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# Material Difference and Regional Institutions in Low Carbon Transitions: some regional examples from Italy and the UK

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## Contents

## Abstract

The paper proposes a novel way of researching low carbon innovation - particularly renewable energy deployment - at the regional level by investigating the evolving relationship between energy and materiality. Following Bakker and Bridge (2006) natural resources are considered as being both a physical (e.g. their geographical occurrence) and a discursive artefact of a diversity of actors that construct and manipulate nature. Providing an arena for a deeper engagement with the concept of materiality of natural resources, we argue that looking at insights from previous work on materiality of resources, and resource geography, can be valuable in helping explain the spatially uneven processes of renewable energy deployment. It does so highlighting the region as a key spatial scale at which materiality and scale coalesce. The research highlights that material differences become significant because they might enable and constrain the social, political and economic relations necessary for renewable natural resource production as viable forms of energy. Giving consideration to analysis of materiality provides additional insights on how and why renewable energy deployment realises - and quite often fails to realise- its potential. The paper provides some empirical evidence of the ways in which the notion of materiality is used to unpack how renewable energy resources are- socially and materially- produced in geographically uneven ways.

**Key Words:** materiality, natural resources, renewable energy transitions, geographies of transition

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## 1. Introduction

Renewable energy (RE) resources presents regional variations, and these variations are not only caused by the resource characteristics (wind speed, solar irradiation and soil quality, to name a few) but also by geographical (land use and land cover), techno-economic (scale, labour cost), institutional (policy regime, legislation) factors (de Vries et al., 2007) and infrastructure endowments. Natural flows of renewable resources are thought to be immense in comparison with global human energy use (Johansson et al., 2004), yet the deployment of natural renewable resources is widely and unevenly dispersed, as they are to an important degree dependent on specific physical, cultural, economic and technological characteristics and appraisal (Zimmerer, 2013).

The paper explicitly explores the importance and role of natural resources, investigating their implicit physical and, partially, socially produced nature (cfr. Bridge, 2008). Our objective is to provide an arena to elicit a critical enquiry and a future research agenda on how insights from work on materiality and, to some extent, resource geography, following Bakker and Bridge (2006), can be valuable in helping to explain the spatially uneven processes of RE diffusion and deployment at the regional scale. The spatially unevenness of these processes are important in their own right, have clear implications for social and spatial justice, and are integrally related to aggregate trajectories of energy decarbonisation.

In contrast to much of the literature on renewable energy innovation and systems innovation, the argument presented in this paper deals with the issue of the materiality of natural renewable resources. The intention here is neither to over-privilege material explanations and to revive the ghost of physical determinism (see for instance the challenges of natural resource-based development) nor to delve into the problematics that surround issues of matter and materiality (Anderson and Wyle, 2009). Nevertheless, we argue that the issue of materiality, and how resources can be both materially manipulated and socially constructed, is valuable in understanding RE diffusion and deployment and as yet under-researched (for an exception see Armstrong and Bulkeley, 2014; Nadaï and Labussiere 2012).The literature on non-renewable resources, especially on oil and gas exploitation, has acknowledged and addressed the issue of materiality (Bouzarovski and Bassin, 2011; Bridge, 2004, 2009; Kaup, 2008, 2014) in ways that the literatures on renewable resources have not.

The starting point of the paper is that natural renewable resources are to an important degree dependent on specific physical, cultural, economic and technological characteristics and appraisal. The argument here is that resources are far more than economic, but rather have irreducibly social and cultural roots (Bakker and Bridge, 2006). Drawing attention to the issue of materiality and how renewable ‘natural’ resources are brought into productive use

as viable forms of energy, offers an opportunity to unpack the ways in which particular renewable energy resources come to be fashioned in some areas and not in others explaining the ways in which the social, material and environmental dimensions of such resources come to be understood and contested, favouring or hampering particular RE deployment paths.

Materiality is used here to explain how natural resources are both naturally endowed (and exert influence through their physical properties and their geographical recurrence) and socially induced (e.g. recognising how a diversity of actors can construct and manipulate nature and create value). Following Bakker and Bridge (2006) what counts as a resource depends on the interaction between its physical quality and condition (the variable quality of biomass and wave resources for example) and social institutions. Referencing the material, they contend, is to acknowledge that 'things other than humans make a difference in the way social relations unfold' (Bakker and Bridge, 2006: 18). In this sense, they continue 'materiality matters because of the way its heterogeneity differentially enables, constrains and/or disrupts the social practices through which resource regulation is achieved' (Bakker and Bridge, 2006: 21). Materiality therefore here provides a way of acknowledging resources in dialectical terms as a combination of physical and discursive practices- a socio-natural phenomenon- that takes shape through interaction between the material/ physical world and individual activities, institutional agendas and industrial forms of organisation. Moreover, what constitutes renewable natural resources as a viable source of energy production will be contained within a particular physical territory but also be socially and politically constructed as such within and between various networks of actors.

The aim of the paper is twofold. Firstly, we argue that giving consideration to analysis of materiality of renewable natural resources- addressing the questions of why it matters, why it is important to give it consideration and unpack the different ways in which it matters- can provide additional insights on how and why RE deployment realises- and quite often fails to realise- its potential. We do so by testing to what extent the relevance of materiality, as addressed by Bakker and Bridge (2006) and tested in the fossil fuels geography literature, applies to renewable energy.

Secondly, focussing our discussion on the regional level, we argue that the region represents a key spatial and governance level in which materiality and scale coalesce in relation to RE deployment. Due to their biophysical presence, natural resources are geographically contingent and confined within a particular physical territory and the regional level becomes a key level to unpack the way in which natural renewable resources for energy are socially and materially produced in geographically uneven ways. Adopting the regional lens can offer, therefore, an opportunity to unfold how materiality influences

institutions, governance and firm decision making at the regional level. This can contribute to the wider geography of transitions debate (cfr. Hansen and Coenen, 2015) that, to a large extent, has lacked appreciation of the regional contexts (for an exception see for instance Cooke, 2010; De Laurentis, 2013; Späth and Rohracher, 2010, 2012).

Our argument proceeds as follows. Firstly, the paper discusses a set of arguments that acknowledge the importance and role that materiality plays in analysing the deployment of natural RE resources, acknowledging the multiple processes through which natural resources are generated as both material artefacts and discursive constructs. Secondly, it starts providing some empirical evidence of how engagement with dimensions of materiality can be used to unpack how renewable energy resources are- socially and materially-produced in geographically uneven ways. The paper concludes suggesting that considering the socio-material characteristics of natural resources can be a valuable addition to the research that focuses on the organisational and institutional issues of renewable energy deployment helping explain the spatially uneven processes of renewable energy deployment.

## 2. Understanding the role of materiality in renewable energy transitions and deployment

Intensifying political and economic interest in the exploitation of RE sources to fulfil a number of objectives (that span from security of energy supply, resource diversification to avoiding the emissions of greenhouse gases and more broadly the issue of climate change) has induced unprecedented developments in RE and RE policies. This has given new impetus to the assessment of potential RE resource availability.

Agreeing that natural renewable resources are to an important degree dependent on specific physical, cultural, economic and technological characteristics and appraisal, we argue that although resource potentials and resource assessment are often presented as ‘objective’, most of them are strongly influenced by assumptions on average values and trends (for example in terms of aggregated data on availability). These are often influenced by the purposes of the assessment and the actors involved. While resource assessment often requires a set of context related additional assumptions and refinements that include site-specific judgments and regional estimates, that are not often widely available (de Vries et al. (2007), the argument here is that resources are far more than economic, but rather have irreducibly social and cultural roots (Bakker and Bridge, 2006). Drawing parallels with the literature on non-renewables, it can be argued that resource potential, and its assessment, is not only the fruit of geological and natural processes but also of a continual socio-economic appraisal about the utility and value of the resource (Bridge, 2009). Zimmerman’s dynamic

concept of natural resources that vary over time and space is useful here. He argues that 'resources are not, they become: they are not static but expand and contract in response to human wants and human action' (Zimmermann, 1951: 15). Hence, Bridge (2004: 416) argues that changes in societal demands, in market prices and/ or cost of extraction, exploration activity and/ or the introduction of new technologies can lead to the identification of new reserves in places where, to all practical purposes, none previously existed (and to their evaporation where costs shift in an adverse direction2).

The intention here is not to over emphasise material explanation of economic and social phenomena, agreeing with Bridge (2008: 411) who highlights concerns around conventional and uncritical claims 'that natural resources abundance can be converted into a long lasting form of regional advantage'. Nevertheless, harnessing the natural resource from the sun, the wind, a river or the sea to generate energy becomes a core feature of any RE project. The way in which natural resources get calculated and valued will influence the nature of investments and returns that are expected from projects that aim at producing and re-casting these resources into viable and legitimate sources of energy production (cfr. in the case of community hydro in the UK Armstrong and Bulkeley, 2014).

Here we provide a set of arguments for the importance and role that materiality plays in analysing the deployment of natural RE resources, acknowledging the multiple processes through which natural resources are generated as both material artefacts and discursive constructs. These include: i) natural resources as predominantly associated with the physicality of resource occurrence; ii) natural resources as discursive constructions that actors use to promote their interests; iii) natural resources as embedding specific physical characteristics and infrastructure requirements.

### *2.1 Natural resources as predominantly associated with the physicality of resource occurrence: targets, resource assessments and land-use conflicts in Renewable Energy*

Before analysing the role of actors in producing and constructing natural resources into potential sources of energy generation, here we want to draw attention to the fact that turning resources into viable and legitimate sources of energy disrupt and challenge established notion of the resources. Agreeing with Armstrong and Bulkeley (2014) the deployment of renewable energy technologies requires that, sometimes, unlikely materials, entities and sites are revised and recast as containing the potential for renewable energy generation (e.g. potential sites for wind turbine, roof space for solar PV, fields for biomass, etc.) challenging the existing resource use. Articulating the materiality of renewable natural

resources in terms of natural resource endowments and energy density (simply defined here as the land requirements per unit of electricity generated from the resource), we argue, influences the socio-economic appraisal of resource assessment and their potential. This occurs via the iteration between spatial resource assessment, land use and land protection and negotiation among conflicting land use interests. We turn to explain this in more detail.

Within the EU, the introduction of legally binding targets for the share of energy production from renewable sources and a sense of urgency to trigger investment of new capacity has induced unprecedented development in RE, RE policies and given new impetus to the assessment of potential RE resource availability and hence its materiality. In particular, Member states have produced strategies and measures to meet their binding 2020 targets, resulting in the publication of associated scenarios and roadmaps at different spatial levels. These roadmaps and scenarios have become important tools for future planning of energy supply developments and helped in identifying targets for RE production at the European, national and (in some cases) regional scales. However, it has been argued that target setting has been influenced by a sense of urgency to trigger investment in new capacity (Haas et al., 2004; Szarka, 2007). This urgency led most of the assessments - and the (mathematical) economic models underlying energy policy designs - to rely on the implicit assumption of an homogeneous space differentiated solely by energy gradients (solar irradiation, wind speed, tidal currents, etc.) (Nadaï and van der Horst, 2010a, cfr. also Shove, 1998).

The problems associated with this approach are evident once we consider that, compared to conventional fossil fuel-based energy systems, RE sources are more space-intensive (given their much lower power density (Smil, 2010), their efficiency of energy production is highly geographically dependent (Dijkman and Benders, 2010; Seager, 2009) and the issue of intermittency.

This spatially extensive nature of the resource means that pursuing low carbon transition through renewables holds unusually profound implications for other goods, services and values attached to the spaces concerned. A role of governments, at different spatial levels, is to regulate the ecological relations between economic and competing social demands that address potential conflicts and trade-offs between RE development and other values. Thus, for example, RE innovation and the production of electricity from renewable technologies involve the use of greater areas of land, per unit of electricity generated, than the more traditional energy forms. Further land requirement is necessary for the construction and maintenance of access roads and buffer zones. Land can also be needed for extensive transmission infrastructure (e.g. rights-of-way and high voltage power lines) where projects

demand that electricity is exported from the sometimes distant points of production, to major urban and industrial areas (Smil, 2010).

Land use therefore, emerged quickly to become 'the most important environmental consideration in the development of these resources' (Pasqualetti, (1990), cited in Walker (1995)). The stimulation of RE technologies and RE development, together with the management of the multiple uses of land and land availability, have prompted a multidimensional debate that encompasses tensions between economic, social and environmental concerns, at the different scales - from local to global - at which these operate (see for instance Walker (1995)). The low energy output per unit area of wind power and the requirements of exposed onshore sites (MacKay, 2009) have created greater potential for extensive disruption of existing landscapes and the values attached to them. This has spurred extensive research that analyses the evolving relationship between landscape, energy and policy (Nadaï and van der Horst, 2010a; Nadaï and van der Horst, 2010b); see also Bridge et al. (2013). Competing interests for land resources and the multiple uses of land are often the result of negotiations between many variables that include, among others, planning systems and institutional infrastructure, socio-cultural characteristics as well as environmental priorities (Keenleyside et al., 2009). Nadaï and van der Horst (2010a) argue, for instance, that looking at energy through the lens of landscape, can provide a situated point of view, which helps grasp how technologies and energies are embedded into territories and local communities. In this respect, landscape can be understood as a complex and multi-faceted cultural and political process (Nadaï and Labussière, 2009). It draws attention to the material as well as the relations and social networks that play a role in providing meaning to a specific area (e.g. the cultural, rural and scenic landscape).

Materiality matters here as it influences the social and economic appraisal of resource assessment and their potential via the iteration between spatial resource assessment potential and land use protection. Moreover, turning resources into viable and legitimate sources of energy disrupts and challenges established resources attached to land. It is the negotiation between turning resources into potential sources of energy and the current land resource use that can provide opportunities but also hindrances for renewable energy deployment. As a consequence, the devices used to frame such negotiations become highly important.

### *2.2 Natural resources as discursive constructions that actors use to promote their interests: narratives and visions of renewable energy*

'Bringing resources into productive use requires calculation, manipulation and commensuration of a wide range of data' (Armstrong and Bulkeley, 2014: 68). Resources therefore can be conceived on the basis of their availability and attributes that can be matters of technical intervention. Yet, 'understanding how, why and by whom calculation takes place, and what is and is not included in such processes' becomes crucial in 'understanding how resources come to be constituted' (Armstrong and Bulkeley (2014: 68-69).

Because natural resources are both physical and social constructs, resource appraisal and assessment imply that more careful consideration needs to be given to which resources do or do not become incorporated into the construction of spatial representation of resources via for instance spatial maps, and the extent to which these spatial representations are accepted or resisted by different actors (cfr. Power and Cowell, 2012). Research on the opposition to RE development argues that, in most cases, the potential for conflict is not strictly technological in nature but lies in the highly contextualised way in 'which (in)compatibility and (un)suitability (of energy and landscape) are perceived, narrated, delineated or negotiated by different stakeholders and the public' (Nadaï and van der Horst, 2010b: 182).

If we understand natural resources as a discursive construction that actors use to promote their interests, then, it could be partly argued that actorscan promote or hinder resources and their abundance with different storylines (cfr. Hajer, 1995). These might narrate the reality to simplify and influence strategic policy priorities (De Laurentis et al., 2016; Teschner and Paavola, 2013). RE resources are often represented in terms of 'development zones' or 'opportunity areas', which can also do governance work of obscuring/demoting competing claims on same space.

As argued, climate change and energy security imperatives have spurred a renewed interest in RE deployment; this has induced a specific configuration of interests (Nadaï and van der Horst, 2010a). Attention towards renewable capacity increases has raised questions about the pace and scale of RE development. This has highlighted two important issues: firstly, the significance of mobilising discourses to attain policy purposes, rally actors and aggregate resources (Szarka, 2007); secondly, it has shifted attention to establishing what discourses related to RE gain hegemonic status and which are marginalised (cfr. Lupp et al., 2014). Szarka (2007), for example, offers an interesting account of the development of RE in France, highlighting how the dominance of the nuclear sector has diluted the power of

discourses that have emerged in favour of RE, reducing the room for manoeuvre and effectiveness of renewables policy.

Similarly, abundant natural resources may lead to 'imaginative geographies' and reproduce ideas about nation-building, national identity and citizenship and territory, as argued by Bouzarovski and Bassin (2011). Energy sources are often woven into discourses and debates about identity, image and significance of nation states in the global arena, and a nation's or region's visions of its own future development (Perreault and Valdivia, 2010). Such incorporation of identity narratives in the articulation of RE and technologies (development) can drive the exploitation of natural resources associated with particular energy development paths (cf. Essletzbichler, 2012). Späth and Rohracher (2010), for instance, highlighted the role of visions for biomass in RE development in Murau (Austria) and the way in which they attracted resources and motivated actors to change.

In this sense, the focus on materiality brings attention to the actors and the way they create particular vision(s) of identity, at different spatial levels, with the aid of, and in relation to, natural resource endowments. Materiality offers an opportunity to broaden the understanding of RE development to fulfil particular visions or trajectories of particular scenarios. It does so in two ways: on the one hand, it allows shifting attention to the discourses and coalitions that emerge using natural resources as energy sources, stressing the conflicts, powers, interests and priorities of the actors involved and, on the other hand, different actors can organise and mobilise particular resources shaping what constitutes a legitimate source of energy.

### *2.3 Natural resources as embedding specific physical characteristics and infrastructure requirements: the natural environment and the built infrastructure*

Both the specific physical characteristics of the natural resources and the requirement of a robust infrastructure to deliver energy (due to, again, the particular characteristics of the natural renewable resources) can exert significant influence over how energy innovation networks generate and capture value. Thus RE technologies and diffusion might emerge in one or more places where natural conditions and specific physical characteristics favour testing of and learning about technical specificities - such as for instance remote and difficult environments for the testing of sensor technologies for offshore or marine technologies. Likewise, technologies might be deployed in places where further enhancements are required to address locally specific problems (e.g. vis-à-vis load transmission capacity, balance management and storage in areas of excessive solar irradiation). Such activities could provide the seedbed for further targeted local, regional and national policy interventions. Moreover, managing grid capacity is a scale and site-specific problem, tackling

intermittency links an inherent material property of (some) renewable to wider conceptions of how electricity networks should operate.

Moreover, RE activities can emerge in places where the physical characteristics of the environment surrounding the natural resource make it more practical to harness the renewable source (e.g. lagoons, sheltered coastline, well-developed grid system and port infrastructure). To clarify with an example, areas that display a well-developed grid system and port infrastructure - deemed to be important characteristics for the commercial success of offshore renewables - and with favourable local weather conditions and local geography (e.g. accessible onshore areas suitable for assembly and maintenance), could strongly influence the exploitation of these resources (Murphy et al., 2011).

Nevertheless, infrastructure networks or their absence could also represent barriers for RE deployment. Thus, global, national and regional power and infrastructure networks become intimately connected through the materially embedded transmission grids within specific territories (Hiteva and Maltby, 2014) and interconnections, if any, between them. The built infrastructure, including the built environment, therefore, becomes an important mediating factor between the physical resource endowments and institutional/ governance structures, creating inertia and path dependencies (such as in the case of the national grid infrastructure in the UK that has hampered and delayed RE developments, see for instance Wood and Dow (2011)), constraining the feasible innovation trajectories. Moreover, areas in which the infrastructure is already present become more attractive to global investments. This highlights the importance and the challenges of strategic investments in the transmission and distribution electricity networks as the number and volume of distributed generation connections increases.

In this respect, materiality matters as it foreground the importance of the specific physical characteristics of the natural resources and the requirement of robust infrastructure to deliver energy. Recasting natural resources as potential sources of energy generation challenges established infrastructure networks that can hinder or favour the way in which natural resources come into productive use. This, in turn, influences energy innovation networks and their ability to generate and capture value in RE development.

## 3.0 How renewable energy resources are- socially and materially- produced in geographically uneven ways: some empirical evidence

### *3.1 Why focus on the regional level*

Foregrounding the materiality of resources highlights that what constitutes renewable natural resources will be contained within a particular physical territory but also be socially and politically constructed as such within and between various networks of actors at different scales. It follows that the region represents a key spatial and governance level in which materiality and scale coalesce in relation to RE deployment. As argued, due to their biophysical presence, natural resources are geographically contingent, at times confined within a particular physical territory and, at times, while they may not be physically confined to political territories at all, political units can impose bordering effects on their regulation. Certainly, sometimes, 'regional government' have powers to mediate exploitation of RE versus other resources, adding geographical contingency to resource 'availability'. But infrastructures also mediate the extent to which regions are bounded spaces for organising the terms of exploitation. RE – more than fossil or nuclear fuel cycles – also dangles the prospect of greater autonomy and control over energy futures for regions (hence '100% Renewable Energy Region' agenda). Our argument here is that the regional level becomes a key level to unpack the way in which natural renewable resources for energy are socially and materially produced in geographically uneven ways. Within the region a broad spectrum of RE systems might co-exist (e.g. wind, solar, bioenergy, marine, geothermal, etc.). These are, as we argue, in turn, influenced by the opportunities and constraints offered by the natural resource's materialities, which in turn influence the different regional institutional, economic and governance contexts.

The account above has highlighted how materiality starts to be seen essential and useful in understanding RE deployment and how RE resource potential and capacity interact with the contextual conditions in which they are developed and deployed. We have argued that as resources are produced as viable form of energy, there is a need to consider:

1. How turning natural resources into viable and legitimate sources of energy disrupts and challenges established notion of the resources; materiality is therefore useful in stressing the way in which the negotiation between turning resources into potential sources of energy and the current land-based resource use can provide opportunities but also hindrances for renewable energy deployment;
2. how different actors can construct, organise and mobilise particular resources, with the aid of, and in relation to, natural resource endowments, creating a particular vision(s) and development path, prioritising interests and recasting resource abundance on the basis of their potential for energy generation;

3. how representing natural resources as potential sources of energy generation challenges established infrastructure networks that can hinder or favour the way in which natural resources come into productive use, influencing energy innovation networks and their ability to generate and capture value in RE development.

Before providing empirical examples to test these propositions and demonstrate the insights that arise from treating materiality seriously, Table 1 summarises the arguments presented here, suggesting how the materiality dimension might influence the institutional, economic and governance dimensions at regional level.

## *3.2 Some empirical evidence*

### *3.2.1 Negotiating resources as potential sources of energy: targets setting and challenging current land use*

As stressed earlier, targets at different scales have been set for increasing the level of electricity production from renewable sources. In some countries, although the centre continues to retain considerable powers over energy policy, there has also been an increasing role and influence of sub-national (regional) actors in promoting renewables. This, often, concentrated in efforts that emphasised processes of resource assessment, target setting at the regional level and spatial planning. Agreeing with Wolsink (2007), the success of national policies for the implementation of RE, ultimately depends on the number of successful projects in which renewable resources are applied at regional and local levels.

Writing about the emergence of regional governance in RE in the English regions in the early 2000s, Smith (2007) argues that a key task at the regional governance level was to persuade others that RE was vital for the development of their region. This process of persuasion often began with the appraisal of renewable resources at regional level, resulting in embedding RE targets into overarching economic strategies. RE resources and the potential renewable capacity available at regional level were then fed back into the UK final RE strategy to ensure the twofold aim of meeting the targets - building from an evidence base - and making sure that sufficient locations for RE deployment would emerge from this process (Arup, 2009).

See also Winskel (2007) for an example of Scotland that points towards the co-evolution between (quite crude) resource assessments and efforts to promote and pave the way for development opportunities, in which figures for ‘resource potential’ play a key role. A detailed assessment of different renewables in Scotland, based on the research of one of the UK’s leading energy consultant, provided the basis for harnessing the resource of the sea to generate energy, spurring from the abundant marine ‘energy’ resource and an established

heavy and offshore engineering skills base (Winskel, 2007). The marine resource provided a viable and legitimate energy source for those seeking to exploit it and Garrad Hassan's report identified a window of opportunity for Scotland to become a 'world leading industrial base for marine energy' (Scottish Executive/ Garrad Hassan, 2001), setting the roots for a number of technology-specific support to stimulate domestic market growth, technology transfer and cost reductions. The Scottish Executive facilitated this process, approving its own Marine Planning Act, establishing a dedicated, in house planning agency, Marine Scotland, to speed up planning consent, and in making high levels of incentives available under the Renewables Obligation, establishing marine renewables as a major political priority.

In Wales, the Welsh Government set up the 2010 target for renewable energy (i.e. 10%), rationalized by concerns for climate change, energy security and the economic development potential of wind together with the belief that fewer, larger-scale onshore wind farms represented the best means of delivery (Cowell, 2007). Given such objects of governance, and the realisation that an insufficient number of locations would emerge sufficiently quickly from loosely guided interaction between developers and local planning authorities, required a revision of the planning processes (Cowell 2007). In 2005, the Welsh Government issued new national planning policy guidance which adopted a spatial planning approach for on shore wind power andcreated a presumption in favour of large-scale on-shore wind development (the technology closer to the market at that time) within specially demarcated 'Strategic Search Areas' (SSAs). The policy, set down in Welsh Government planning Technical Advice Note 8 (TAN 8) and Planning Policy Wales, provided the main guidance for plan making and decision making in Wales. In the case of Wales, spatial planning policies have been mobilised around a dominant strategic line to deliverspecific targets and objectives, which reconstructed the plentiful and available resource as a viable energy source. These promoted the preferential siting of large-scale renewable schemes, led by a technocratic approach based on resource potential (cfr. Stevenson, 2009). Spatial planning therefore reflected the capacities and willingness of a number of regional government actors to render land available for RE development and manage social responses (Cowell et al., 2015). Potential exploitation was to be further facilitated by Forestry Commission Wales, acting as an agent of the Welsh Government, in organising a preferred bidder strategy for wind farm sites on areas of SSA that coincided with the National Forest Estate.

Table 1. The Influence of Materiality at the regional level

| | materiality | how materiality might influence regional preconditions (such as institutions, governance and firms decision making) |
|---|---|---|
| **natural resource 'occurrence'**<br><br>*Natural resources as predominantly associated with the physicality of resource occurrence* | *Negotiation between turning resources into potential sources of energy and the current land resource use providing opportunities but also hindrances for renewable energy deployment* | The regional level often has responsibilities over regional economic development and planning and for the construction and operalisation of mapping methodologies e.g. spatial planning<br><br>The processes of resource assessment stimulates deliberation between regional stakeholders about weighing of different environmental values against RE targets<br><br>Negotiation between the delivery of EU/ national and regional targets vs. land use policy traditions and values<br><br>- Limit to expansion and pressures for & regional responses for RE deployment<br><br>Strategies that draw upon siting criteria to create new representation of development opportunities:<br><br>- incentivise local communities to make more sites available<br>- Developers dash to exploit most commercially attractive locations<br>- Attraction of inward investments<br><br>Regional renewable companies might hold research or land-use permits and have the know-how to negotiate/ understand local planning issues<br><br>International players seek local ties to negotiate planning environment (e.g. global companies have often financial ties with regional renewable companies that hold research or land-use permits) |
| **natural resource 'abundance'**<br><br>*Natural resources as discursive constructions that actors use to promote their interests* | *Different actors construct and mobilise particular resources creating a particular vision(s) and development path, prioritising interests and recasting resource abundance on the basis of their potential for energy generation* | Which characteristics of the resource become incorporated into mapping and which get excluded and the extent to which (these spatial representation) are accepted or resisted by different actors<br><br>Locations as sources of inward investment ('open for business')/ simplification of legal and regulatory frameworks to support ambitious deployment policies<br><br>Coherent narratives provide legitimisation on a particular process of regional development and RE and are used as a conduit and a way of communicating the articulation of particular RE development paths<br><br>Regional actors and governance systems channel finance and support of RE technology/ promotion of R&D solutions and deployment<br><br>Creation of discourses that offer opportunities to produce ideas about nation/region building and/ or regional and national identity and citizenship<br><br>Nature is something governed, consumed and marketed locally |
| **natural resource 'characteristics'**<br><br>*Natural resources as embedding specific physical characteristics and infrastructure requirements* | *Challenging established infrastructure networks that can hinder or favour the way in which natural resources came into productive use, influencing actors ability to generate and capture value in RE development* | Researchers and technology developers choose sites for testing and experimental activities according to the availability of natural resources. this is particularly relevant to emerging technologies<br><br>Potential sites are promoted for demonstration projects and experimental platforms<br><br>Existing local economic and technological structures, knowledges and competences are mobilized through the purposive actions of agents resulting in the local emergence of new paths<br><br>Regional governments provide funding for local infrastructure development (e.g. production, distribution and storage)<br><br>Areas in which certain characteristics of the resources provide great market potential and best climatic conditions- attract the attention of large foreign utilities that aim at exploiting the resource (e.g. offshore wind in UK and Geothermal in Italy) |

Nevertheless, local authorities, during the policy (TAN 8) consultation shared industry concerns about the validity of centrally mapped wind farm locations. One of the prime concerns was that the Welsh Government had neglected local aspirations for the potential of other uses of the land resource. Almost all the SSAs clashed with recent, local initiatives to valorise the environmental, recreational and economic potential of upland areas, based on qualities of 'wilderness', 'remoteness, tranquillity and naturalness' (Cowell, 2007). Moreover, localized technical and environmental constraints such as slope, individual residential properties and access issues - within the SSAs- have been neglected by WG's analysis restricting the generation capacity of the different projects. Since the adoption of TAN 8, however, a number of wind farm applications within the SSAs have actually been rejected and renewable energy developers have argued that these areas were not entirely suitable to yield the desired implementation targets for renewables. Reasons for this include access, noise issues with residential properties and particular localised topographical issues which did not show up at the national scale of the original assessment, such as the effects of turbine construction on deep peat deposits and the challenges of expropriating common land (as at the Mynydd-y-Gwair project).

The devolved governments of Scotland and Wales have each produced energy strategies, including setting their own renewable energy targets, together with their own regional visions and aspirations for RE development. The process of target setting was not influenced by Westminster seeking to steer the devolved organisation into delivering any specific share of the national commitments; rather the strategies were driven by regional growth agendas. Other countries such as Italy, on the contrary, adopted a principle of 'burden sharing', through which regions, starting from their regional technical, economic and potential for each RE source, estimated by the ENEA (the Italian National Agency for New Technologies, Energy and Sustainable Economic Development), are asked to contribute towards the national target via a binding regional target.

The process of giving Italian regions normative and regulatory functions in the energy field began in 1991, in which the regions were given the task of formulating Regional Energy Plans, aimed at managing the system of incentives with regional applicability for initiatives to reduce energy consumption, support renewable sources and elaborating plans for the reduction of greenhouse gases. Each regional energy plan, known as the Regional Environmental and Energy Plan (PEAR) constitutes the reference frame for every initiative in the energy field in an Italian region. The 2011'sprinciple of 'burden sharing' in Italy indicated a strong signal, cascaded down to the regional and local levels, for the fulfilment of the European renewable energy burden-sharing agreement. As the targets were set on the

basis of regional level's resource assessment and potential, together with the already deployed RE capacity, regions found themselves, committed by law to maximise RE deployment, to achieve intermediate targets (set within the burden sharing commitment). As in the UK, a sense of urgency over RE capacity increase has encouraged the support of market-ready technologies that could deliver the cheapest renewable electricity by promoting RE investment in the best available sites especially in the Mediterranean regions, such as Puglia, in which solar irradiation and wind speed are optimal. Puglia, for instance, at the end of 2012 had 78% of installed PV capacity generated by large scale solar farms- ground based- much higher than the Italian average (in the same period this was 43%, (Giannuzzi, et al., 2013). Regions such as Toscana and Lombardia, which had higher capacity of renewable energy resources already deployed, such as geothermal and hydro resources respectively, on the other hand have been able to reach intermediate targets choosing to invest in micro-generation rather than larger scale deployment.

In Italy, it is often the regional (and local) levels that are tasked to weighing resource potential and different environmental values against RE targets. Two issues are worth emphasising here. On the one hand, although the regions shared responsibility and competence with the national government in term of energy and renewable, the national government has the responsibility to set guidelines for the siting of the renewable plants while the regions can limit the size of the installations on their territories. Nevertheless, the guideline from the Italian national government came six years later the originally planned date, leaving regions, in the meanwhile, to legislate in the their absence. This vacuum, however, created a situation in which some regions were more amenable to large-scale development and targets achievement, while other restricted the sizes of RE development by valuing the environmental (as well as the economic and recreational) potential of the alternative use of the land, which triggered decisions to protect the landscape earlier in the process of RE targets. This has been the case in Toscana, where the land is fertile, supporting higher end agriculture productions (such as wine) and the landscape is valued and accepted as a major tourism attraction. In Puglia, on the contrary, the agricultural sector has been seen as a key player in the regional process of energy transition in which agricultural land (less productive and perceived less valuable) acted as a 'land reservoir' for PV and wind plant installations, especially since the first national feed in tariff system was implemented in 2005. It signifies that for almost a decade green energy production has been regarded as a financially interesting alternative to agriculture economic crisis a 'major factor in thwarting economic crisis and social isolation of rural activities' (Perotti, 2015). It is only with the approval of the Regional Landascape and Territorial Plan (PPTR 2010), that a

regulatory framework for RE planning was approved in the Puglia region[1]. This prohibited the installation of ground based PV plants on agricultural land and authorised them only on the roof tops of greenhouses and other agricultural structures in industrial and/or urbanised areas (roofs, facades and parking lots). This triggered resistance to large scale deployment, albeit at a point in time at which an impressive level of installed capacity had already been achieved.

This shows that, in terms of our analytical framework above, one can see how materiality of the resource is relevant (though usually addressed simply by mapping for instance the availability of average wind speeds of the required strength), and its further incorporation into spatial planning strategies that construct opportunities for wind energy development, including by organising the relationship between the energy resource and other material factors. As we discuss it later, this strategy foundered, in part, on its failure also adequately to incorporate grid capacity or – more accurately – to fully appreciate how it might act as a constraint. Moreover, as in the case of the Italian region of Puglia has shown. adding the dimension of materiality allows to capture regional differences expressed in terms of the way in which the negotiation between turning resources into potential sources of energy and the current land-based resource use can provide opportunities but also hindrances for renewable energy deployment.

### *3.2.2 Recasting resource abundance on the basis of their potential for energy generation creating a particular vision(s) and development path and prioritising interests*

As argued, understanding natural resources as a socio-material phenomenon brings to the fore the discursive construction that actors use to promote their interests and the way in which actors can promote or hinder resources and their abundance with different storylines that simplify and influence strategic policy priorities. Although, in many cases, regions may lack control over economic framework conditions (e.g. subsidies and feed in tariffs), they can mobilise a coherent shared vision(s) for the exploitation of their indigenous renewable resources. This enables them to be translated into more concrete agendas that reflect the specific requirements and opportunities of particular regional contexts. For instance, identity narratives can be linked to regional resource abundance.

[1]It is interesting to point out that the PPTR was made regional law as early as 2008, but adjudged unconstitutional and abolished in 2010 by the Italian Supreme Court) (Perotti, 2015).

Post-1998 Scottish independence debates offer an example of how such imagery of natural resources, identity and RE paths can play out (cfr. Dawley et al. (2015) and Toke et al. (2013)). In particular, the Scottish independence debate was presented as an opportunity to take control over energy policy and ultimately to increase the opportunity of pursuing RE priorities due to the abundance of natural resources. In the Scottish case, the rhetoric on renewable energy has been considered an extension of the key objective of gaining control over 'Scotland's oil' (Toke et al., 2013). The centrality of energy issues, and renewable energy development, has been central to the Scottish National Party's agenda for many years (Cowell et al., 2013). This political commitment also benefitted from cross- party support resulting into a promise to 'increase the proportion of electricity derived from renewables in Scotland to around 18% by 2010', made by the Coalition Government as early as 2001. Nevertheless, the focus on, and the high level of business engagement around, renewable energy development has also been supported by a coalition of interests that opposed an increase in nuclear capacity. The political vision to harness the comparative advantage of Scotland's natural resource (such as hydro, wind, wave and tidal) potential and to oppose nuclear new-built, therefore, has enabled the creation of a cohesion of elite interests around renewable energy expansion. This shared construction has helped the Scottish Government to utilise its available powers assertively to facilitate the implementation of projects, sometimes in the face of significant conflict about the wider land use and environmental consequences e.g. grid enhancement and on-shore wind) (Cowell et al, 2013).The successful growth that the renewable energy sector experienced in Scotland, added 'an upward spiral of credibility among key business interests' reinforcing the impact of the strong leadership that the Scottish Government has had in driving the renewable energy agenda forward – i.e. material development outcomes helped sustain elite cohesion, and to grant a degree of reality to the aspirational policy narratives.

The Welsh Governments from 2003 onwards have expressed strong support for renewable energy, with a close conjunction forged between renewable energy and climate change mitigation between 2007 and 2011.In Wales, political vision was also seen as key for the mobilisation of a renewable energy development path. Jane Davidson, the Minister who held the environment and sustainability portfolio from 2007-2011, was seen, from many, as an instrumental actor in forging new, clear strategies for renewable energy and raising the profile of climate change. However, many remained sceptical of the capacity and willingness of the Welsh Government leaders to demonstrate leadership as suggested by Cowell et al. (2013). For the business sector, this is confirmed by the lack of backing of the supportive statements made about renewable energy in the face of public dissent. We could argue that in Wales, there is a tentativeness to the 'visions' – with targets expressed as 'aspirations'

based on resource assessments and assumptions about projects in the pipeline, rather than targets that drive significantly policy action outwith the planning policy sphere. Moreover, RE aspirations need to be seen within a broader, pragmatic approach to energy development per se that embrace major nuclear and fossil investment (Cowell, et al., 2013). This is seen as a disposition, from the Welsh Assembly officials and many politicians, to identify all energy development- including new gas power stations or other fossil fuel facilities- in terms of their investment and employment benefits to Wales, with their emphasis on the local jobs dividend. Such an accommodating stance is, arguably reinforced by the limited powers of the Welsh Government to influence such projects, lacking (at the time of writing) the kind of powers that the Scottish Government possesses over the consenting of such schemes.

Puglia, in 2012, outperformed the rest of the Italian regions in terms of PV installed power and wind energy and was third in bioenergy production. Since the onset of the Regional Energy Plan (PEAR, 2007), the favourable climate and natural resource endowments such as wind, solar and agricultural land were represented as a means to overcome the current patterns of uneven development in the region (see De Laurentis, et al., 2014). Capitalising on favourable geographical conditions meant that renewable energy developments could provide opportunities to alter patterns of economic growth and development. Breaking the old trajectory of path dependence in the region become therefore a major goal of regional energy policy in which the public sector – through a combination of green public procurement, more permissive planning regulations and the deployment of EU funds- played a significant role. Moreover, similarly to Scotland, the renewable energy development path received more favourable consensus following debate over the re-introduction of nuclear capacity in Italy with the Puglia regional government voting against siting new nuclear reactors in its territory[2]. Recasting resource abundance on the basis of their potential for energy generation created a particular vision and political commitment to assume a leadership role in the renewable energy stakes. As the case of Puglia shows, driven by discursive constructions, regional institutional systems can form temporary windows of opportunity for technological innovation and deployment(cfr. Dewald and Fromhold-Eisebith, 2015), as they set up ambitious deployment policies, facilitate and simplify approval and licensing system (e.g. adopting a fast track approval and a simplified licensing system for the authorisation process for renewable energy installation, as in the case of Puglia), support demonstrative projects and experiments aimed at harnessing natural resources, speed up planning consent, and mobilise resources and interests. Narratives and visions around RE in

[2] Puglia is the most industrialised region of the Mezzogiorno, with CO2 emissions second only to Lombardy's, the most industrialised region in Italy and host three large power plants for electricity production (ENEL group, Edipower and EniPower).

the examples provided have mobilised resource abundance and resource availability to promote particular deployment path that ultimately have increased the opportunity of pursuing RE priorities due to the abundance of natural resource. Nevertheless, regional 'visions' could also oppose large scale RE development aimed at harnessing natural resources, in the pursuit of maintaining a balance between energy production, landscape values and conflicts (cfr. Bridge et al. (2013).

### *3.2.3 How representing natural resources as potential sources of energy generation challenges established infrastructure networks*

We have suggested that the materiality of natural resources, and their representation as potential sources of energy generation, draws attention to the importance of the pre-existing built infrastructure and how they might influence innovation processes in RE. RE deployment is influenced by contextual factors, including the built environment and the established energy infrastructure. As RE capacity increases, the current infrastructure (e.g. grid connections, electricity distribution and transmission lines) might represent a constraint or an opportunity for future development. In the UK, as suggested by Wood and Dow (2011), the obduracy of the national grid infrastructure, among other factors, has hampered and delayed RE developments. We argue here though that the regional level is often where the problem of grid saturation (and unavailability of new grid connection) is felt. Regional governments might have both the political legitimacy and the resources to participate actively in infrastructure renewal (e.g. channelling European funding for infrastructure development and update). However, in the UK, for instance, steering, especially at the regional level, the electricity network is problematic. The electricity network was configured for the long distance transmission of major electricity flows from large power stations, especially in the north, and capacity is lacking in many of the more remote, rural areas, in which renewables potential has been identified, and not for the kind of interaction between producers, storage and consumers that a more decentralised network might require.

The infrastructural inheritance has institutional concomitants that also problematise regional-level steering. Since privatisation, key decisions are taken by arms-length regulators that operate on a UK-basis. Ofgem oversees the regulation of prices and capital spend by the distribution and transmission companies across the UK as well as rules for grid access and provisions of grid transmission charging[3]. However, such regulatory arrangements makes it difficult to drive forward major system reinforcements in advance

[3]National Grid Company owns the transmission network in England and Wales and manages the arrangements for power dispatch and balancing for the whole of England, Scotland and Wales.

for new generation capacity as the network developments and enhancements are often placed 'in a response-mode relationship to new electricity generation' (Cowell et al., 2013: 37). This creates challenges and delays, making difficult to steer enhancements that might offer wider strategic enhancements that go beyond the single project and that are important for the UK-wide renewable energy agenda. It is an additional problem that new terrestrial network developments have also attracted significant public opposition4 (Cowell et al, 2013); a further dimension of the difficulties of reconciling the exploitation of renewable energy resources with existing land uses. One can see these issues unfolding in a number of spheres.

Despite the limit to the Scottish and Welsh governments to exert direct effect on the pace of grid development, Cowell et al. (2013) show that the Scottish Government has signalled consistently the importance of the most significant piece of grid reinforcement that was essential to exploit the renewable energy potential of northern Scotland (the replacement of the Beauty to Denny 132KV line with a 400 KV line). Beyond the immediate and practical management of the decision making process, the Scottish Government has provided a clear signal and commitment to the project going ahead, which in turn helped to sustain industry efforts to renewable energy generation during a contested consenting process from the public and landscape groups. Moreover, the Scottish Government has also played a key active role in the negotiation around grid issues at strategic level. This allowed the Scottish Government to push forward an agenda for reforms, at national level, of the grid transmission charges that could allow renewable generators to pay lower rates and reduced transmission charges for exporting their power, making renewable energy schemes more economic.

Infrastructure challenges are also present in Wales. During the process of identification of strategic zones for onshore wind development (the strategic spatial planning guidance TAN8) considerations were given to areas in which there was already sufficient grid capacity in place to export the renewable power. Nevertheless, zones were identified in mid-Wales due to their wind potential despite a lack of suitable grid connections, on the basis that these rural areas needed significant grid enhancement for the renewable energy to be exploited. The difficulties of steering new grid into existence has arguably done as much to shape the implementation of the TAN 8 strategy as the direct material effects of the wind farms themselves. By and large, wind farm proposals targeting the strategic search areas in south Wales have been the most successful, able to exploit sites needing

[4] Cowell et al, 2013 argues that because electricity generation and grid developments are put forward by separate companies, as separate applications, there are difficulties in assessing the overall environmental impacts of what are systemically connected projects.

little grid enhancement (a legacy of the higher network capacity created during earlier eras of coal-based industrialisation), as well as inserting wind farm projects within tracts of industrial forestry physically and socially detached from local populations. In mid-Wales, although the wind farm applications targeted SSA areas on less visible upland plateaus, the surge in applications precipitated plans for major new 400 kV grid lines across more visible valley locations, greatly amplifying and politicising anti wind farm protests, in local-, Welsh and UK/national arenas. In September 2015, under the auspices of a Westminster government more critical of onshore wind, the majority of the remaining mid-Wales wind farms were denied consent and financial support for the sector was radically cut back.

Therein lies more systemic governance consequences of grid configurations. The grid networks for Wales, reflecting post-War agendas of integration and centralisations, ignore the Welsh Border, treating Welsh territory as an integrated sphere of UK space. Partially as a consequence, Welsh Government – neither as an arm of central government up until 1998 nor the devolved governments after 1998 – has been able to exercise control over grid regulation[5], or the financial resources governed through it. Our point here is that control over market support for renewables at regional level tends to reflect the materiality of networks i.e. the physical separation of the infrastructure through which the electricity flows and the presence/absence/nature of boundaries. This explains why the growing politicisation of renewable energy in the National Assembly has tended to focus on issues of planning – ordering the relationship between renewable energy infrastructure and other environmental values – and be largely silent on potential alternative modes of resourcing the sector. It also explains the difficulties of conceiving of how more localised control of grid networks, to facilitate the management of decentralised and intermittent renewable energy sources, could be inserted into current arrangements. The absence of boundaries is an issue, and a contrast with (say) Germany, where grid networks were never centralised, allowing diverse ownership and control to emerge to facilitate decarbonisation.

A further example of how established energy infrastructure can affect RE deployment is provided by the region of Sardinia, where the physical constraints and peculiarity of the energy system infrastructure (such as the limited distribution and transmission infrastructure) are hampering the opportunities offered by the plentiful regional resource endowments. The installed capacity of 1.500 MW of wind power constitutes the maximum limit that the current infrastructure in the region can accept (further capacity could alter the continuity and stability of the electricity service and generate a negative effect reducing productivity of current installations (Regione Sardegna, 2012b). This problem is also present in many

[5] Even in planning and consenting, only planning applications for substations has been determined by local planning authorities in Wales; the Wales Act of 2016 offered steps towards greater consenting control.

Mediterranean regions in Italy, following the very rapid development of the electricity production capacity from renewable sources, especially on shore wind and ground-based solar farms that require connection to the national high voltage grid. These are areas in which the Italian national grid is less extended presenting a more limited transport capacity, causing the implementation of production cuts of renewable energy plants – despite the generation investment, the electricity produced has nowhere to go. The transmission grid, in Italy, is a natural monopoly mostly owned and operated under a concession regime by TernaSpA, a publicly listed company. The development and construction of new facilities (for example, transmission lines and power plants) require permits mandated by state and regional legislation to ensure environment protection and compatibility with existing infrastructure. The process for obtaining such approvals is regulated by a combination of state and regional legislation and depends on the nature and location of the facility to be realised and permits required. The process is usually led by the regions (or sometimes the provinces), which co-ordinate the process involving all the agencies and authorities whose consent or opinion is required to finalise the permission process.

## 4.0 Concluding remarks and future research

The paper has shown that drawing attention to the issue of materiality and how renewable natural resources are brought into productive use as viable forms of energy, offers an opportunity to unpack the ways in which particular renewable energy resources come to be fashioned in some areas and not in others explaining the ways in which the social, material and environmental dimensions of such resources come to be understood and contested, favouring or hampering particular RE deployment and diffusion paths. The paper shows that considering natural resources as being both a physical (e.g. their geographical occurrence) and a discursive artefact of a diversity of actors that construct and manipulate nature offers additional insights on how and why renewable energy deployment and diffusion realise- and quite often fail to realise- its potential.

The paper, firstly, addresses the questions of why materiality matters, why it is important to give it consideration and unpack the different ways in which it matters. Secondly, it focuses the discussion on the regional level, arguing that the region represents a key spatial and governance level in which materiality and scale coalesce in relation to RE deployment. The paper provides some empirical evidence on the ways in which the notion of materiality is used to unpack how renewable energy resources are- socially and materially- produced in geographically uneven ways. Adopting the regional lens offers an opportunity to unfold how materiality influences institutions, governance and firm decision making at the regional level.

The arguments presented suggest that understanding renewable energy natural resources as a socio-material phenomenon emphasise that resources can be highly context specific, influenced by complex place-base interactions, which occur at both local and regional levels. Many studies, from both the innovation systems and sustainability transitions literature have analysed the role of institutions and institutional structures for renewable energy such as the regulatory support, the role of technological standards and specific R&D programs in support of renewable energy deployment. What the paper shows is that the materiality lens can be a useful addition to these literatures. In particular future research could usefully investigate how economic and regulatory institutions can be moulded and influenced by place-specific informal institutional conditions, such as trust, culture, history and identity (Farole et al., 2011; Rodríguez-Pose, 2013; Tomaney, 2013). This- the influence that culture, identity and trust can exert on institutional conditions- has received less attention (an exception is Wirth et al. (2013)) in innovation and transitions literature and the paper has shown that in order to understand processes of renewable energy deployment and transitions increased attention should be payed to the institutional conditions that refer to:

- the interplay between energy and land use planning and land use ownership;

- the role of regulatory infrastructure conditions, such as connection rights, rules and transmission charges;
- how the inherited boundaries in grid networks (or their absence) continue to shape the distribution of formal regulatory powers and political imaginations;
- how a culture of collaboration can spur collaborative practices in planning but also in promoting cooperative and community based energy initiatives and
- how identity can provide meanings to particular areas and influence the social attachments to the environment and the landscape.

This future research agenda can meaningfully contribute to the wider geography of transitions debate (cfr. Hansen and Coenen, 2015), that lacks appreciation of the regional contexts.

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