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## Section 1 – Introduction: relational perspectives on energy futures

At a time when the climate emergency calls for a deep and rapid decarbonisation of our societies, countries all over the world are faced with the challenge of transforming their energy systems [1]. Urgent policy questions need to be addressed, and thinking about the intersection between energy and broader societal futures is more necessary than ever before. Robust theories of sociotechnical change are needed to reflect on the depth, pace and scope of the transformations needed and on how we might implement them in a way that is just, equitable and acceptable. The academic literature on sociotechnical imaginaries (STIs) provides useful resources for thinking about the relations between energy futures and social change. However, there remains room to refine our thinking by recognising the extent to which sociotechnical change is a geographical project [2–4]. Energy system transformation involves more than technological conversion: it drives social and spatial change, impacting socio-spatial practices, relations, identities and outcomes. Contending that space is a key constituent of all social processes, this paper develops an approach that addresses the spatiality of STIs in order to better understand energy transitions and how positive change may occur.

Two recent review papers have done impressive work in mapping the productive intersections between science and technology studies (STS) and energy social science [5,6]. What STS bring to energy studies, they emphasise, lies in their attention to the co-production of science, technology and society, and in their interest in the material dimensions of social life. Sociotechnical approaches involve a recognition that ‘more is at stake in energy systems than the capture, conversion, distribution and consumption of energy’ [7]: energy systems are shaped by and constitutive of social, political and economic processes. This relational perspective makes STS open to insights from other fields and disciplines – and the review authors stress that STS-informed energy studies should be a ‘field for theoretical testing’, where STS perspectives can be hybridized with other social science approaches [5]. In this paper, we take the authors at their word and experiment with STS to explore the intersection of energy transitions and concepts of place, space and scale.

Indeed, we believe that the two review papers failed to include one area where STS and energy social science can meet in complementary ways, which is research on the spatial dimensions of energy transitions. In the last few years, an increasing body of work, lamenting the lack of attention paid to space in energy studies, has aimed to demonstrate the value of spatial thinking to understand energy systems [2–4,7–12], endeavours which have been echoed in the field of transition studies [13–16]. This body of research is multi-faceted, attending to the productive ‘academic borderland’ [3] without providing one unified approach to the field. In its diversity, it has shown that spatial outlooks are necessary to fully understand energy transitions, opening up generative research possibilities [7]. Most importantly, many of these contributors argue that space is not only relevant for the analysis of energy systems and transitions, but an active participant in their constitution [3,7–10], and as such, a geographical perspective is ignored at our peril.

In this respect, approaches which are merely sensitive to spatial difference and touch on spatial concepts are insufficient. Along with others [3,7–9], we advocate a more fundamental acknowledgement of the mutually constitutive relationships between energy, society and space. This is where perspectives from human geography, environmental psychology and other cognate disciplines that emphasise the co-production of space and society and the emplacement of social life [17] come to complement STS perspectives in energy social science.

Neo-marxist scholarship in human geography has long made the argument that space cannot be separated from the social, as a neutral receptacle passively awaiting to be filled by human activity [18,19]. Rather, space is foundational to the nature and trajectory of social life [10,18–20]. It is at once socially produced – the outcome of social and power relations that shape ‘consequential geographies’ [18] – and a medium of these relations, being an active and dynamic force that affects social processes [18,19]. This socio-spatial dialectic is based on the premise that ‘human life is, consequently and consequentially spatial, temporal and social, simultaneously and interactively real and imagined’ [18 p.18]. This approach has implications for how we understand energy system change. It encourages moving away from top-down ways of thinking about the future of energy systems and acknowledging that their spatiality is always differentiated and dynamic, and consequential for multi-scalar change [3,7,10,building on 20]. It also involves viewing energy transitions as socio-spatial processes that both shape and are shaped by socio-spatial patterns, relations, practices, identities and imaginaries [2–4,9,13,16,21,22].

If STS perspectives already provide resources to analyse the socio-political dimensions of energy transitions, we believe that their intersection with this spatial approach can produce useful insights on the production and unfolding of energy transitions. We demonstrate this here by focusing on the STS concept of sociotechnical imaginaries (STIs). Scholars use the concept of STIs to capture the ways in which sociotechnical projects reflect wider socio-political normativities and collectively held representations of what a desirable society would look like. In energy social science, they have been a productive avenue to study the implications of broader societal, political, economic and environmental rationalities for energy futures. However, few works have yet attempted to tackle head on the relations between sociotechnical imaginaries and space, and asked: if space is constitutive of social reality, and energy transitions are to be understood as socio-spatial processes, what becomes of STIs?

We believe that answering this question would help to advance the social science literature on energy transitions. A deeper appreciation of space would sharpen analyses of visions of the ‘good society’ which underpin sociotechnical projects, and are, in many cases, also visions of the ‘good place’, involving particular ideas and assumptions about space and place. Addressing these ideas and assumptions can contribute to explaining why and how imagined sociotechnical futures vary and diverge in different places and contexts. Attention to the spatial and scalar politics of STIs and to the various ways in which space and place are brought to bear on their framing by different actors also helps to problematise and understand their circulation, adoption or contestation across scales (i.e. local, regional, national, international) and contexts. Looking at how STIs are entwined with ideas about space, place and scale furthermore allows for better understandings of the various ways in which sociotechnical projects contribute to the reproduction and transformation of socio-spatial relations, practices and imaginaries. In these respects, we believe that our perspective could benefit researchers interested in a) the interweaving of sociotechnical change and socio-spatial transformations inherent in energy transitions; b) the logics and dynamics of the uptake of imagined energy futures by actors and communities in a range of contexts and at different scales; c) the divergence and potential competition of different imagined energy futures, as spatiality may provide researchers with an additional lens for comparison and explanation.

In this paper, we draw on the concept of spatial imaginaries to propose an approach to analysing the spatial dimensions of STIs which holds together the ways in which space, place and scale feed into sociotechnical projects, and the capacity of sociotechnical endeavours to shape and transform how we think about and experience spatiality. In section 2, we contend that STIs have spatial

dimensions, but that they have yet to be fully conceptualised in the literature. In section 3, we build bridges between STIs and spatial imaginaries and argue that they are co-produced. In section 4, we describe two implications of our perspective for research on energy futures. First, we illustrate how spatial imaginaries provide a helpful lens to explore the visions of the desirable society that underpin energy projects and contribute to better understanding energy transitions as socio-spatial projects. Second, we show how addressing the spatial politics and scalar dynamics of imaginaries can complement analyses of the uptake, negotiation and contestation of energy transitions and associated STIs.

## Section 2 – Space, place, scale and sociotechnical imaginaries

Sociotechnical imaginaries were developed as an approach to understanding the relations between scientific and technological projects and political institutions and power. In their seminal paper, Jasanoff and Kim argue that technoscientific projects are imbued with implicit understandings of what is desirable in the social world and encode ‘collective visions of the good society’ [23]. Two core claims underpin the STIs perspective: (a) collective social values influence the design of technological systems; and (b) technoscientific projects reflect normative commitments to social life and convey particular understandings of society [23,24]. Energy research has engaged with STIs to understand transformations of energy systems and the diffusion of energy technologies, exploring how energy visions bring forward ‘particular [...] imagined social, political and economic orders which extend beyond the exposition of future energy systems’ [25, p. 974]. Although Jasanoff and Kim’s initial definition of STIs located them as emanating from national centres, they have since then extended the approach to encompass other collectively held and stabilised visions of desirable futures [24] which are situated and partial, produced and performed by collectives in specific times and places [25–27].

The scope of the field has widened in recent years [5], with increasing emphasis on the plurality of energy futures and the ‘diversity of actors, stories, discourses, imaginings and practices at different scales that might shape their imagining and realisation’ [27, p. 210]. Works have addressed the multiple collectives engaged in constructing STIs, from local communities [28–32] to transnational networks of actors or corporations [33–35]. They have shown that diverse STIs, formulated by competing collectives, coexist and struggle for dominance within society [25,36–38]. They have attended to the complex dynamics of STIs, from construction, performance, resistance and extension across society [24,39], showing that the formulation and concretisation of energy futures is a power struggle that often leads to the marginalisation of less dominant alternatives [27].

To understand the processes by which STIs come to be shared across society, researchers have increasingly touched on spatial concepts and concerns. A growing body of work has stressed the importance of multi-scalarity in the analysis of STIs, to address both how STIs are articulated by networks of actors working at different scales, and the potential of STIs to travel across scales. Exploring the modalities of the uptake of national STIs by regional and local actors, research has shown that place matters. National STIs are framed and responded to differently in different contexts, as ‘locals’ – be they local citizens [28,32,40,41] or regional policymakers [27,37,42] – draw on lived experiences [32,36,40,41], representations of space [27,40], histories and experience with infrastructure [28], energy values [42], cultural models [41] and place-specific expectations [43,44]. Others have shown that more ‘local’ STIs, influenced by particular histories and spatialities, are recurrently ‘flattened up’ [26] by national STIs or remain bounded at the local level, clashing with national STIs but failing to scale up because their proponents lack the resources to propagate them widely [29,32]. Another body of work has touched on space by addressing the role of STIs in spatial transformations. In urban studies, recent research has shown how STIs prescribe certain urban futures, and consequently, have implications for the material, social and symbolic fabric of cities [34,35,45,46]. Relatedly, some, focusing on infrastructure planning, have highlighted the role of STIs in the production of space [47,48], showing that infrastructure projects involve the projection of social

meaning into space and concluding that STIs are useful tools to investigate operations of ‘space-making’ [47].

Although space is not the primary focus of most of these works, they still suggest that space, as lived, imagined and practiced, influences the construction, circulation, framing and uptake of STIs, and that STIs have a role in the production of space. A two-way relationship therefore appears to exist by which space influences STIs, and STIs influence space – but there remains room to further conceptualise this relation. Indeed, most of the evidence remains indirect, and when the aforementioned works address space, they provide invaluable results but often do not build further into theory. Better appreciating this relation would, on the one hand, refine analyses of the construction, circulation, take up and impact of particular STIs across scales, contexts and groups. On the other hand, it would help further address their (re)productive roots in particular spaces and places, their impacts on socio-spatial relations and identities, and the inevitable intersection between sociotechnical futures and socio-spatial transformations.

We believe that progress along these lines requires wider acknowledgement amongst STS researchers that STIs are, themselves always spatial. Indeed, as society is constituted in time and space and as space is both a social product and an essential dimension of the social, STIs *must* have a spatial dimension. This means recognising that spatiality is both constitutive of and constituted by STIs, and thus that sociotechnical visions not only interact with socio-spatial imaginations and transformations but that they themselves are never spatially neutral. Technological projects are underpinned by particular visions of socio-spatial relations and order and the collective visions of the ‘good society’ which they encode involve specific forms of space, scale and place.

Different concepts and approaches could be used to fully incorporate the spatial dimensions of STIs and formalise an assertively spatial take on STIs in relation to energy transitions. No consensus exists in the academic community on the most productive way of elaborating spatial dimensions of energy studies. Concepts such as place-frames [13] or energy landscapes [e.g. 4,22,49,50], even if they have not been specifically combined with STIs theories, have been used to highlight the geographical dimensions of energy futures. Here, we bring space into STIs theory by drawing on the concept of spatial imaginaries. We have three reasons for doing so. First, by their emphasis on performativity, spatial imaginaries are highly compatible with STIs and facilitate analyses of their role in the production of space. Second, by presupposing little of what the object of the imagination is, they provide a flexible framework for all scales of analysis, applicable to a variety of socio-spatial constructs. And third, they allow for two complementary uses of the concept of scale, as a methodological gateway into the circulation of imaginaries and as a type of spatial imaginary in itself. In the next section, we build bridges between theories of sociotechnical and spatial imaginaries and highlight how spatial imaginaries provide a conceptual toolbox which can help formalise and develop inquiries into space within STI research, as well as assisting in understanding energy transitions.

### Section 3 – Spatial imaginaries and their co-production with sociotechnical imaginaries

Spatial imaginaries can be defined as ‘deeply held, collective understandings of socio-spatial relations that are performed by, give sense to, make possible and change collective socio-spatial practices’ [51]. They are ‘socially held stories, ways of representing places and spaces’ [52] imbued with implicit understandings of the spatialised social world [53], that help shape material practices and geographies through their propagation [51,52,54]. Collectively held and produced by groups through struggles over conceptions, perceptions and experiences of space and place [51], they are diverse, situated and contested. Like STIs, they are usually normative, a perspective on what the world is and should be, building on narratives of the past to promote understandings of what the future should look like [51,52,55]. They are often tied to processes of ‘othering’, by which certain people and places are constructed to be naturally different and often unequal [52, building on 56]. They thus have a role

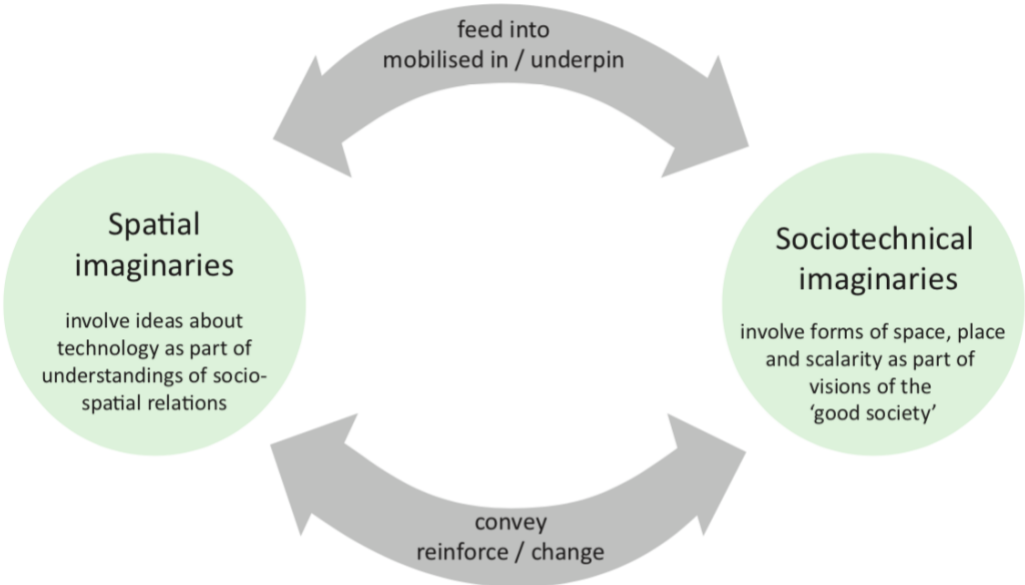
in identity-building, contributing to both forging group bonds and differentiating between social groups [51,52,56] and articulating particular social anxieties and desires [51,52].

As Watkins [52] shows in a review of the concept, spatial imaginaries are not a monolithic and uniform approach. If superficial differences pertain to the terminology used and the scale at which evidence of imaginaries is provided, from very local to planetary imaginaries, more profound divergences exist in relation to their ontological foundations. Even if most scholars in this tradition build on the seminal work of Edward Said [56], some see imaginaries as worldviews, others as semiotic orders, most as representational discourse, and increasingly they are being conceptualised as performative. In this Perspective, we focus on the performative approach to spatial imaginaries, contending that it is the most compatible with STIs theories, as well as the most appropriate to understanding energy futures.

Viewing imaginaries as performative implies seeing them as embodied and enacted in certain material practices, as well as linguistic representations that are produced, stabilised and circulated through images and texts that legitimise practices. As such, they are a medium through which socio-spatial relations, practices and geographies are both reproduced and changed [52]. The dynamic by which imaginaries become embedded in thought, practice and materiality is infused with power relations: imaginaries are not equally valued or powerful [51,52]. They are more or less hegemonic depending on their degree of naturalisation through representation (i.e the degree to which they are taken as common sense), and their materialisation and ‘concreteness’ [54,building on 57]. Such a take on spatial imaginaries builds on an ontology that sees the material and the symbolic, the ‘real’ and ‘imagined’, discourse and practice, not as separate planes but as co-constituted [52].

Building on this, we argue that spatial imaginaries and STIs are co-produced and that addressing this co-production is a useful way of analysing the spatial dimensions of STIs. Particular spatial imaginaries are drawn on by collectives in the construction of sociotechnical visions and feed into STIs. STIs are underpinned by, convey and, as they are performed, contribute to reinforcing particular spatial imaginaries. Conversely, STIs can feed into the construction of spatial imaginaries, which in turn reinforce them in a mutual relationship (see [Figure 1](#)). This does not mean that STIs and spatial imaginaries are the same, but rather that they feed into and channel one another. This aspect has been touched on by Jasanoff et al. [24], whose work recognises that ‘space and social order are co-produced in part through the spread of ideas and practices [...] across times and territories’ (p. 22). Just as STIs can configure ‘shared understandings of space and time’ (p. 26) and influence actors’ sense

Figure 1 – Co-constructing STIs and spatial imaginaries



of the right scale of action, pre-existing spatial imaginations can also channel the spread of science and technology, as discussed further in section 4.

Watkins [52] distinguishes three types of spatial imaginaries (see [Table 1](#)), which we believe can productively inform this integration. *Place imaginaries* involve the definition of a distinct,

Table 1 – Spatial imaginaries: a framework
<i>Place imaginaries</i> : involve the definition of unique spaces of distinction and ideas about the particular characteristics of those spaces E.g., Broadway, London, Fukushima, France, Africa, Earth
<i>Idealised spaces</i> : descriptions of kinds of places and spaces sharing generic and universal characteristics E.g., the global city, the ghetto, the smart city, the countryside
<i>Spatial transformation imaginaries</i> : narratives of generic processes by which spaces and places change which often convey senses of inevitability that "'othe[r]" different ideas about what has been, is or may come' [52, p. 513] E.g., globalisation, modernisation, localism, industrialisation
Source: adapted from Watkins [52]

particular space, and associated ideas about the characterisation of that space. *Idealised spaces* are descriptions of places sharing generic characteristics, such as the 'global city' or the 'ghetto'. *Spatial transformation imaginaries* are narratives about the processes by which spaces and places change, and examples would be 'gentrification' or 'globalisation'. These imaginaries are interrelated: for example, place imaginaries shape how actors imagine socio-spatial transformations, while ideas of spatial transformations and idealised spaces are embedded in place imaginaries.

Engaging with spatial imaginaries through this three-dimensional framework would help to formalise, structure and develop emerging forays into space within the STIs literature. The value of regarding spatial and sociotechnical imaginaries as co-constructed is that such a perspective is able to hold together the multi-faceted relationships between space and sociotechnical projects: how ideas about space and place influence the construction of STIs, underpin sociotechnical projects and are essential in their legitimation as well as their framing and contestation; and how STIs, as they are embedded and extended, contribute to the reproduction or transformation of socio-spatial relations, practices and imaginaries.

By contending that space is co-constitutive of STIs and of social reality at large, we do not mean to argue that it needs to be the central focus of *all* inquiries on imagined energy futures: issues of place, space and scale will be more or less important depending on the empirical issue being discussed. We believe that our approach would particularly benefit four pathways of STIs research - into: a) the power-laden production and transformation of spaces and places in times of sociotechnical change; b) the variation of imagined sociotechnical futures across contexts; c) the competition between divergent STIs in the same context; and d) the logics and dynamic of their framing, uptake or contestation across scales and contexts. Beyond these specific concerns, STI researchers can draw on spatial imaginaries in order to provide an additional lens of comparison when inquiring into the logics of specific imaginaries, which may sharpen the analysis of visions of 'good society', or of particular framings within these visions.

Researchers addressing how ideas about justice are featured in imagined energy futures, for example, will primarily look at the values and normative framings apparent in particular STIs, which may be more abstract and less context-dependent. They will thus be interested in spatiality to a lesser degree, but may still benefit from an additional lens with which to understand particular framings of procedural or distributive justice. In the same way, researchers interested in the processes by which ideas about the future become imaginaries, shared and embedded in social practices and institutions, will mainly focus on the economic, material and social practices and infrastructures which are mobilised to make imaginaries take hold within particular societies. Even if it is not sufficient in itself to understand the various and overlapping processes by which imaginaries are embedded,

materialised and extended, nevertheless, looking at space helps to understand how and why imagined energy futures take root in certain places and at certain times, or how particular socio-spatial imaginaries are mobilised to embed imaginaries into group identities [58].

In the next section, we describe the implications of our perspective for research on energy futures and transitions and illustrate in more detail which particular issues, processes and situations it would help to address.

## Section 4 – Understanding low-carbon energy futures through integrating socio-technical and spatial imaginaries

In the context of low-carbon energy transitions, spatial imaginaries can be used to address two particular dimensions of STIs. First, spatial imaginaries can enable understanding of the forms of space and scalarity, and associated spatial imaginaries, which underpin energy transition STIs: how particular ideas about spaces, places and their transformations are mobilised, reflected and transformed in imagined energy futures. Second, spatial imaginaries can be used to address the spatial politics and scalar dynamics involved in the uptake of energy transitions and associated STIs: how spatial imaginaries are brought to bear in the legitimation, framing, uptake and contestation of energy transition imaginaries, as they travel across scales and contexts. We describe both of these below and believe that, together, they complement our understandings of how energy transitions unfold, at different scales, as socio-spatial projects, entwined with wider social and spatial transformations.

### 4.1. The spatiality of energy transition STIs

Engaging with spatial imaginaries would help researchers address the forms of space and scalarity that underpin energy transition imaginaries. Longhurst and Chilvers [25] characterise energy transition visions as assemblages of meanings, knowings, doings and organisings. Analyses could build on this framework to ask: Are specific spatial narratives part of these assemblages? How are each of these dimensions spatialised and scaled? Drawing on Watkins' [52] typology, which place imaginaries, idealised spaces or spatial transformation imaginaries do they mobilise, and to what end? The typology can usefully guide analyses of how energy transition STIs reflect and propose particular visions of socio-spatial order, involving interrelated ideas about the identity, characteristics and evolution of places and their inhabitants, and the transformations that are desirable or not in light of these. Looking at how low-carbon energy visions and projects build on particular spatial imaginaries and constitute themselves as transformative socio-spatial narratives would contribute to our understandings of how energy transitions are produced and unfold as socio-spatial projects, shaped by and shaping socio-spatial relations, identities, patterns and practices. It would also help better characterise and analyse the logics and framings of particular energy transition STIs, and, in that respect, provide an additional lens to compare imagined energy futures, both across contexts and in the same context over time, thus contributing to better understandings of the modalities and dynamics of their divergence and competition. We illustrate this below with a few examples and suggestions of how research might take these questions further.

- *Place imaginaries.* The STI literature already provides evidence of *place imaginaries* being co-produced with STIs. Examining imaginaries of the renewable energy transition conveyed by international organisations in Senegal, Simmet [26] highlights how they are underpinned by a framing of Africa as a 'dark continent' in need of imported technological solutions and financial support, reproducing and reinforcing a continental imaginary inherited from European colonisation. Reversing the lens, Trencher [27] shows that the energy transition imaginary of Japan's Fukushima prefecture is an attempt at rebuilding both 'a battered energy system and a geographical identity' after the triple disaster of 2011 – thus contributing to the construction of a more positive place-imaginary and adopting a place-making function. Future research should continue to address both ends of the



relation: how, on one hand, energy transition imaginaries can support the stabilisation of emerging place imaginaries by enabling the projection of narratives linking the imagined past of a place to a more desirable future, acting as catalysts for socio-spatial transformations, and how, on the other hand, actors draw on the imagined characteristics of places of different kinds to legitimise energy transitions by embedding sociotechnical pathways into existing socio-spatial identities, presenting them as adequate, ‘fitting’ and necessary. In this vein, research could also inquire into how certain named locations and their purported characteristics play a role in the emergence and legitimisation of STIs at different scales. Papazu [59], for example, addresses how the Danish island of Samsø’s energy transition has been cast as an idealised example of the virtues of community ownership and participation in renewable energy development. Looking at the specific places mobilised in energy transition discourses, as both good practice examples or deterrents, and at the kinds of argument which they support, can provide insight into which wider societal futures are considered desirable.

- *Idealised spaces*: With their rough edges smoothed, abstracted from their messy contexts, particular places such as the island of Samsø [59] can also become quasi-*idealised spaces* which crystallise the benefits of a sociotechnical option. In a study of European renewable energy transition imaginaries, Skjolsvold [60] shows how a specific imaginary of ‘islandness’ generates a double-edged idealised space. Islands are characterised as small, remote and populated by tightly-knit communities, and at the same time, framed as micro versions of larger societies. They thus become ‘other’ in some ways and ‘similar’ in others, justifying their choice as test-beds for energy innovations while highlighting the potential generalisability of these solutions. However, places are not always painted in such a positive light. Particular local renewable energy controversies, such as the Midlands wind energy proposals in Ireland [61], illustrate ways that a place imaginary (the Midlands region) and an idealised space (the Irish countryside and its inhabitants) combine to feed into STIs at wider scales and reinforce a particular imagination of rural spaces, the ‘local’ area and its people, as particularly problematic in energy deployment. Idealised spaces of rurality shape planning policy, project design and siting choices as well as legitimise energy policies. Research has shown, for example, that the move towards offshore wind development in the UK was partly driven by a representation of onshore wind as problematic because of its spatial proximity to local communities [62] and the countryside as a ‘rural idyll’ [63], as well as an imaginary of the ocean as an un-habited blank space, a ‘terra nullius’ where project development is facilitated by spatial distance [64]. Such a perspective can thus help call attention to how the processes by which types of places come to be constructed as ‘acceptable locations’ [65] and considered more appropriate than others for renewable energy deployment are linked to comparative valuations, power relations and the reproduction of unequal socio-spatial relations.

- *Spatial transformations imaginaries*. Work investigating STIs of the smart city has shown that they are underpinned by visions of the city as a ‘system of systems’ populated by good citizens that can be observed from above, made manageable by urban elites equipped with panoptical power [34,46], highlighting the deeply political nature of STIs. These visions are associated *with spatial transformations imaginaries* that connect past urban crises to future salvation through technology, and feed into a narrative in which the ‘smart’ transformation becomes necessary and inevitable, a self-fulfilling prophecy [34] – a rhetoric that has been noted for other spatial narratives [66]. Such a line of questioning could be imported into energy transitions research to better investigate the spatial dimensions and implications of the transformative imaginaries that feed into particular energy STIs, such as globalisation, localism [67] or modernisation. Works have indeed suggested that competing energy STIs are underpinned by different understandings of space and scale [37,68]. Burnham [37] shows how, in the US Northeast bioenergy economy, two diverging bioenergy imaginaries hold the ‘local’ as central to the industry but differ in how they circumscribe it. While one defines the local scale via an economic threshold shaped by transport and costs, the other associates it with community ties, direct consumer-producer relationships, co-ownership and reclaiming energy from corporate interests – reflecting two alternative imaginaries of the ‘local’, connected to different perspectives on which kind



of socio-spatial relations are desirable. This also highlights how disputes over energy transitions provide a window into dominant socio-spatial ideologies and, at the same time, can provide an impetus for the construction of alternative energy futures which invoke different spatial transformation imaginaries and visions of the 'good place'. The implicit spatiality of imagined energy futures can be made more explicit by asking questions such as: To what extent do these energy futures differ from existing forms of socio-spatial organisation? Which socio-spatial transformations would be required to achieve them? Who would steer them? In turn, this may help researchers better understand and explain the competition between diverging energy transition STIs, by examining how particular socio-spatial ideologies feed into, shape but can also stem from the imagination of energy futures.

#### 4.2. The politics of space and scale involved in the uptake of energy transition STIs

Addressing spatial imaginaries would also help further illuminate the politics of space and scale and power relations involved in the circulation, uptake and resistance to energy STIs. In that respect, drawing on spatial imaginaries contributes to our understandings of the nature and dynamics of contestations around energy transitions. STIs research, as we outlined in previous sections, has already shown that the extension of STIs across scales and contexts is a complex, contentious and friction-laden process. However, we believe that engaging with spatial imaginaries is essential to further our understandings of the processes and conditions by which particular energy transition STIs scale up and down, and travel across contexts. Three lines of questioning could be explored in greater depth; all of them involve addressing the various ways in which spatial imaginaries are brought to bear on the framing, appropriation and contestation of energy STIs across scales and contexts. First, how pre-existing spatial imaginaries might pre-empt or facilitate the adoption of particular energy transition pathways. Examining concurrencies or complementarities between spatial imaginaries and energy transition STIs helps explain why specific STIs extend more or less easily in particular locales, a line of questioning that has already started to be explored [27]. Second, how spatial imaginaries are strategically drawn on and used by involved actors to adapt, anchor, legitimate or contest particular energy STIs in different contexts. Finally, how local contestations over energy STIs can spur the (trans)formation of spatial imaginaries and the construction of alternative visions of the 'good place' which then can scale up or transfer to other locations, challenging assumptions over which energy futures are to be considered desirable. Here, we develop the example of energy infrastructure siting to illustrate how such a perspective is helpful in analysing the multi-dimensional conflicts and contestations surrounding energy transitions.

Research has long shown that disputes over energy infrastructure deployment have to do with more than not-in-my-backyard (NIMBY) reactions to developments but are driven by a plurality of issues, both local, national and global including not only the location and design of energy projects, but the very economic, environmental, social and political rationales underpinning them [49,69–71]. STIs are a useful tool to investigate these multi-faceted conflicts, as they enable analyses of the narratives, meanings and values that are articulated by groups in the framing of proposed energy development [40]. Integrating spatial imaginaries into this perspective would help researchers better understand their scalar complexity and spatial politics.

The STIs literature already provides evidence that pre-existing spatial imaginaries influence how local actors respond to, appropriate or contest wider energy transition STIs in specific contexts [27]. Looking for incompatibilities or complementarities between local place imaginaries and wider energy imaginaries may thus help explain and potentially anticipate the logics and dynamic of contestations around specific energy projects. Such a perspective intersects with the broader literature on energy siting disputes, which has long shown that representations and experiences of place and space are important drivers of community responses to energy infrastructure projects. Evidence from this body of work suggests that both place imaginaries – ideas around a particular locale's culture, history or aesthetic value [50,71–74], idealised spaces – such as imaginaries of rurality [49,72]– and spatial transformation imaginaries – for example, energy development as a 'scarring' of the pristine

British countryside [75] – influence how people, in a specific time and place, relate to and engage with energy deployment.

However, by this we do not mean to imply that spatial imaginaries are only local constructs that are brought to bear on the framing of STIs emanating from above, nor that they are static, fixed in time and space. On the contrary, they are relational and dynamic, strategically drawn on, used and transformed by actors in the context of siting disputes. Research has shown that there is a spatial and scalar politics in how siting conflicts play out, as different forms of space and scale represent strategic resources for groups to promote specific perspectives on proposed developments [62,72,75–77]. Batel and Devine-Wright [77], for example, examined how spatialised narratives of difference and inequality, emphasising divides between both the productive countryside and energy intensive cities, a colonial England and an exploited Wales, and desert and sunlit Africa and a green-hilled Britain, were strategically remembered by communities to legitimise opposition against proposed high-voltage power lines in the UK. Their paper calls attention to the broader spatial and narrative politics involved in siting disputes, and incidentally shows that they involve entwined imaginaries of places, idealised spaces and past, present or future transformations imaginaries which can pertain to both the very proximate and the very distant. Spatial imaginaries thus represent a lens into the claims formulated by groups in siting disputes and their different legitimising strategies. Examining spatiality closely provides insight into how competing framings of energy deployment are constructed and negotiated both in reference to a particular context, and to wider socio-spatial, technological, political, economic and historical issues which often get crystallised in siting conflicts.

Energy siting disputes can also spur the (trans)formation of spatial imaginaries. Indeed, if groups draw on particular spatialities to stabilise positions and frames, these spatialities often get re-interpreted in light of the present [40]. Garavan [71] for example argues that, in local place defence movements, place often acts as ‘a shorthand for notions of holistic human wellbeing’ (p. 858). He shows how a natural gas refinery and pipeline proposed by a trans-national corporation in a rural location in the west of Ireland spurred a reflection on the nature and value of place that led to a criticism of the particular version of development, growth and modernisation that was seen as proposed by developers, and supported by the state. Pictured as exploitative and imposed by outsiders, it was contrasted with a vision of a more sustainable ‘good life’ rooted in place and community. In this case, one could argue that opposition to what was interpreted as an undesirable local energy future sparked the creation of an alternative spatial and sociotechnical imaginary, a local vision of a good society rooted in place. Such visions of the ‘good place’ can involve interwoven ideas about particular places (place imaginaries), about the value and role of places in general (idealised space – see [78] for elaboration), and about which kind of socio-spatial relations are desirable (spatial transformation imaginaries). Spatial imaginaries can thus be a helpful tool in analysing how the value and meaning of places and spaces get re-examined and re-framed in light of energy transitions and, in that respect, in addressing how the negotiation of energy futures involves particular socio-spatial ideologies being challenged.

Finally, and by way of conclusion, spatial imaginaries also draw attention to the ways in which this negotiation is fraught with power, raising the question of who does the imagining and who can speak for the future of places [26,49,78]. Indeed, if we drew on the example of local energy siting disputes, we wish to stress that space gets politicised at all scales, and national or global STIs are not more ‘spatially neutral’ than imaginaries emerging from local contexts. The circulation of STIs across scales is shaped by existing power relations, socio-spatial inequalities and the differentiated material and symbolic resources available to actors. In terms of economic, political and symbolic capital, the playing field is all but level between multinational energy companies, international energy organisations, central governments, cities, regions and local communities. Bringing scale into the equation helps to see this asymmetry more clearly. As an analytical entry-point, scale can help to shed light on imaginaries that are marginalised, ‘flattened’ by national STIs or bounded at the local level. It illuminates imbalances between voices that predominate and others that are silenced, and thus helps address important energy and environmental justice issues. Relatedly, it also highlights the scalar

complexity of disputes around energy transitions, of which the Corrib gas controversy examined above is a good example. This place-based contestation of the developmentalist imaginaries promoted by transnational and national actors, rooted in a particular vision of the good life, looked outwards at the same time and involved networks of objectors across Ireland and in Nigeria, where communities were engaged in similar struggles against Shell's unfair siting practices. This trans-scalar extension of the conflict is in many ways representative of the contemporary localisation strategies of place-based social movements, combining a defence and valorisation of place, territory and culture, and a networked politics of scale 'from below' through coalition-building with translocal and transnational forces [79]. Thus, in a complementary way, viewing scale as a social and political construction, actively produced and contested by actors, provides insight into the different scaling strategies of competing collectives and the wider scalar politics involved in energy transitions.

## Conclusion

In this Perspective, we identified a 'spatial' gap in both review papers [5,6] that stimulated this special issue and highlighted the benefits of integrating STS and perspectives emphasising the co-production of space and society in our approaches of energy futures. Spatiality is both constituted by and constitutive of sociotechnical imaginaries, as they encode specific imaginations of socio-spatial order. To formalise this assertively spatial perspective on STIs, we drew on spatial imaginaries theory and showed how holding that STIs and spatial imaginaries are co-produced is a productive way of conceptualising the spatial dimensions of STIs. Drawing on three types of spatial imaginary (place imaginaries, idealised spaces and spatial transformations), we described the implications of our perspective for research on energy transitions. In particular, we delineated two main lines of inquiry, first around the spatialities underpinning energy transition imaginaries and second, around the politics of space and scale involved in their circulation and uptake. We do not claim that spatiality must be central to *all* inquiries on imagined energy futures. However, we argue that this approach contributes to richer understandings of how energy transitions unfold, and offers further insights into how spatial concepts are actively mobilised within processes of social change. It also reminds us of the inevitable spatial constitution of socio-technological change, such as energy transitions.

At a time when the climate emergency and urgent decarbonisation goals drive societies to transform energy systems, reflecting on the socio-spatial futures entwined with energy futures has the potential to open up essential questions about who gets to imagine the future and spur reflections on how just and acceptable energy transitions will be. The spatialisation of STIs is critical in assembling and reproducing energy decisions, especially in understanding how they translate to and impact on the local. In this respect, we acknowledge that geography is one of a number of related material (economic, political and technological) processes that shape particular outcomes. How such discursive framing is variously used by a diversity of actors, institutions, energy companies and others is an important area for future empirical research.

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