustainability. *Environmental Politics,* 26**,** 193-211.

PERREAULT, T. & VALDIVIA, G. 2010. Hydrocarbons, popular protest and national imaginaries: Ecuador and Bolivia in comparative context. *Geoforum,* 41**,** 689-699.

RUDEK, T. J. 2021. Capturing the invisible. Sociotechnical imaginaries of energy. The critical overview. *Science and Public Policy*.

TESFAMICHAEL, M. 2022. Caught between hope and reality: how citizens reconcile ambitious dominant energy imaginaries with everyday service shortfalls. Journal of Environmental Policy & Planning, 1-12.

SILVER, J. 2021. Decaying infrastructures in the post-industrial city: An urban political ecology of the US pipeline crisis. Environment and Planning E: Nature and Space, 4, 756-777.

SOVACOOL, B., K., & COOPER, C., J., 2013. *The Governance of Energy Megaprojects,* Cheltenham, Edward Elgar Publishing.

SOVACOOL, B. K. & BRISBOIS, M.-C. 2019. Elite power in low-carbon transitions: A critical and interdisciplinary review. *Energy Research & Social Science,* 57**,** 101242.

SOVACOOL, B. K., HESS, D. J., AMIR, S., GEELS, F. W., HIRSH, R., RODRIGUEZ MEDINA, L., MILLER, C., ALVIAL PALAVICINO, C., PHADKE, R., RYGHAUG, M., SCHOT, J., SILVAST, A., STEPHENS, J., STIRLING, A., TURNHEIM, B., VAN DER VLEUTEN, E., VAN LENTE, H. & YEARLEY, S. 2020. Sociotechnical agendas: Reviewing future directions for energy and climate research. *Energy Research & Social Science,* 70**,** 101617.

SVENSSON, O. 2021. The matter of energy emerges: Bridging the divide between conflicting conceptions of energy resources. *Energy Research & Social Science,* 72**,** 101895.

WESCHE, J. P., NEGRO, S. O., DÜTSCHKE, E., RAVEN, R. P. J. M. & HEKKERT, M. P. 2019. Configurational innovation systems – Explaining the slow German heat transition. Energy Research & Social Science, 52, 99-113.

WHILE, A. & EADSON, W. 2019. Households in place: socio-spatial (dis)advantage in energy-carbon restructuring. European Planning Studies, 27, 1626-1645.

WIIG, A., KARVONEN, A., MCFARLANE, C. & RUTHERFORD, J. 2022. From the Guest EditorsSplintering Urbanism at 20: Mapping Trajectories of Research on Urban Infrastructures. Journal of Urban Technology, 29, 1-11.

WINDEMER, R. 2019. Considering time in land use planning: An assessment of end-of-life decision making for commercially managed onshore wind schemes. *Land Use Policy,* 87**,** 104024.