The material dimensions of renewable energy deployment: understanding spatially uneven processes at the regional level in Italy and the UK

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Summary

This thesis examines the processes of transformation underway within energy systems, specifically the move towards a higher share of renewable energy technologies. It aims to improve our understanding of the regional level and its role in shaping the pace and direction of renewable energy deployment.

It proposes a novel way of researching renewable energy deployment - at the regional level - by investigating the evolving relationship between energy and materiality. It argues that the deployment of renewable energy, the process of turning renewable 'natural resources' into productive use as viable forms of energy through stages of energy conversion, storage, transmission and distribution has material aspects like those involved in the deployment of fossil fuels. This thesis considers the role of natural resources, investigating their implicit physical and partially socially produced nature and identifies several material dimensions of renewable energy discussing how they matter, why it is important to give them consideration and unpacking the different ways in which they matter. It develops an analytical and conceptual framework and its application and testing in the regions of Apulia, Tuscany and Sardinia, in Italy, and Wales and Scotland, in the UK.

Drawing on the empirical material gathered this research shows how the various material dimensions of renewable energy have affected its spatial distribution and deployment. The thesis shows, by focusing on solar and wind energy, how the significant spatial variations in renewable energy deployment in the case study regions can be explained in terms of the influence of a number of material dimensions.

This thesis aims to show how understanding these aspects of renewable energy offers an opportunity to unpack and explain how particular renewable energy paths come to be favoured or hampered, and yields useful insights into the spatial unevenness and variation of renewable energy deployment at the regional level.

Dedication

This research is dedicated to my husband, Sean, and to our children, Luca and Sofia. They have supported me all along on this project with their encouragement, patience and willingness to listen. With gratitude and affection to all my family, friends and colleagues, who have been with me during this journey.

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List of Abbreviations

ARTI= Agenzia Regionale per la Tecnologia e l'Innovazione (Apulia Development Agency)

CfDs= Contracts for Differences

EU= European Union

FiTs= Feed in tariff schemes

GOST= Geography of Sustainability Transitions

MLP= Multilevel Perspective

MW= Megawatt

NES= National Energy Strategy- Strategia Energetica Nazionale

NFFO= Non-Fossil Fuel Obligation

NRW= Natural Resources Wales

PAN= National Renewable Energy Action Plan- Piano D'azione Nazionale per l'Energia Rinnovabile

PAS= Simplified Authorization Scheme

PAER= Piano Ambientale ed Energetico Regionale Regione Toscana.

PEAR= Piano Energetico Ambientale Regionale

PIER= Piano di Indirizzo Industriale Energie Rinnovabili

PV= Photovoltaic

RE= Renewable Energy

RIS= Regional Innovation System

RISs= Regional Innovation Systems

RO= Renewables Obligation

SNM= Strategic Niche Management

ST= Sustainability Transitions

STSM= Short Term Scientific Mission

TIS= Technological Innovation System

TM= Transition Management

Chapter 1

'Context and rationale for the research'

Summary

This thesis examines the processes of transformation underway within energy systems, specifically the move towards systems that incorporate a far greater share of renewable energy (hereafter RE) technologies. It aims to improve our understanding of the regional level and its role in shaping the pace and direction of renewable deployment. This chapter represents the prospectus of the thesis. It introduces the research problem in terms of how we can explain regional differentiation in RE deployment and why it merits further study. In this chapter, I briefly introduce the study's context, the relevant literature and the research questions, and indicate how they will be approached and explored.

1.1 Introduction

As many policy documents at international, national and regional levels stress, there is evidence that climate change is an issue that must be tackled if planetary environmental conditions are not to be further jeopardised (Stern 2008; Galarraga et al. 2011; IPCC 2014). Complex architectures of political power and spaces of governance have emerged as governments seek to reconcile environmental protection with multiple pressures and demands. The pressures associated with tackling climate change and reducing carbon emissions, it is often argued, have given rise to a rescaling of environmental governance in which the state has explicitly devolved and redistributed environmental responsibilities downwards to cities and regions (Gibbs and Jonas 2000; Bulkeley and Betsill 2005; While et al. 2010). The regional level (see Box 1.1) is of growing significance, although, it is argued, not so much in terms of redistributed formal powers, and represents the governance scale where many environmental responsibilities and policies are actually implemented and realised (Gibbs and Jonas 2000; Morgan 2004; While et al. 2010). Moreover, regional governments in many parts of the world 'hold a wide range of the competences to implement policy actions for both adaptation and mitigations' (Galarraga et al. 2011: 164).

Energy systems are not only conditioned by individual technologies - such as fossil fuel and RE technologies, but are shaped by a complex interaction of social, economic, technological and political factors. As Smith et al. (2010) have argued this requires a broadening of the problem framing in order to link the notion of innovation with the broader goal of sustainable development in a systematic way that looks beyond discrete policy and technological innovations to whole systems change.

One such broader analytical perspective that has emerged in the last decade is represented by the *sustainability transitions* (ST) literature (Geels 2002, 2004; Kemp and Rotmans 2005; Geels 2011; Geels 2014). This work shares the earlier criticism of studies of socio-technical transitions of adopting a pervasive 'methodological nationalism' (Späth and Rohracher 2012). In particular, transition analyses have been criticised for overlooking where transitions take place and the socio-spatial relations and dynamics within which transitions evolve (Coenen et al. 2012).

Such criticisms have generated a buoyant interest, resulting in a developing research agenda aimed at investigating the role of geographical thinking and perspectives in ST. It is increasingly accepted, therefore, that if the prospect of change in systems of energy provision is to be fully understood, then it is vital to understand how 'energy systems are constituted spatially' (Bridge et al. 2013). In addressing this quest for a more spatially sensitive conceptualisation of transition studies, *this research focuses upon the role of regions in RE deployment; it identifies the factors that could explain spatial unevenness and regional variation in RE deployment and provides empirical evidence about the importance of the region for our understanding of low carbon RE energy transitions.*

This chapter represents a prospectus of the thesis that explains what the problem is, why it is worth studying, what the research questions are, how they are going to be approached and explored, and how the thesis is organised. The chapter begins with a brief account of the theoretical context that informs this work. It follows with an introduction to the research questions and methods adopted to conduct the research. The chapter concludes with an outline of the thesis.

Box 1.1 The definition of region used in this thesis

The concept of region, originating from Latin regiō/ regere alias to govern, is often used to identify a sub-national level of governance that assists processes of economic development (Cooke and Leydesdorff 2006). In this thesis, I follow Cooke et al. (1997: 480) and define regions as 'territories smaller than their state possessing significant supra-local governance capacity and cohesiveness, differentiating them from their state and other regions. Amongst the governance powers all possess, to varying degrees, are certain capacities to develop innovation support policies and organisations'.

Although geographers increasingly regard regions as a social construct, this definition aligns with Paasi and Metzger (2016: 5) as they argue that 'many regions are actually territories deployed within the processes of governance and are made socially meaningful entities in processes characterised by multifaceted power relations'.

1.2 Theoretical context and gaps in knowledge

A transition has been unfolding in energy systems, subject to a set of forces that span across an increasing awareness of the environmental consequences of the existing hydro-carbon energy system, to the challenges of nuclear energy production and the new awareness of 'green' energy. The development, application, and proliferation of RE technologies are seen as part of a shift underway in energy systems. These far reaching changes have been recently addressed as ST, in that they affect both the technological systems and social institutions (cf. Unruh 2000), and relate to more sustainable or environmentally friendly modes of production and consumption, in sectors such as transport, energy and water (Markard et al. 2012). The broader analytical perspective (Smith et al. 2010) of ST has emerged within innovation studies and brings together theories of technological, industrial and economic change complemented with a sociological analysis of technological change. Often used interchangeably, the concepts of transitions and systems innovation (Geels 2002, 2004; Kemp and Rotmans 2005; Smith et al. 2010) emphasise the set of processes- and the system-wide approach required to understand them that may lead to fundamental shifts in socio-technical systems (cf. Kemp 1994; Geels and Schot 2010).

Understanding the prospect of change in systems such as energy provision requires a systematic approach that looks beyond discrete technological innovations to whole systems change (Smith et al. 2010). While innovation plays a key role in transitions studies, the challenge for innovation no longer resides only in economic potential but also in the changes induced by innovative activities and the consequences for environmental and social sustainability (Smith et al. 2010). Innovation systems analysis is useful in explaining the level of innovative activity and in highlighting some of the difficulties of the processes by which 'green' innovation come about (Smith et al. 2010). However, the ST approach focuses more on the way broader contexts put pressure on innovation systems to become greener, acknowledging the strong interdependencies between various elements of the system, such as technology, regulation, user practices, markets, cultural meaning, infrastructure, maintenance networks, science and supply networks, that inform their reconfiguration. In other words, transitions require the development of a wide range of new technologies- such as renewables in energy systems- alongside the development of new institutions and social practices that can influence their diffusion and incorporate the peculiarities of transformative change.

While the essential role of innovation as a driver of sustainability transition is widely acknowledged (Elzen et al. 2004; Coenen and Díaz López 2010; Jacobsson and Bergek 2011), there is a need to further explore the mechanisms that lead to an effective diffusion of RE technologies and to explore their spatial differential (the how and where these technologies might be deployed (cf. Balta-Ozkan et al. 2015)). Hence, the choice here is to situate the work undertaken within the broader analytical perspective of ST as *it seeks to understand the transformations that are underway in energy systems, in particular via the deployment of RE technologies, and to pay further attention to the spatial and institutional contexts in which such changes take place*.

As the focus of this work is on understanding the spatial unevenness and regional variation in RE deployment, I situate the discussion within the geography of sustainability transitions (GOST) literature, that originated from the cross-fertilisation of ST research and economic geography (for a review see Hansen and Coenen (2015) and two special issues on the topic - European Planning Studies (2012); EIST (2015)). Many studies within the ST and innovation systems literatures show how RE deployment involves a relatively strong influence of policy regulation and economic support. They have focussed, for instance, on the role of institutions (see Box 1.2) and institutional conditions for RE, such as regulatory support, the role of technological standards and specific R&D programmes in support of RE transitions (see for instance Jacobsson and Lauber (2006) and Haas et al. (2004)). Furthermore, the GOST literature provides a number of meaningful contributions that stress the central role of institutional variations as foundations for geographical differences in the adoption of RE, highlighting how norms, values and practices at local and regional levels condition the potential for different socio-technical configurations.

Nevertheless, as Hansen and Coenen (2015) argue, its often the case that, the GOST literature considers localised institutions, especially the informal ones, as a residual category for a largely heterogeneous set of social and cultural conditions that enable and constrain change (for exceptions see Wirth et al. (2013); Wirth (2014) and Späth and Rohracher (2010)). This work aims to address this deficiency, *highlighting the various components of the institutional make-up that influence RE deployment, foregrounding the types of institutions that can promote or hinder processes of deployment and how these influence the reasoning and decision making of actors at the regional level.*

Although the wider GOST debate, to a large extent, has lacked sufficient appreciation of the regional context (for an exception see for instance Späth and Rohracher (2010); Cooke (2011); Späth and Rohracher (2012); De Laurentis (2013)), the literature on innovation systems has had the merit of enhancing and explaining how different territorial institutional environments favour certain types of activities and technological development paths over others, including the territory of the region (Cooke 1992; Braczyk et al. 1998; Asheim et al. 2003; Asheim and Coenen 2004). This work, therefore, engages with the regional innovation systems (RISs) approach - Asheim and Gertler (2005: 299) refer to a RIS as 'the institutional infrastructure supporting innovation'- and it looks at the way in which it considers and identifies the distinct local institutional environments that are conducive to innovation.

Box 1.2 The definition of institutions used in this thesis

Following mostly neo-institutional economics, innovation scholars identified institutions as simply 'rules of the game in a society' (North 1990). For the purposes of this work, institutions are characterized, following Gertler (2004: 7) as 'formal regulations, legislation and economic systems as well as informal societal norms that regulate the behaviour of economic actors: firms, managers, investors and workers. (..) Collectively they define the system of rules that shape the attitudes, values and expectations of individual economic actors'. Martin (2000: 80) distinguishes between formal and informal institutions: 'rules, laws and regulations (formal institutions) as well as norms and values (informal institutions) are seen as key constituting factors of space'. Together these formal and informal institutions produce specific institutional settings (Martin 2000), providing incentives for actions and limiting the range of possible (desirable) activities (Rohracher et al. 2008).

The approach followed here remains rooted within the Regional Innovation System studies and, in that literature, institutions are used as a point of entry from which to investigate certain aspects of processes of economic development (cf. Cumbers et al. 2003). The intention here is to investigate and highlight the various components of the institutional make-up that influence RE deployment.

The RISs approach shares with the ST approach the focus on governance, the role of political actors in steering and governing change, and the regulatory and institutional support involved. Investigating the couplings with both approaches is therefore valuable. In particular, this work looks at the success of the RISs approach as an analytical frame that points towards i) the purposeful action of policy actors, at the level of the region, in influencing institutional conditions via processes of regional policy- making and ii) the way in which, although some institutions might share common features across territories, they also adopt a place distinctiveness influenced by culture, history, religion and identity that can affect the potential of any territory to develop economic activity (Rodríguez-Pose 2013). These are important factors in understanding RE deployment variation across regions.

As shown, the complementarities between the GOST literature and the RISs can offer valuable insights for understanding processes of RE deployment. Nevertheless, I argue, that these recent contributions can be enhanced by defining the regional context more broadly, in terms of the wider institutional, economic and governance dimensions that may influence processes of RE deployment and in terms of the natural and built environment and resource occurrence of energy and RE in particular. The literature lacks sufficient appreciation of the role played by resource endowments at the regional level, and how they can support or hinder RE deployment. This occurs despite the acknowledgement of the key role played by localised institutions and resource endowment for the development and diffusions of environmental innovations (cf. Hansen and Coenen 2015). I argue that to understand processes of RE deployment, and their spatial unevenness, *there is a need to develop an analytical and conceptual framework that places more focus on the type of localised institutions that might influence RE deployment and to foreground the role played by resource endowments at the regional level.*

1.3 Exploring the material dimensions of renewable energy

The framework developed in this thesis to address these issues draws on an approach to the analysis of materiality originally developed in the extractive industries literature, including fossil fuels (Bakker and Bridge 2006; Kaup 2008, 2014; Bridge and Bradshaw 2017). The deployment of RE, the process of turning renewable 'natural resources' into productive use as viable forms of energy through stages of energy conversion, storage, transmission and distribution has material aspects like those involved in the deployment of fossil fuels, although fossil fuels present broader material aspects than many forms of RE.

Nevertheless, bioenergy, which requires biomass feedstocks, and large hydropower and geothermal energy, for instance, all share some materialities with fossil fuels, which largely relate to the material extraction and/or processing of the resource. Yet, even solar and wind energy, while lacking such materialities, also present material dimensions, in particular those associated with processes of energy capture, conversion, transmission and distribution, including the physical infrastructures that support them. These material dimensions not only directly influence RE deployment potential but also interact with the ways in which these physical entities are socially constructed as exploitable energy resources through political-economic and cultural processes (cf. Calvert 2015). The literature review will show that there has been little research on the material dimensions of the deployment of RE (for exceptions see Armstrong and Bulkeley (2014) and Nadaï and Labussière (2012) and also Bridge et al. (2013) in their discussion of the low carbon economy). Box 1.3 explains how the concept of materiality is understood in the thesis.

My argument is that through such processes these material dimensions can, and do, influence the geographical deployment and dispersion of RE. This work therefore aims *to show whether and how various material dimensions have affected the spatial distribution and deployment of RE, in particular solar and wind energy*[1]*, offering an opportunity to unpack and explain how particular RE paths come to be favoured or hampered, at the regional level*.

Box 1.3 How the concept of *materiality* is used in this thesis

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). 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. 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.

[1] The focus on wind and solar energy deployment is determined by the fact that during the time of this work (between 2014 and 2017) government policies have concentrated, in the countries under investigation, on the deployment of these mature technologies and also throughout this work, the attention is often focussed on larger generation systems- such as wind and solar farms- as these have been prioritised.

1.4 Objectives and methodological approach

1.4.1 Research questions and research objectives

The central themes of this study are i) to identify the factors that could explain spatial unevenness and regional variation in RE deployment and ii) provide empirical evidence about whether the region represents an important level from which to understand low carbon RE energy transitions. In particular, this work contributes knowledge towards understanding the spatially uneven processes of RE deployment at the regional level.

This thesis proposes a novel way a novel way of researching RE deployment by investigating the relationship between energy and materiality. It asks:

> *Q1. What influence could the material dimensions of RE exert on its spatial distribution and deployment*?

In answering this question, the thesis develops an analytical and conceptual framework that, in contrast to much of the literature on innovation and systems innovation, foregrounds the importance and role of renewable natural resources and their material dimensions in explaining the uneven processes of RE deployment.

For this purpose, this work asks the following sub-questions:

> *Q1.1 What are the material dimensions of RE? and*
>
> *Q1.2 How might they matter?*

The research identifies a number of material dimensions that influence RE deployment, and considers how and why they matter. I then investigate how the material dimensions influence RE take up and deployment at the regional level, addressing a second question:

> *Q2. Could these material dimensions of RE explain regional variations in RE deployment?*

After discussing the material dimensions of RE and how they can influence the characteristics, assessment, and possibilities of RE that might help to explain differences in its take- up, deployment and spatial distribution, the research asks:

Q2.1 How might the material dimensions of RE influence regional institutions, governance and decision making? and

Q2.2 How can we study the variations of RE deployment at the regional level?

A set of analytical themes are developed, applied and tested empirically, in 5 regions within Italy and the UK (Tuscany, Apulia and Sardinia and Wales and Scotland, respectively) to unpack how and why the material dimensions of RE influence regional institutions, governance, and decision making, providing empirical illustrations of how these material dimensions have affected regional deployment and its distribution.

The specific research objectives are:

- to understand how and why RE deployment realises its potential (or why it fails to realise its potential) in some regions and not others;
- to identify the factors that could explain regional differentiation in RE deployment;
- to develop an analytical and conceptual framework to study RE deployment at the regional level;
- to test and refine the analytical and conceptual framework with empirical material and case study evidence from five regions, two in the UK and three in Italy;
- to provide empirical evidence about whether the region represents an important level from which to understand the transitions to energy systems (in particular the deployment of RE);
- to inform research users (policy makers, academics and firms) of the value of foregrounding the role of materiality, and its influence, in energy transitions, particularly RE deployment.

1.4.2 Brief description of the research strategy, methods and data collection

This thesis addresses the research questions both conceptually and empirically. The empirical work provides the reader with an illustration of how the conceptual arguments can be applied empirically. The thesis consists of two main interrelated parts: the development of an analytical and conceptual approach and its empirical testing across 5 regions within the UK and Italy.

Methodologically, a qualitative approach –based on case studies analysis – was found useful here. A case study[2] approach can both illustrate and add to further development of theoretical concepts (cf. Siggelkow 2007). A further strength of qualitative methods is that they provide a means of accessing and understanding the role of context (Yin 2014). Although case studies are helpful to interrogate, examine and tease out some of the effects of context, there is also a need to extend case study methods to incorporate comparative methodologies, especially cross regional, multi-site and transnational fieldwork in order to better identify the influence of context and to aid the transferability of the arguments presented. The process of engaging in comparative empirical case study analysis can also be useful in helping the researcher to understand the influence that institutions exert on economic processes and how they unfold at different geographical scales (see for instance Gertler (2010), Farole et al. (2011), Peck (2003) and Wirth et al. (2013)). Therefore, this study adopts primarily a qualitative research strategy that focuses upon multiple-case studies of a selected sub-set of particular regions.

The thesis draws upon an extensive critical review of the academic literature, press reports and policy documents to build up a detailed picture of the theoretical considerations associated with innovation and energy systems at the regional level. As highlighted, the empirical research focuses on different regional settings, across two different national institutional contexts, to help unpack the importance of context specificity, including the importance of renewable natural resources and their material dimensions, and to contribute major insights for the testing of the framework. The framework is applied in order to analyse regional differences across 5 regions, three in Italy (Apulia, Tuscany and Sardinia) and two in UK (Scotland and Wales)[3].

[2] Simons (2014: 457) defines case study as an 'in-depth exploration from multiple perspective of the complexities and uniqueness of a particular project, policy, institution or system in a real-life context'.

[3] Throughout this thesis, the attention and focus of the analysis are the regions of Scotland and Wales. When the UK is referred to, the reader should be aware that the focus is still on Scotland and Wales as components of the UK. Unless otherwise stated both Northern Ireland and England are not included in the analysis.

Secondary data collection focuses a) on the investigation of existing regional/national policy and planning frameworks and b) on a review of RE deployment in the different regional settings under investigation. In the primary data collection, 35 semi-structured interviews were conducted across the five regions, together with two study visits in Italy. The interviews included key regional and national stakeholders (including national and regional governmental organisations, public and private research institutions and industry players).

Both Italy and the UK have been subject to similar pressures from European and international regulatory frameworks, as well as domestic pressures, and have each introduced a system of incentives- specifically in terms of subsidies and investment incentives for the production of electricity from renewable sources aimed at achieving the EU 2020 targets (set at 17% and 15% of total energy needs respectively). These policy interventions stimulated: i) the UK to undergo rapid RE deployment, overturning the view that the UK was a laggard in terms of deploying RE (Mitchell et al. 2006; Toke 2011), in particular thanks to on shore and off shore wind energy development; and ii) Italy with the world's largest share of PV generation[4]. The two countries are interesting because, while the Italian central government shares responsibility for energy policies with regional governments, energy policy in the UK is a reserved function much of which is not devolved. All the devolved administrations in the UK- Scotland, Wales and Northern Ireland- have full responsibility for spatial planning policy and decision making in other areas such as transport and economic development. Recent research shows there to be institutional differences across Wales, Scotland, Northern Ireland and England that open up fundamental questions about differences in the development and deployment of RE in UK regions (for an example of this for bioenergy in the UK, see De Laurentis (2013) and for comparisons between England, Scotland, Wales and Northern Ireland, see Cowell et al. (2015)).

Moreover, a high proportion of the potential RE resources of the UK lie within the territory of Scotland and Wales and the extent to which they are realised will affect whether the UK RE and decarbonisation targets are met. Regions in Italy for instance vary in terms of solar radiation, orography, climate, population, area and economic conditions. However, it is

[4] The installed PV power in Italy was negligible until 2007. A series of feed-in-tariffs scheme, uncapped until 2012, and good solar radiation favoured a large growth of solar PV installation and capacity.

important to note that, unlike in the UK, the incentives applied in Italy have the same value throughout its territory (for instance solar feed-in tariffs were high enough to make a PV plant economically feasible even in the least insolated areas of northern Italy (Antonelli and Desideri 2014)). Apulia, in the south, for instance played a pioneering role in RE deployment and became the leading region in wind and solar energy production in 2012 and both Tuscany and Sardinia have not been able to exploit their regional renewable resource endowments in the same way as Apulia has. Similarly, in the UK, Scotland accounts for 29% of UK's RE installed capacity, while Wales, with a similar wind resource characteristic, only accounts for 7% of total installed capacity and 9% of wind installed capacity.

1.5 Outline of the thesis

This **Chapter 1** has introduced the thesis, explaining what the problem is, why it is worth studying, what the research questions are and how they are going to be approached and explored. The rest of the work is organised as follows.

Chapter 2 '*Setting the boundaries of the research: a critical literature review*' situates the research conducted, critically and reflexively, within the sustainability transitions and territorial innovation systems literatures and, in relation to the research questions, highlights the shortcomings and gaps identified in these two complementary bodies of literature. It suggests that looking at the relationship between energy and materiality can provide additional insights into how and why RE deployment realises, or fails to realise, its potential.

Chapter 3 '*Research design and methods*' reviews the methodological approach to be used and justifies the research strategy and methods adopted. The chapter discusses the two main interrelated phases of the work, namely the development of an analytical and conceptual approach that foregrounds the material dimensions of RE materiality and its empirical application and testing across 5 regions within Italy and the UK. The chapter also reviews the data collection strategy and activities undertaken during the research for this thesis to collect material and evidence that supports the method of inquiry to conduct the empirical testing of the framework.

Prior to introducing the conceptual framework, **Chapter 4:** '***Renewable energy at the international and national levels: institutional and governance differences and similarities in Italy and UK*'** highlights the pressures and influences that have arisen from European and International policy and governance frameworks and the role that they are playing in promoting RE deployment. The chapter discusses the energy systems of Italy and the UK- in relation to RE- providing a brief analysis of how, in both countries, these have undergone major changes in recent years. The focus is on highlighting how pressures for change and key regulatory and support mechanisms have supported RE deployment in each country. The discussion shows that an appreciation of regional specific institutional structures is important.

Chapter 5 '*Developing an analytical framework to study renewable energy deployment at regional level*' proposes a novel way of researching RE deployment - at the regional level - by investigating the evolving relationship between energy and materiality and identifies the material dimensions of RE. The chapter considers, as a starting point, the importance and role of natural resources, investigating their implicit physical, and partially socially produced, nature. It presents a set of arguments that acknowledge the importance and role that materiality plays in analysing the deployment of natural RE resources. The chapter identifies the material dimensions of RE, why they matter, why it is important to give them consideration and unpacks the different ways in which they matter. The chapter provides an analytical framework and highlights key analytical themes that are used in later chapters to help understanding how RE deployment processes are shaped by the material dimensions of RE. From Chapter 6 to Chapter 8, I provide a number of illustrations from the regions under investigation that show how each material dimension can explain differentials in regional RE deployment.

Chapter 6 'Renewable Energy Sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use' highlights, drawing from the empirical evidence from the case study regions, the processes under which natural resources are turned into potential sources of energy at the regional level. It provides examples of how differences can emerge in the way regional actors calculate and construct targets and resource assessments and challenge the current land-based resource use affecting RE deployment and in what ways.

Chapter 7 'Discourses, narratives and visions for renewable energy deployment' provides empirical illustrations of the way in which different regional discourses and narratives for RE abundance and opportunity can provide a compelling narrative – *visions* - to promote RE deployment to protect and exploit regional renewable resources for the benefit of their own territory.

Chapter 8 'Physical characteristics and built infrastructure requirements for renewable energy deployment' focuses on the challenges that turning natural resources into sources of energy generation present for the established distribution and transmission infrastructure network. It shows, with empirical examples, how current and established infrastructure have provided opportunities and barriers to RE deployment and also shows that often regions might have varying levels of the political legitimacy and resources needed to participate in infrastructure renewal.

Chapter 9 '**The value of understanding the material dimensions of RE and their influence in explaining regional spatial variation in RE deployment: Concluding remarks and Issues for further research'** concludes the thesis and summarises the journey undertaken during this research. The chapter reviews explicitly whether the aims and objectives of this research have been realised, highlighting the value of foregrounding the role of the material dimensions of RE and their influence in the study of RE deployment at the regional level. It discusses the value of this approach for understanding and explaining the differences that have occurred in RE deployment in the two countries under investigation. The chapter suggests how the conceptual and analytical approach used in this work can be applied to highlight similarities and differences across a range of places, scales and countries and identifies implications for policy, research limitations and areas of future research.

Chapter 2

Setting the boundaries of the research: a critical literature review

Summary

This chapter has two aims. Firstly, it sets the boundaries and background to the research and secondly, it highlights the shortcomings identified in the two complementary bodies of literature, setting the scene for how the thesis seeks to address these shortcomings. The processes of transformation underway within energy systems- including transitions toward RE- involve a variety of social and political processes and can be studied from different theoretical perspectives. This chapter situates the research conducted, critically and reflexively, within the sustainability transitions and territorial innovation systems literatures. It argues that, to address the research questions, a broadening of the perspective in innovation studies is necessary as energy systems are not only conditioned by individual technological developments- such as the development of RE technologies- but are shaped by a complex interaction of social, economic, technological and political factors that condition their application and diffusion. Nevertheless, although the ST literature is useful in framing energy systems in terms of socio-technical systems, it is increasingly accepted that if such complexity is to be fully understood, then it is vital to understand how 'energy systems are constituted spatially' (Bridge et al. 2013). In addressing this quest for a more spatially sensitive conceptualisation of transition studies, the research looks at the territorial innovation models, and the regional innovation systems approach in particular, to help identify the factors that could explain regional differentiation in renewable energy deployment. This critical literature review also aims at clarifying the extended meaning of 'regional context' that the research intends to adopt.

2.1 Introduction

The development, application and proliferation of RE technologies are seen as part of a shift that is underway in energy systems. As discussed in Chapter 1, in order to understand the prospect of change in energy systems there is a need to apply a systematic approach that looks beyond discrete technological innovations to whole systems change (Smith et al. 2010). Greening energy systems requires the development of a wide range of new technologies- such as RE technologies- alongside the development of new institutions and social practices that can influence their diffusion and incorporate the peculiarities of transformative change. The ST literature offers an important contribution to understand the interdependencies between elements of the system, such as technology, regulation, user practices, markets, cultural meaning, infrastructure, maintenance networks, science, and supply networks that inform their reconfiguration.

The ST literature has widely acknowledged the essential role of innovation as driver of systems change (Elzen et al. 2004; Coenen and Díaz López 2010; Jacobsson and Bergek 2011). This thesis focuses on exploring further the mechanisms that lead to an effective diffusion of RE technologies and to explore their spatial differential (the how and where these technologies might be deployed, cf. Balta-Ozkan et al. (2015)). Hence, the choice here is to situate the work undertaken within the broader analytical perspective of ST as it seeks to understand the transformations that are underway in energy systems, in particular via the deployment of RE technologies, and to pay further attention to the spatial and institutional contexts in which such changes take place. This research is directly aimed at understanding and identifying the factors that could explain regional differentiation in RE deployment and providing empirical evidence about whether and how the region represents an important level from which to understand such energy transitions in the making.

In order to provide the boundaries and background to the work undertaken and to identify the shortcomings this thesis wishes to address, this chapter has been organised as follows. It reviews briefly the main heuristics that have received increasing attention over the past 10–15 years within the ST field. It considers the GOST literature that seeks to bring some ‘territorial sensitivity’ (Coenen et al. 2012) to studies of ST, arguing that to a large extent the GOST literature has lacked appreciation of the regional contexts (for exceptions see for instance Späth and Rohracher (2010); Cooke (2011); Späth and Rohracher (2012); De Laurentis (2013)). The chapter explores the complementarity with the RISs approach (Cooke 2008), investigating how regions have become legitimate agents of economic governance and the increasingly important role played by localised informal institutions. The chapter argues that while both the GOST and RISs literature are useful in understanding RE innovation and transitions, analysing the spatially uneven processes of RE deployment calls for a renewed attention to the potential offered by natural resource endowments. It argues that adding the lens of *materiality* can be valuable in identifying the type of localised resources and institutions that influence RE deployment and explaining the spatially uneven processes of RE deployment.

2.2 Sustainability transitions

Approaches to ST and their management have generated considerable interest in academic and policy circles in recent years as they reflect a response to the complexities and uncertainties that many societies are facing in organising 'sustainably'[5] various aspects of different systems of production and consumption (such as energy, water and transport). In theoretical terms, four frameworks are considered to be central for the analytical framing of ST (Markard et al. 2012). These include: the multi-level perspective on sociotechnical transitions (Rip and Kemp 1998; Geels 2002; Geels and Schot 2010; Smith et al. 2010; Geels 2011a); strategic niche management (Kemp and Rotmans 2005; Smith 2007); technological innovation systems (Hekkert et al. 2007; Bergek et al. 2008) (Jacobsson and Johnson 2000) and transition management (Rotmans et al. 2001; Kern and Smith 2008; Loorbach and Rotmans 2010)[6]. A useful review of the ST approach and literature is offered by Loorbach et al. (2017) and also Köhler et al. (2017).

The multi-level perspective (MLP) uses the three analytical and heuristic levels of landscape, regime and niche to analyse transitions and to help understand the complex dynamics of socio-technical change (see figure 2.1). The main contribution of the multi-level perspective is that transitions are produced by interaction processes that occur between all the three levels. Changes in the regime are triggered either by increasing pressures from the societal context or landscape forces or by upcoming, rivalling socio-technical configurations or niche

[5] Transition research, it is argued, is complementary to sustainability debates both at 'the 'macro'-level (e.g. changing the nature of capitalism or nature-society interactions) and the 'micro'-level (e.g. changing individual choices, attitudes and motivations)' (Köhler et al. 2017: 5).

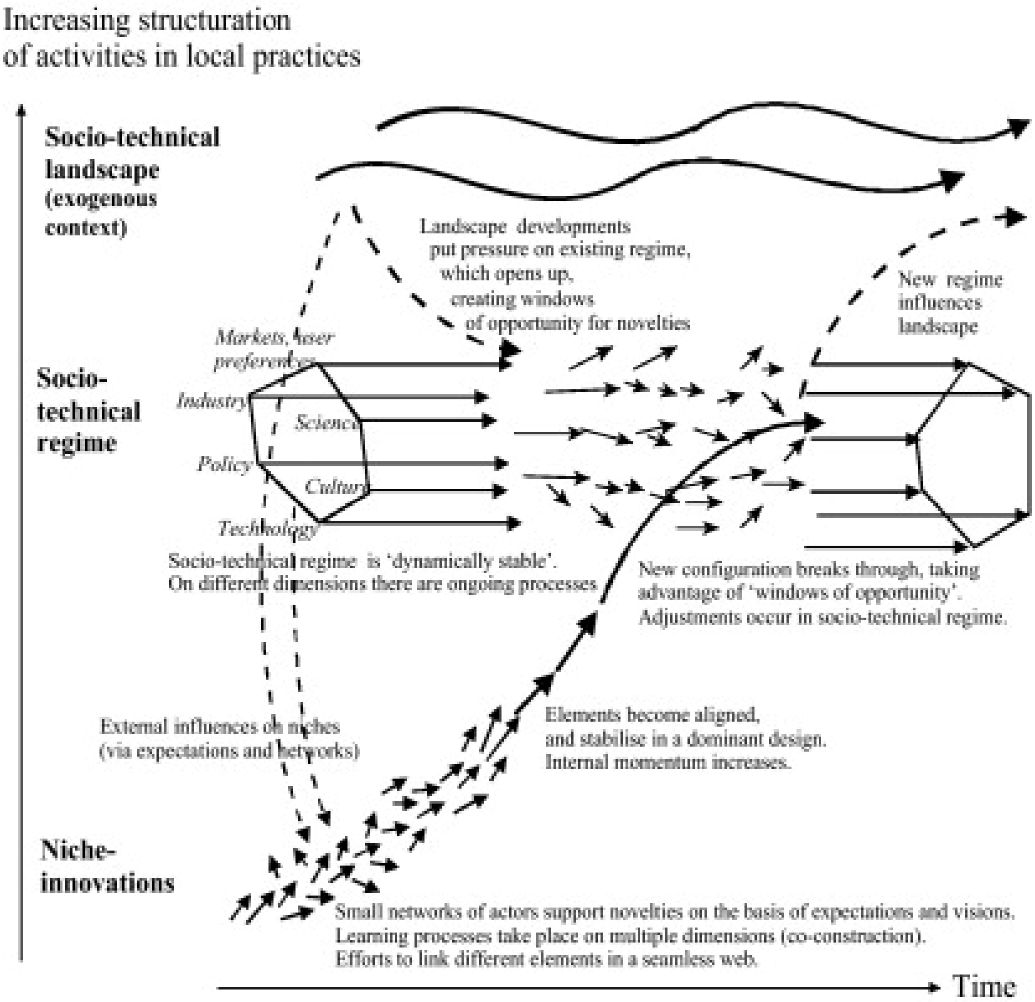
[6] These theoretical approaches have developed specific analytical and empirical preferences establishing themselves as different schools within the broader field of sustainability transitions.

developments. For instance, energy practices and technological innovations such as RE technologies emerge in protected spaces or niches evolving over time, some of which are scaled up and start to compete with the dominant regime (the existing or incumbent technologies and practices), and in the long term, replacing it.

The understanding of niche experimentation and development plays a crucial role in transition research. Borrowing from a combination of two theories of technological change- social constructivism and evolutionary economics- transition studies often utilise the Strategic Niche Management (SNM) approach as a conceptual framework to understand niche innovation dynamics (Verbong et al. 2008). SNM refers to the understanding of the processes of technological (and market) niche creation and development that enable regime-shifts. The SNM literature focuses on niches as a product of agency (Schot and Geels 2007) and argues that nurturing processes operate across the articulation of expectation; social network processes and learning processes (Hoogma et al. 2002; Verbong et al. 2008; Raven et al. 2016; Ruggiero et al. 2018).

A focus on policy is also explicit in the Transitions Management (TM) literature that puts forward the idea of active interventions to steer change. It adopts the concept of a 'transition arena' of interested parties and the use of visions, experiments and reflexive governance to express selective pressures and channel resources to influence ongoing transitions into more sustainable directions (Kemp and Loorbach 2006; Loorbach and Rotmans 2010) (see figure 2.2 for the graphical representation of transition management and its cycle). Debates about transition management give much attention to the potential, and barriers for, RE options, and possible policy measures to stimulate them.

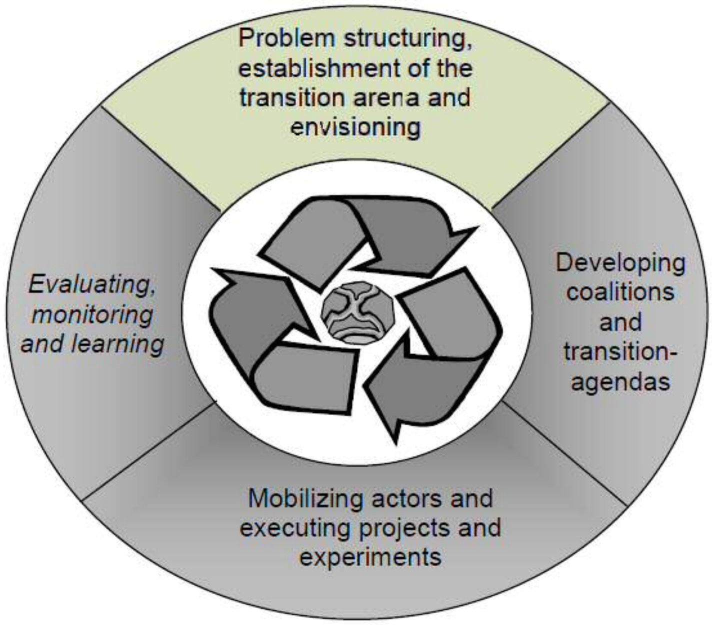
Figure 2.1 The multi-level perspective (MLP): Graphic Representation



Source: Geels (2011a)

Research on technological innovation systems (TIS) has emerged as a major line of inquiry in transition studies. The TIS tradition (Carlsson and Stainkiewicz 1991; Bergek et al. 2008; Markard and Truffer 2008) developed as a framework to analyse the interplay between the structural (actors, networks and institutions) and the functional components of innovation systems (Hekkert et al. 2007; Bergek et al. 2008). The framework has often focussed on the emergence of novel technologies and the institutional and organizational changes that have to go hand in hand with technology development. According to Markard et al. (2012), recent TIS studies have also developed a much stronger focus on specific technologies (see Hekkert et al. (2007)), with greater attention to radical (and often more sustainable) innovations in an early stage of development with a potential to challenge established socio-technical systems.

Figure 2.2 Transition Management and its cycle



Source: Rotmans and Loorbach (2008)

A number of studies have focussed upon the case of RE, such as for instance Jacobsson and Bergek (2011); Jacobsson and Johnson (2000); Negro and Hekkert (2008), paving the way for suggesting technology-specific policies on the bases of TIS analysis (Markard et al. 2012).

The burgeoning and quickly evolving literature on socio-technical transitions, from the MLP, the SNM, TIS and TM have provided researchers with a number of conceptual frameworks and methodological underpinnings that have increasingly been successful in terms of organising analysis and ordering policy interventions. Scholars from different disciplines have raised a debate on the merits and shortcomings of these different approaches. A useful review of these is presented in Markard et al. (2012), Smith et al. (2010), Geels (2011a), Van Den Bergh et al. (2011) and Loorbach et al. (2017). Here, however, it is worth emphasising that one of the merits of these theoretical and analytical approaches[7] is that they have highlighted that both guidance and governance processes have a central role to play in steering and governing socio-technical system change (see also Smith et al. (2005)). It follows that political actors, as well as regulatory and institutional support are expected to play a key role in transitions processes. Therefore, both governance and institutional frameworks play an increasingly important role for the deployment of RE as part of the energy transition (see also Jacobsson and Lauber (2006) and Haas et al. (2004)).

I now turn to a specific criticism raised by earlier scholars of ST, namely the lack of an adequate conceptualisation of space (Coenen et al. 2012) and understanding of the role of place in processes of transition (Hodson and Marvin 2009)[8]. While earlier studies of socio-technical transitions have been criticised for adopting a pervasive 'methodological nationalism' (Späth and Rohracher 2012), a number of contributions have provided theoretical enhancement, empirical evidence and illustrations that a spatial perspective on ST is meaningful. I turn to these contributions in the next section.

2.2.1 The 'geographical turn' in sustainability transitions

In this section, selected theoretical insights from the GOST literature are examined. Recent development in this field shows a significant amount of theoretical and conceptual overlap with the economic geography field. This brief review serves as an entrance point to highlight the contribution that this research seeks to make in addressing deficiencies- vis-à-vis the importance of the regional context- in the current geography of transitions literature.

[7] Some of these criticisms, including those of Smith et al. (2005); Shove and Walker (2007); Meadowcroft (2009), highlighted that the theories SNM, TM and MLP had tended to pay inadequate attention to issues of power and politics and the practical realities of and difficulties of trying to 'manage' transitions. For a review of how recent contributions have sought to address these see Geels (2011a); Köhler et al. (2017); Loorbach et al. (2017).

[8] The spatial concepts of space and place recur often in the economic geography literature. Hansen and Coenen (2015) present the most important conceptualisations of space within this literature, highlighting how different understandings of how space is constructed lead to emphasis on different aspects of places (place specificities).

In response to earlier studies criticised for their 'methodological nationalism' (Späth and Rohracher 2012) an increased interest in, and a research agenda on, the role of geographical thinking and perspectives in ST has emerged, including several empirical studies and two special issues on the topic (European Planning Studies (2012); EIST (2015). Hansen and Coenen (2015) offer a review of the main contributions.

Here, it is important to highlight that the geography of transitions field grew up from a dissatisfaction with how early contributions of ST treated the issue of space and place. These concepts were only indirectly and implicitly addressed within both the dominant MLP and TIS heuristics[9]. Within the MLP framework, for instance, much of the early research on the importance of space consisted of ascertaining the role of the local and global dialectic (Smith and Raven 2012). It is argued that local experimental projects (with new technologies, user preferences, infrastructures, regulations) occur in different localities and when they become supported by global actors/networks they accumulate and transcend the local contexts (sometimes this process is interpreted in terms of local or urban transitions vis-à-vis national transitions; see for instance Geels (2011b)). These references to the 'global' and 'local' processes are, however, considered highly abstract and are used in a spatially de-contextualised sense (Truffer and Coenen 2012). While Hodson and Marvin (2009) emphasise that the importance of geography is often confined to 'some sort of bounded experimental local context' at a niche level, Bridge et al. (2013) argue that concepts such as the local-global dialectic and landscapes are often mistaken for having a quite specific geographical meaning. A recent response to these criticisms, provided by Sengers and Raven (2015) highlights the complexity of networks in niche development, arguing that global networks become entangled with place-specific power relationships, institutions and infrastructure.

Initial contributions to the geographies of transitions explored the role of cities (Hodson and Marvin 2010; Bulkeley et al. 2011), regions (Cooke 2010; Späth and Rohracher 2010, 2012; De Laurentis 2013) and power relations and social processes in regime and niche dynamics (Lawhon and Murphy 2012; Murphy 2015). Yet, it is since the contributions of scholars such as Markard and Truffer (2008); Truffer (2008); Coenen and Díaz López (2010); Truffer and

[9] The role of TM has also been observed at city (see for instance Bulkeley et al. (2011)) and regional (De Laurentis et al. 2016) levels. Similarly, Coenen et al. (2010) looked at how the approach of Strategic Niche Management relates to proximity advantages in innovation processes.

Coenen (2012) and Raven et al. (2012) that a new research agenda for the geography of transitions has been set. This agenda encompasses many fields and a number of methodological approaches (Hansen and Coenen 2015) and according to Truffer et al. (2015) gravitates around three main building blocks: socio-spatial embedding, multi-scalarity and issues of power.

Responding to the call from Coenen et al. (2012: 976) that 'transition research would do well to take a closer look at the global networks and local clusters of transition processes in conceptual, methodological and empirical terms', both the socio-spatial embedding of transitions processes and the issue of multi-scalarity have predominantly been investigated. In particular, this research focussed on exploring the complementarities between different innovation system approaches and contributions from economic geography.

How the complementarities between different innovation system approaches and the contribution from economic geography are fruitful in understating the spatiality of transitions is better understood through looking at work that has emerged from the TIS tradition (Carlsson and Stainkiewicz 1991; Bergek et al. 2008; Markard and Truffer 2008). The work of several scholars (Binz and Truffer 2011; Binz et al. 2012; Dewald and Truffer 2012; Binz et al. 2014; Dewald and Fromhold-Eisebith 2015; Wieczorek et al. 2015a; Wieczorek et al. 2015b) has contributed, both theoretically and empirically, to the understanding of the role of geography in TIS. In particular, this work highlighted four issues:

i) the coupling between the national and international levels of the innovation process. It argues that a multi-scalar TIS incorporates both localised and internationalised structures as the international and multi-scalar networks of actors, localised clusters and institutions enable and coordinate the creation, utilisation and diffusion of a new technology. Transnational linkages, therefore, often complement local, regional and national capabilities enabling sustainability experiments;
ii) how national and international linkages not only depend on the technology in focus, but will vary according to the three layers of networks (science and technology systems, companies and markets and institutional contexts) within a TIS;
iii) the relative importance and relevance of different scales and actor constellations not only varies in sector or technologic specific way but also shifts in time throughout the

innovation process (for example with the 'maturing' innovation system, see for instance the case of photovoltaics in Germany in Dewald and Fromhold-Eisebith (2015) and

iv) TIS actors have to rely on critical resources that are often co-located in specific spatial contexts (at an early phase of a TIS's development, for instance, important system functions such as market formation depend on locally bounded conditions, such as recurrent face-to-face interactions and the availability of locally specific institutional structures (Dewald and Truffer 2012).

Moreover, as argued by Hansen and Coenen (2015), a number of contributions to the GOST literature follow the emphasis found in the institutional economic geography field on the central roles of institutional variations as foundations for geographical differences in economic activity and performance. These contributions highlight the main components of a 'place's institutional environment' (Hansen and Coenen 2015: 95). These refer to the role of governmental policies at local and regional levels and informal localised institutions, understood as territorially bound norms, values and practices, that are equally important for ST. Research on the former focussed on the role of urban and regional sustainability policies as well as urban and regional visions for sustainability (see for instance Hodson and Marvin (2009) and Späth and Rohracher (2010)). Hansen and Coenen (2015) argue, however that what is lacking in these contributions is an appreciation of locally specific institutional structures (understood as territorially bound norms, values and practices) and the way in which informal institutions condition the potential for different socio-technical configurations.

This review, although necessarily selective in nature, has revealed that there are already meaningful contributions that acknowledge i) the importance of network relationships and the issue of spatial connectivity among actors and networks and ii) the relevance of locally specific institutional conditions. I discuss this in further detail in the next section.

2.2.3 Sustainability transitions and the geography of sustainability transitions: their relevance to this work

The review conducted so far has suggested a set of issues that are relevant for, and support the focus of this thesis. Firstly, understanding the prospect of change in socio-technical systems, such as that of energy, requires a systematic approach that looks beyond discrete technological innovations to whole systems change. Transitions scholars emphasise that transitions are closely connected to fundamental processes of institutional change and stress the role played by the institutional frameworks influenced by policy makers (such as regulatory and institutional support) and the broader governance processes that steer and govern socio-technical system change. For this purpose, the transitions literature offers a useful inspiration for the research conducted here. Processes of change in the energy system involve not only the development of a wide range of new technologies- such as renewables- but also the development of new (and the adjustment of current) institutions and social practices that can influence their diffusion. Addressing the ultimate aim of this research which is to provide insights that can help explain the spatially uneven processes of RE deployment, calls for a focussed attention and analysis of the institutional and regulatory conditions that support RE deployment (such as for instance financial incentives, standards and legislative target setting).

Secondly, adopting a stronger geographical perspective to the study of energy transitions is useful in understanding these processes of change. As argued, the cross-fertilisation of ST research and economic geography builds primarily upon contributions that draw together territorial and relational approaches in analysing economic flows (Jonas 2012; Bridge et al. 2013; Harrison 2013; Hansen and Coenen 2015). The former stresses the positive effect of geographical spatial proximity in stimulating network formation and the latter draws heavily on relational geography and the view that spatial scale is a fluid, relative and socially constructed concept (Bunnell and Coe 2001). Relational approaches, in particular, emphasise how processes of change are intertwined across a range of scales and spheres of governance that call for a better understanding of the role of actors, institutions and networks as they operate simultaneously across multiple scales. Inversely, territorial approaches have so far focussed on new industry creation and cluster formation, investigating the way in which they are facilitated by localised knowledge spillovers and specialised labour markets.

Both of these complementary approaches identify a crucial aspect of the geography of ST, namely the important role of the national and international institutional frameworks and their interaction with regional and local institutions and organisational networks. The work conducted here therefore shares with these approaches the appreciation for institutional embeddedness and spatial scale. However, as Hansen and Coenen (2015) argue, these two approaches often consider localised institutions, especially the informal ones[10], as a residual category for a largely heterogeneous set of social and cultural conditions that enable and constrain change. While some exceptions are represented by the work of Wirth et al. (2013); Wirth (2014) and Späth and Rohracher (2010), more needs to be done to investigate the effects of informal institutions and how they interact with formal institutions.

The role of regions has received relatively little attention in the GOST literature (for a review on ST in regional studies see Truffer and Coenen (2012). Equally, the regional studies literature has often focused on analysis of locational dynamics in mature sectors as well as high tech and biosciences industries and it is considered not sensitive enough to analyse the breath of transformation processes implied by ST (Truffer and Coenen 2012). An exception is represented by a specific focus on the region and RE by Cooke (2010, 2012); De Laurentis (2013); Gress (2015); Mattes et al. (2015). I suggest that the region can constitute a critical level from which to understand processes of change within the energy system (in particular the deployment of RE) as they occur at, and across, various spatial scales.

The next section focuses on the regional innovation systems framework, as this can provide useful insights for understanding the relationship between institutions, technology and the regional level. This, I argue, can be helpful and provide useful insights to answer the question that this research poses to understand and to identify *the factors that could explain regional differentiation in RE deployment and provide empirical evidence about whether, and how, the region represents an important level from which to understand such energy transitions in the making.*

[10] This for instance have been identified by Wirth (2014) as the locally shared frame of references to which local actors refer to and the identity and values that span from historical experience, that can form the basis for social identification.

It is worth emphasising that economic geographers have increasingly paid attention to the interdependencies among institutional configurations at different spatial scale (see for instance Gertler (2010) and Martin (1994)). Following these contributions, it can be argued that regional-specific institutions result from processes that take place at, and across, various scales, becoming entwined beyond any given jurisdictional territory (Goodwin 2013). Focussing on regional institutions, and institutional embedding, can therefore offer valuable insights into the way in which such institutional configurations interact with institutions at different spatial scales.

2.3 The Regional Innovation Systems approach: unpacking regional and local institutional dynamics

The analysis of institutional infrastructures in the TIS approach, as well as the alignment of institutions in regimes and niches, have contributed substantially to our understanding of how institutions enable and constrain the development, diffusion and embedding of technology in a systematic way Coenen et al. (2012). Adding a spatial sensitivity helps, therefore, to unpack the spatially bounded ways in which institutions operate, the spatial ranges over which relevant institutions work and how institutions enable and constrain innovation and new technology diffusions, such as RE, in spatially differentiated ways (Coenen et al. 2012).

In particular, the literature on innovation systems have enhanced and explained how different territorial institutional environments favour certain type of activities and technological development paths over others. Much innovation systems research has been elaborated based on the territorial boundaries[11] of the global space (Carlsson and Stainkiewicz 1991; Cantwell 1997; Bunnell and Coe 2001; Narula and Zanfei 2005; Carlsson 2006); the nation[12] (Freeman 1987; Lundvall 1992; Nelson 1993; Edquist 1997, 2005); and the region (Cooke 1992; Braczyk et al. 1998; Asheim et al. 2003; Asheim and Coenen 2004). The relationship between all the different innovation systems is represented in figure 2.3. Nonetheless, it is

[11] A variation is also represented by the sectoral innovation system approach, which adopts a sectoral focus.

[12] These are often seen as variants of a single 'generic' system of innovation approach. These different variants co-exist and complement each other (Edquist 2005); often the regional and sectoral variants of the generic SI approach complement each other and are, often, considered as parts of national ones.

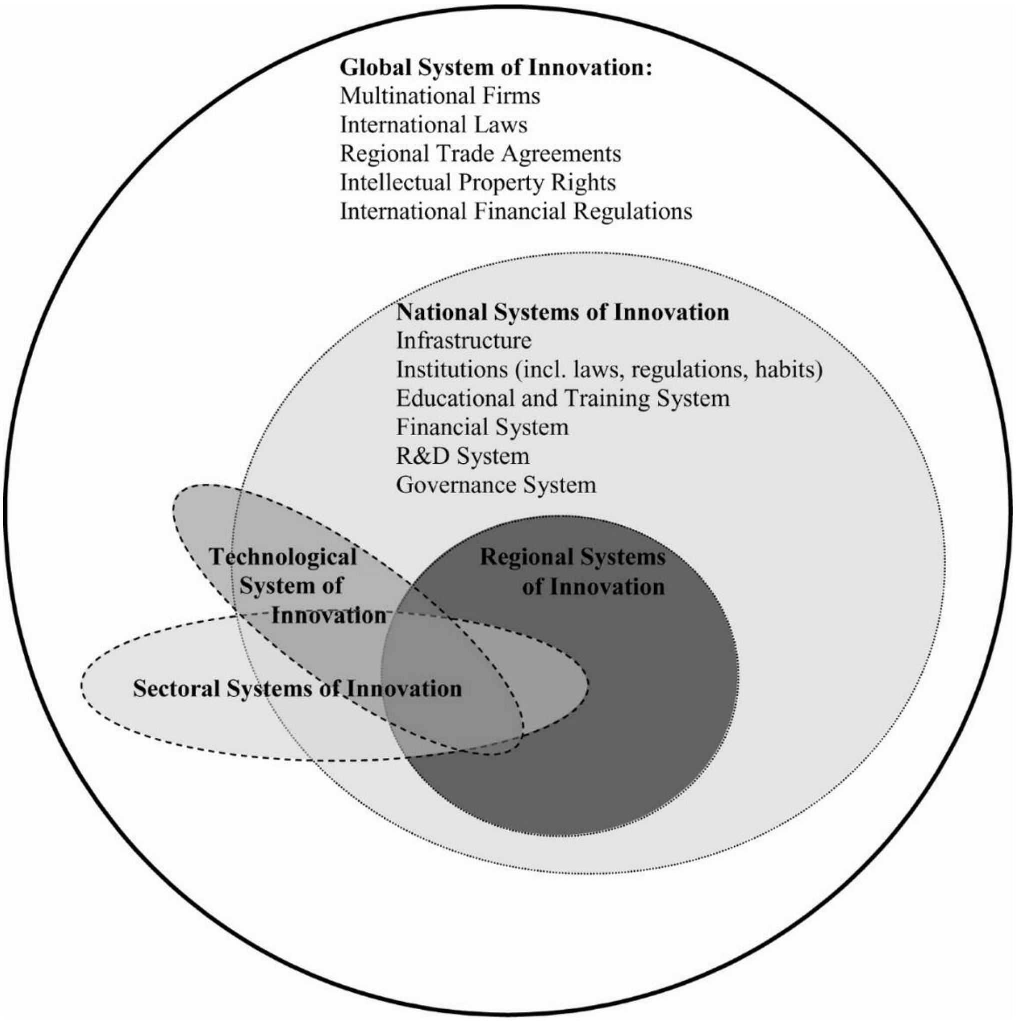
the conceptual underpinning of the regional innovation systems (RISs) approach that has perhaps been more pronounced in identifying distinct local institutional environments conducive to innovation. This section will briefly review the approach and its rationale, while next section will unpack the role that the RISs approach can play for this research and its shortcomings.

The concept of RISs first appeared in the early 1990s and emphasises that place and territory-specific features play an important role in nurturing and enhancing innovation. Asheim and Gertler (2005: 299) refer to a RIS as 'the institutional infrastructure supporting innovation within the production structure of a region'. Similarly, Cooke and Schienstock (2000: 273-274) define a RIS as a 'geographically defined, administratively supported arrangement of innovative network and institutions that interact regularly and strongly to enhance the innovative outputs of firms in the region'. A regional innovation system therefore 'comprises a set of institutions, both public and private, which produces pervasive and systemic effects that encourage firms within the region to adopt common norms, expectations, values, attitudes and practices, where a culture of innovation is enforced and a learning process is enhanced' (De Laurentis 2006: 1060) (a schematic representation is given in figure 2.4).

The increasing importance of the RIS overlaps with the success of regional agglomerations such as that of clusters, industrial districts and innovative *milieu* in the post-fordist era (Piore and Sabel 1984; Porter 1990; Maillat 1998; Porter 1998; Asheim and Cooke 1999; Asheim 2000; Crevoisier 2004). It also includes a revival, in the social sciences, in an interest in the region as a learning site of economic interaction and innovation (Morgan 1997)[13]. The elaboration of the concept within the economic geography field has represented an attempt to understand better the central role of institutions and organisations in promoting innovation-based regional growth (Asheim et al. 2003; Gertler and Wolfe 2004; Asheim and Gertler 2005).

[13] Distinctions and similarities among RISs and these other approaches are highlighted in Asheim et al. (2011c).

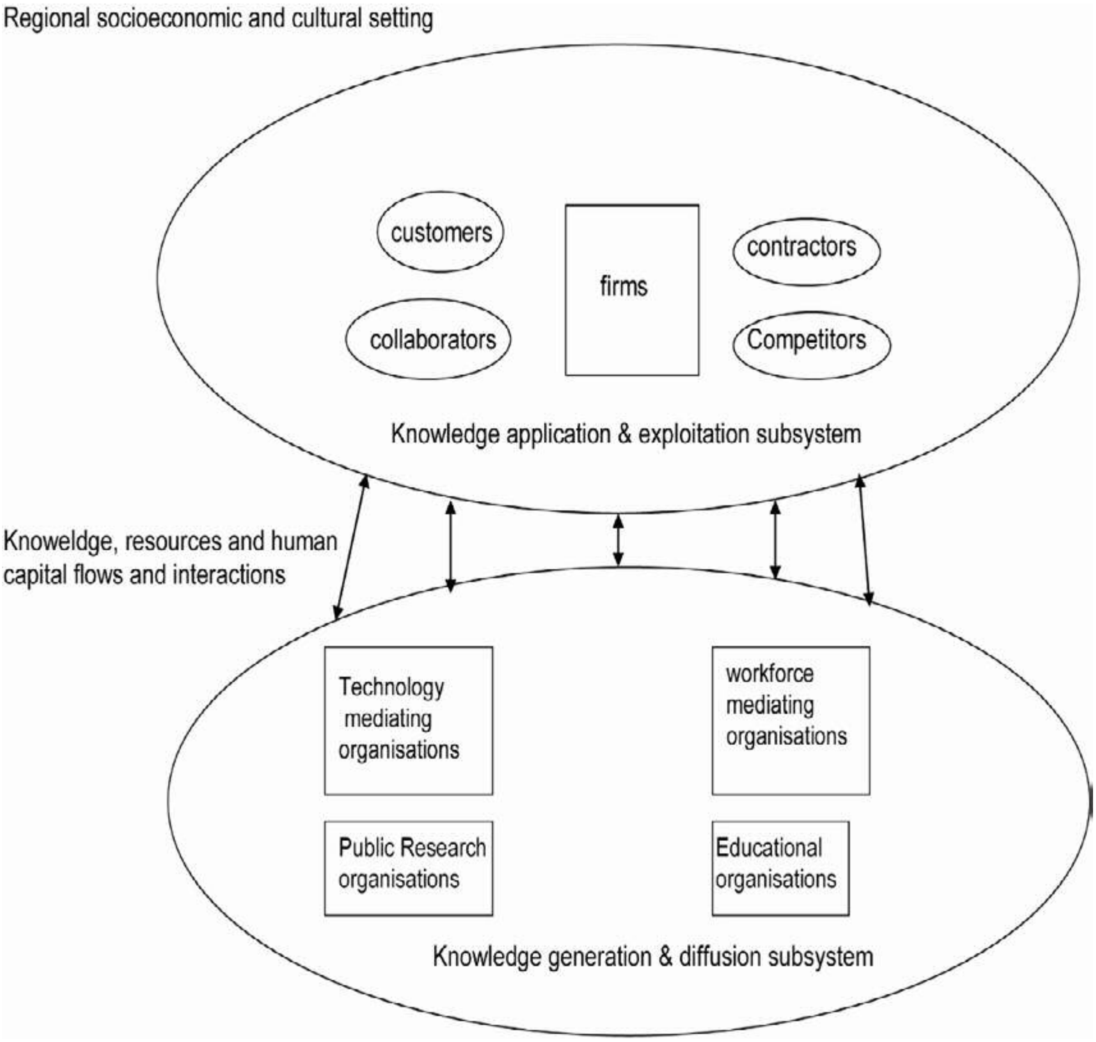
Figure 2.3 Relationship between global, national, regional, sectoral and technological systems of innovation



Source: Frenz and Oughton (2005) cited in Asheim et al. (2011c)

Regional innovation systems scholars argue that technological trajectories are based on 'sticky' knowledge and localised learning processes that are bounded within the region. The regional spatial level therefore becomes, increasingly, the level at which innovation is produced through regional networks of innovators, local clusters and the cross fertilising effects of research institutions (Cooke 1992; Braczyk et al. 1998; Asheim et al. 2003; Asheim and Coenen 2004; Benneworth et al. 2017; Coenen et al. 2017).

Figure 2.4 Regional Innovation System: a schematic illustration



Source: De Laurentis (2006)

This '*institutional thickness'* (Amin and Thrift 1995)[14], it is argued, of regional institutional and organisational infrastructure, within a particular region, can explain different innovation paths and the reasons why some regions lead and some lag behind in terms of innovative performance. Institutional thickness also refers to the comparative performance of regional

[14] The concept, according to Zukauskaite et al. (2017), directs attention to a set of place-specific factors (that is, institutional presence; interaction patterns; structure of domination and/or patterns of coalition-building; and a mutual awareness of being involved in a common enterprise). Yet, they also point out that, often, empirical applications collate institutions among a wider conceptualisation of organisations.

governments and governance bodies in terms of their ability to work together locally, and persuade or compel sufficient external agents to support their activities[15].

For the purposes of this thesis, it is worth emphasising that the RISs approach, as argued in chapter 1, shares with the ST approaches the increasing emphasis on governance, the role of political actors in steering and governing change, and the regulatory and institutional support. Moreover, with its focus on the regional level, agreeing with Coenen et al. (2012) and Truffer et al. (2015), the concept is useful in explaining how regions can mobilise resources to influence economic change, including transitions, and be more or less amenable to the promotion of ST. The relevance of the approach to this thesis resides in the following set of issues: i) the success of the RIS approach as an analytical frame to inform innovation policy making at the regional level and ii) the role of culture and informal institutions. I analyse these in turn in the next section. Before turning to these issues, it is important to highlight here that the arguments that are presented next take into account only selected aspect of the RISs approach. This selection is driven by the rationale of the work undertaken here and, specifically, by the focussed attention on RE deployment rather than technological development. It is for this reason that other aspects of the RIS approach, such as learning dynamics, labour mobility, cooperative and interactive dynamics and the importance of distinctiveness of the knowledge base of various industries are not considered in this literature review.

[15] Earlier accounts of regional innovation systems have been criticised for their exclusive attention to the regional scale, at the expenses of other spatial scales. The literature on economic agglomeration and clustering processes, for example, offers important insights into the role of global-local networks and institutions that cut across and link different geographical scales (Maillat 1998; Scott 1998; Bathelt et al. 2004). Both Oinas (1999) and Bathelt et al. (2004) argue that the creation of new knowledge is best viewed as a result of a 'combination' of close and distant interactions. Bathelt et al. (2004) refer to these external linkages as the 'global pipeline', whereas 'local buzz' implies knowledge generated and shared locally. Whilst economic success often then has local roots, it also crucially depends on combining local and trans-local or global linkages (Bathelt et al. 2004; Asheim and Gertler 2005; Bathelt and Glückler 2011). This relational approach also has much in common with the heuristic framework of global production networks (GPN). In which, it is argued, the geographical complexity of the global economy is better understood using the concept of a network (Bunnell and Coe 2001; Coe et al. 2008).

2.3.1 The regional innovation system approach: its relevance to this work

2.3.1.1 Regional policy relevance

Asheim and Gertler (2005: 311) argue that 'the basic rationale of the RIS approach is that the systemic promotion of localised learning processes can improve the innovativeness and competitive advantage of regional economies', bringing a policy focus to the RISs literature. The concept, despite its limits, criticisms and ambiguities[16], has become particularly influential in economic policy discourses and has gained prominence, largely, within the European Union regional policy agenda (Asheim et al. 2011c; Lagendijk 2011; Coenen et al. 2017). In the past, regional policies, based on the regional innovation system approach, were shaped by 'best practice models' of interactive innovation derived from empirical analysis of high-tech areas and well performing regions (see for instance Tödtling and Trippl (2005)). This translated into a tendency to draw policy advice from a generalisation of a limited number of successful cases, neglecting the diversity and context specificity of regions. The analysis of the main innovation barriers in different types of 'problem regions' has clearly shown, however, that there is no single 'best practice' innovation policy approach applicable everywhere (Tödtling and Trippl 2005), highlighting the need for 'tailor-made' regional innovation policy interventions that address the specific challenges, problems and opportunities found in each type of region.

Attention has therefore shifted to the way policy initiatives need to pay closer attention to sector and territory specificity in order to *construct regional advantage* (Asheim et al. 2011a; Asheim et al. 2011b). This implies that effective policy making requires localised action attuned to the specific needs and available resources of regions (Boschma 2014). As a result, it could be argued, regional innovation policy approaches based on the RISs approach have evolved by capitalizing on region-specific assets, rather than selecting from a portfolio of policy recipes that owed their success to different environments. In particular, scholars refer to the opportunities offered by 'related variety' and the opportunities offered by the local

[16] The RIS approach derives from a mix of theoretical approaches and its critics argue that is characterised by a number of conceptual ambiguities. These refers to: the identification of key system components, their causal relationships and the measurement of systems performance as well as the definition of system boundaries (including the definition of region). See for reviews Doloreux and Parto (2005); Uyarra (2010); and Asheim et al. (2011c).

presence of a wide range of technologically related industries that provide opportunities and growth potential for existing industries as well as local sources of growth for new industries (Frenken et al. 2007; Boschma and Iammarino 2009; Asheim et al. 2011a; Boschma 2014)[17].

In the context of understanding RE innovation processes, this is particularly relevant. For instance Cooke (2010, 2012); Fornahl et al. (2012); Klitkou and Coenen (2013) show the extent to which the issue of related variety is important for the emergence of RE clusters within regions and for policies that aim at stimulating industrial development of clean tech industries. Emerging industries often arise out of a process of recombination, renewal and knowledge spillovers facilitated by a combination of complementary industries within a region (Klitkou and Coenen 2013). The attention to regional policy within the RISs approach is therefore useful. In other words, it stresses how public policy, at the regional level, may affect the processes through which existing local economic and technological structures, knowledge and competences can be mobilized by regional governance actors to renew the economic structure and promote new development paths in RE (cf. Dawley et al. (2015) and Cooke (2012)). Notwithstanding this, research also points to the fact that market development and user-producer interactions are also important drivers for the development of the RE industry (Dewald and Truffer 2012) and the hampering effect that its absence can have (De Laurentis 2012; Klitkou and Coenen 2013)).

This also brings to the fore the fact that although regional-level policies and strategies can enhance a region's innovation system, attention should also be paid to whether sufficient and appropriate levers are available at the regional level to do so (Uyarra and Flanagan 2010). In other words, regional patterns of innovation are likely to be influenced by policies formulated at, and/or coordinated with, other levels and other policy domains. As Fritsch and Stephan (2005) and Uyarra and Flanagan (2010) note, the active role of regions in innovation policy is a question of 'degree and mode'. Different policy elements such as policy objectives, design, implementation and funding are articulated across various spatial scales (e.g. region specific objectives vs. national wide; design and implementation differentiated by region vs. identical

[17] The promotion of industrial renewal processes at the regional level is also one of the core aims of smart specialisation strategies, labelled by Morgan (2015); (2016) as the new generation of regional innovation policy in the EU. Differences and similarities between constructed regional advantage and smart specialisation policies are analysed in Boschma (2014).

in all regions). Moreover, the popularity of the RIS approach in policy-making has helped, to some extent, to provide a way of constituting regions as legitimate agents of economic governance (Bristow 2005), putting the region as an emerging political-economic unit, with increasing autonomy of action both at national and international levels.

However, scholars have criticised the narrow focus of the discourse of competitiveness and economic metrics vis-à-vis regional productivity performance (Smith et al. 2003; Morgan 2004; Bristow 2005, 2010), pointing to the ecological imperative of promoting more sustainable forms of economic growth and development (see for instance Healy and Morgan (2012). Similarly, the pressures associated with tackling climate change and reducing carbon emissions, as discussed in chapter 1, have given rise to a rescaling of environmental governance in which the state has explicitly devolved and redistributed environmental responsibilities downwards to cities and regions (Gibbs and Jonas 2000; Bulkeley 2005; While et al. 2010). It follows that the regional level is of growing significance. Although not always so much in terms of redistributed formal powers, but more that the regional level represents '*a key*' governance scale where environmental responsibilities, and a wide array of policies aimed at combining ecological goals with economic competitiveness, are, or could be developed, implemented and realised (Gibbs and Jonas 2000; Morgan 2004; While et al. 2010; Galarraga et al. 2011).

This discussion provides useful insights for the research in this thesis. Firstly, it points towards the purposeful action of policy actors, at the level of the region, in influencing institutional conditions via processes of regional policy-making. Secondly, agreeing with Cooke et al. (2000), policy competences and institutions are only partly bound to regional territories. In terms of RE deployment, for instance, some regions can control economic framework conditions that can stimulate markets (e.g. subsidies and feed in tariffs), that are often set at the national level, while others cannot. Some regions can organise policy implementation, design and procurement initiatives to promote the region as a test bed for RE experimentation that differ from other regions. These have important implications for studying the uneven processes of energy transitions, specifically the deployment of RE technologies.

2.3.1.2 The importance of informal institutions: culture of cooperation

The literature on RISs suggests that a region's innovation potential is partly a function of its institutions. Empirical applications of the innovation systems literature have often focused on institutions as organizations (research organizations, governments, banks, venture capital, training organizations, etc.) rather than more broadly on the institutional environment (the legal system, norms, etc.) (Farole et al. 2011; Zukauskaite et al. 2017). Nevertheless, one of the key contributions from this approach is that it does emphasise the role of informal institutions such as social and cultural factors, often labelled as 'a culture of cooperation' (Cooke et al. 1998). Within the RISs literature, norms and values, in the form of social capital (Putnam et al. 1993; Putnam 2004), it is argued, allow for cooperative practices to emerge and take place, facilitating the dialogue among key actors in order to mobilise and integrate them into development processes[18]. Such a culture of cooperation can promote or constrain interaction among different social actors and is perceived to be highly influential for the way actors perform, shaping trust, commitment, and mutual understanding. As the interactions between actors and the set of relational linkages is at the core of the RIS concept (Asheim et al. 2011c), informal institutions, among which is the culture of cooperation, can smooth the processes of knowledge transfer and facilitate innovation processes, by lowering uncertainty and information costs.

This is relevant here as a renewed attention to local informal institutions can help explain that while some institutions might share common features across territories, they also adopt a place distinctiveness influenced by culture, history, religion and identity that can affect the potential of any territory to develop economic activity (Rodríguez-Pose 2013; Tomaney 2014; Pike et al. 2017). Moreover, as argued by Morgan (1997), place-based habits and routines generate an institutional capacity which determines the degree of ability to learn and adapt to changes. This implies that local informal institutions can affect RE deployment and diffusion in different ways across different regions. However, a key question remains as to how the relevant institutions can be identified and the relationships and interactions that exist between institutions at different spatial levels that can affect RE deployment.

[18] Here, I refer in particular to the link between social capital and innovation in the sense that, according to (Putnam et al. 1993: 169) 'trust lubricates cooperation'.

2.4 The missing element: understanding the role of natural resource endowments

As highlighted, analysing the complementarities between the GOST literature and the RISs can be valuable for understanding processes of RE deployment. In this thesis, however, I argue that there is a need to define the regional context more broadly. The regional context needs to be understood, as argued in chapter 1, in terms of i) the wider institutional, economic and governance dimensions that may influence processes of RE deployment and ii) the natural (and built) environment and resource occurrence of energy (and RE in particular). Here the argument is that considering the regional context in this way can help identify the role played by resource endowments and how they can support or hinder RE deployment, at the regional level. I contend that in order to understand processes of RE deployment, and their spatial unevenness, there is a need to develop an analytical framework that places more focus on the type of localised institutions (the territorially bound values, norms and practices- formal and informal) that might influence RE deployment and that foregrounds the role played by resource endowments, at the regional level.

The next section briefly reviews how resource endowments have been considered in the innovation systems and transitions literature. I then suggest that this shortcoming can be addressed by adding the conceptual lens of *materiality* and looking at the material dimensions of RE.

2.4.1 Natural resource endowment in innovation systems and transitions literatures

Resource endowments are often analysed in terms of the opportunity to provide comparative advantages for specific places. Relatively few contributions have dealt explicitly with the importance of natural resource endowments (Hansen and Coenen 2015) for ST. Although it is argued that more could be done in taking local natural resource endowments into account in transition strategies (Trutnevyte et al. 2012), some empirical contributions point towards the positive influence that natural resources have played in RE innovation processes. Examples of these include, for instance, how the success of Brazil’s ethanol production depended, to some extent, on climate and soil conditions that allowed sugarcane production to thrive in the São Paulo and adjacent areas (which account for 85% of sugarcane cultivated in Brazil- see Goldemberg (2007); Solomon and Krishna (2011)). The influence of natural resources is further stressed by Carvalho et al. (2012) in their discussion of biodiesel and regional production of soya crops in Curtiba (Brazil) and also by Späth and Rohracher (2010; 2012) in their account of sustainability transition in the Murau region and the role played by woody biomass. Also, a recent study by Murphy and Smith (2013) analysed wind energy projects on the Scottish island of Lewis. This study explored the implications of land ownership and tenure on untapped renewable resources in the Highlands and Islands of Scotland. The authors also raise the issue, and importance, of transmission infrastructure in RE, as natural resources are often concentrated in peripheral regions where the lack of infrastructure becomes a significant barrier. Moreover, the growing appreciation of the scale of offshore wind (Jay 2011), and marine and tidal energy sources available to the UK (ABPmer 2008), suggests that they are rapidly becoming recognised as valuable assets. In particular ABPmer (2008) and Jay (2011) stress that the availability of relatively shallow windy waters, wave and tidal currents with centres of high demand close to the coast might facilitate the appropriability of these resources. In addition, Essletzbichler (2012) also points to the effect of resource scarcity within traditional fossil-fuel resources in the Navarra region of Spain that helped in stimulating investment in ST.

To summarise (see also Hansen and Coenen (2015)), these contributions have focussed on the following roles played by natural resource endowments: i) how they might act as locational advantages for clean-tech cluster formation; ii) how can they influence choices between renewable technologies and iii) how resource scarcity might stimulate investments in RE development and diffusion. Hansen and Coenen (2015) also stress that even though these endowments might offer comparative advantage for specific places, they do not guarantee sustained competitive advantage unless localised value creation processes are in place. However, I suggest that despite these meaningful contributions, there is a lack of a framework for analysing resource endowments and how they support or hinder ST, in particular RE deployment.

2.4.2 The material dimensions of renewable energy: introducing the concept

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 methods of appraisal (Zimmerer 2013). RE resources present regional variations. 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 but also differences in climate), techno-economic (scale, labour cost), institutional (policy regime, legislation) factors (de Vries et al. 2007) and infrastructure endowments.

I adopt here the concept of *materiality*[19] and use it to explain how natural resources are both naturally endowed (as they 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)[20]. In this sense, '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

[19] As the concept of materiality is used here in this thesis is identified in chapter 1 (see Box 1.3). Materiality features often in the geography literature, encompassing a heterogeneity of work that goes under the broader name of 'material geographies'. This work is aimed at challenging the use of the term matter to refer exclusively to the physicality of actual object (Anderson and Tolia-Kelly 2004). Anderson and Wylie (2009) identify three clusters of research that represent a material turn- or return- to geography. These are the material-cultures literature; the materialities of nature, science and technology forms and a strand that looks at materiality around the spatialities of the lived body, practice, touch, emotion, and affect. For reasons of space and focus, I do not explore these debates here. Therefore this discussion acknowledges these contributions but focuses on a much narrower literature that helps to highlights the peculiarity of what has been referred to as a socio-material assemblage called 'natural resources' (Whatmore 2006) as highlighted in the text.

[20] This brings to the fore principles of actor-network theory, such as the role of both human and non-human elements and processes of translations and negotiations (Callon and Latour (1981), Murdoch (1998, 2001)).

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 argument here is that resources are far more than physical and economic, but rather have irreducibly social and cultural roots (Bakker and Bridge 2006). Consequently, 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 RE resources come to be fashioned in some areas and not in others. Moreover, it can help explain how the social, material and environmental dimensions of such resources come to be understood and contested, favouring or hampering particular RE deployment paths. This is in contrast to much of the literature on RE innovation and systems innovation, as discussed above. The intention 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[21]) nor to delve into the problematics that surround issues of matter and materiality (Kearnes 2003; Whatmore 2006; Anderson and Wylie 2009). Nevertheless, I argue that understating natural resources as socio-material assemblages that can be both materially manipulated and socially constructed is valuable in understanding RE diffusion and deployment and is, as yet, under-researched (for an exception see Armstrong and Bulkeley (2014); Nadaï and Labussière (2012)).

The deployment of RE, the process of turning renewable 'natural resources' into productive use as viable forms of energy through stages of energy conversion, storage, transmission and distribution through pipes, wires or other form of transport, has material aspects like those involved in the deployment of fossil fuels. As argued in chapter 1, fossil fuels presents much broader material aspects than most forms of RE. However, the consideration of some of the material dimensions addressed by Bakker and Bridge (2006), Bridge (2004); Kaup (2008); Bridge (2009); Kaup (2014) and others, and originally applied in the geographic resource extraction and fossil fuels literature, can help identify and focus on those material dimensions

[21] The natural environment has historically often been seen as a source of regional comparative advantage. Within the human geography literature, resource extraction (mining, oil and gas, etc.) is underpinned by the classical theory of comparative advantage in international trade as an agent of regional development (Watkins 1963; Gunton 2003). However, empirical evidence of natural resource-based development has led to considerable controversy (see for instance Bridge (2008) for a review of the two schools of thoughts that have emerged within the field). Also earlier work by Richard Auty (e.g. Auty 2000; Auty 2001).

that particularly influence RE deployment. As I have suggested in chapter 1, these material dimensions not only can directly influence RE deployment potential but also interact with how these physical entities are socially constructed as exploitable energy resources through political-economic and cultural processes (cf. Calvert 2015; Gailing and Moss 2016; Bridge 2018). The argument developed in this thesis therefore aims at investigating how these material dimensions can, and do, influence the geographical deployment and dispersion of RE, while focussing on the regional level. I will return to this in chapter 5 which presents some of the material dimensions that derive from the resource extraction and fossil fuels geography literature and highlights the material dimensions of RE, how they matter, why it is important to give them consideration and to unpack the different ways in which they matter.

2.5 Concluding remarks

This chapter has aimed to provide the boundaries and background to the work undertaken and highlighted the shortcomings identified in the complementary bodies of literature on ST and innovation systems that this thesis aims to address. The research sits within the ST field and seeks to contribute to the emerging GOST literature that aims to bring a spatial sensitivity to the study of transitions in the energy system, including the move towards energy systems that incorporate a far greater share of RE technologies. The chapter argues that despite these meaningful contributions, the GOST literature has lacked sufficient appreciation of the regional context. The chapter has explored the complementarity with the RISs approach and highlighted how regions have become legitimate agents of economic governance. The RIS literature is also useful in further highlighting the importance of localised informal institutions. Nonetheless, the chapter argues that while both the GOST and RISs literatures are useful in understanding RE innovation and transitions, analysing the spatially uneven processes of RE deployment calls for a renewed attention to the potential offered by natural resource endowments. Analysing the material dimensions of RE and addressing the questions of how they matters, why it is important to give them consideration and to unpack the different ways in which they matter, can provide additional insights on how and why RE deployment realises, or fails, to realise its potential. This, I argue, can be valuable in identifying the type of localised institutions that influence RE deployment and helps to explain the spatially uneven processes of RE deployment.

Chapter 5 presents an analytical and conceptual framework that builds from the insights and complementarities from the literatures presented here but that foregrounds the material dimensions of RE. Before that, this thesis turns to explain the research designs and methods adopted for the research (chapter 3) and to illustrate the similarities and differences of the financial and legislative incentives for RE, at the national level, in both Italy and the UK (chapter 4).

Chapter 3
Research design and methods

Summary

As argued in Chapter 1, this thesis aims at investigating the spatially uneven processes of RE deployment, contributing towards an improved understanding of the regional level, and its role, in shaping the pace and direction of RE deployment. I argue that, in order to address this, there is a need to develop an analytical and conceptual framework that places more focus on the type of localised institutions that might influence RE deployment and foreground the role played by resource endowments at the regional level. In order to do this I suggest that acknowledging the role of materiality in energy development, in particular RE deployment, can provide additional insights on how and why RE deployment realises its potential (or why it fails to realise its potential) in some regions and not others. Addressing these research aims has important implications for the research design and methods to be used. This chapter reviews the methodological implications of the research and specifies the research strategy and methods adopted. The chapter argues that while the analytical and conceptual framework can add theoretical clarity and helps to describe the key factors and concepts that underpin the research, its testing across 5 regions within Italy and the UK, requires the adoption of a qualitative approach. The chapter justifies this approach and reviews the data collection strategy and activities that have been undertaken during the course of the research to collect material and evidence to support the method of inquiry.

3.1 Introduction

As presented in chapter 1, the central themes of this thesis are i) *to identify the factors that could explain regional variation in RE deployment* and ii) *to provide empirical evidence about whether and how the region represents an important level from which to understand low carbon RE transitions.* The arguments already presented in Chapter 2 have allowed for the development of sharper and more insightful questions about the topic of investigation and have helped indicate a number of analytical choices, guided by these research questions. In particular, the critical literature review indicates a number of issues that influence the methodological choices of the research.

Firstly, I argue that in order to understand the uneven processes of energy transitions, specifically the deployment of RE technologies, there is a requirement for a more focussed attention on the relevant institutions that affect RE deployment such as those at the regional and local levels (especially informal institutions). Chapter 2, drawing from the review of the GOST and RISs, also argues that while some institutions might share common features across territories, they also adopt a place distinctiveness influenced by culture, history, religion and identity that can affect the potential of any territory to develop economic activity (Rodríguez-Pose 2013). Such distinctiveness, in turn, can determine the degree of ability of any territory to learn and adapt to changes (Morgan 1997). Acknowledging that local informal institutions can affect RE deployment in different ways across different regions raises a number of issues. These, in particular, refer to i) how the relevant institutions that affect RE deployment can be identified and ii) how local and regional institutions relate to institutions at other spatial levels (e.g. the national and international).

Secondly, this research is situated within the GOST and RISs approaches and the choice of the unit of analysis, *the spatial level of the region*, partly reflects the nature of the questions that this research wishes to address. Additionally, as highlighted in Chapter 2, the regional level is also of growing significance and, represents the governance scale where environmental responsibilities and a wide array of policies (e.g. ecological goals and economic competitiveness) are being (or could be) developed, implemented, and realised (Gibbs and Jonas 2000; Morgan 2004; While et al. 2010; Galarraga et al. 2011).

Thirdly, the literature review shows that current conceptual frameworks do not allow for a full appreciation of the role that the combination of the broader institutional dimension and the physical geography of natural resources play in RE deployment. This implies that there is a need to develop a framework that links the analytical concepts of institutions, regions and the material dimensions of RE together. As one might expect, there are significant methodological challenges associated with developing such a framework. This chapter aims to investigate these challenges and to specify the logic of the design, the research strategy, and methods adopted. In particular, what they are, and how, and why, they have been selected. This chapter is structured as follows.

Section 3.2 re-introduces, from chapter 1, the research questions and objectives and reviews the analytical and methodological implications of researching institutions, regions and acknowledging renewable natural resources in dialectical terms as a socio-natural phenomenon. The chapter identifies the two main interrelated phases of the research, namely the development of the analytical and conceptual approach and its empirical testing across 5 regions within Italy and the UK and provides a justification for the qualitative approach utilised. Section 3.3 explains the data collection strategy and activities that have been undertaken during the course of the research to collect material and evidence to support the method of inquiry. Before reflecting on the limitations of the research, the chapter provides insight on the data analysis conducted. It concludes by summarising the main outcomes of the chapter.

3.2 Research Questions, objectives and methodological implications

The research identifies a number of questions and objectives. These, as summarised in chapter 1, aim at identifying the influence that the material dimensions of RE exert on their spatial distribution and deployment and to explore the extent to which they can explain regional variations in RE deployment. In chapter 1, I also identify the specific research objectives for the research.

The literature review has shown that current conceptual frameworks do not allow for a full appreciation of the role that the combination of the broader institutional dimension and the physical geography of natural resources play in RE deployment. This implies that there is a need to synthetize and enrich current conceptual frameworks in order to develop a framework that links the analytical concepts of institutions, regions and material dimensions of RE together. The research questions clearly raise issues that are both conceptual and empirical. The framework, conceptually, i) deals with the complexity of understanding RE deployment as it occurs at different spatial levels, while recognising the socio-material influence of nature, ii) defines and further elaborates the interrelatedness between institutions, regions and material dimensions and iii) builds from multidisciplinary bodies of knowledge.

Acknowledging resources in dialectical terms – as a socio-natural phenomenon that takes shape and form through interaction between the material/ physical world- implies that a diversity of actors, at different spatial levels, can influence institutional agendas and industrial forms of organisation. Secondly, accounting for institutions requires specification of the spatial levels at, and through, which they are being studied (cf. Doloreux and Parto 2005); in addition, informal institutions and their effects are more difficult to study than formal institutions as they only become visible in the reasoning or decision making of actors (cf. Wirth et al. 2013; Wirth 2014).

The key concepts that underpin the analytical and conceptual framework such as institutions, regions and material dimensions, strongly draw from ideas originated from different disciplines and perspectives. These are often characterised by multifaceted conceptualisations and conceptual difficulties (often ambiguities[22]) that are generated from the way in which scholars translate- or 'import'- concepts from other fields without their meaning being adequately defined or specified (Lagendijk 2003). I define these concepts in Chapter 1 and the analytical and conceptual framework, I argue, can add theoretical clarity by investigating the interrelatedness among these key concepts. The conceptual framework therefore is used here, following Miles and Huberman (1994), as a narrative account that describes the key factors and concepts to be studied and the presumed relationships among them.

Furthermore, as the research questions raise issues that are both conceptual and empirical and to gain explanatory power, there is a need to test and supplement the development of the framework with empirical work related to RE deployment. This consists of an iterative process. The conceptual framework -and its analytical frame and key themes induced by the discussion presented in Chapter 5 – provides the structure for exploring the data and the empirical material collected. This testing through empirical research helps reflect on the usefulness of the framework and the lessons that can be learnt for future conceptual and

[22] See for instance Hollingsworth (2000)'s discussion of a lack of consensus on to what is meant by institutions or Markusen (1999)'s early critique of the state of conceptual development in regional studies.

analytical approaches to study RE deployment. While the development of the framework is discussed in more detail in chapter 5, the next section briefly reviews the philosophical stance of the research and the remainder of this chapter turns to the research strategy developed for conducting the empirical part of the research.

3.2.1 The methodological stance of the research

This section summarises the philosophical approach taken during the research. This includes the degree of philosophical reflection required to make sense of the research but also to strengthen the quality and comparability of the empirical research conducted. Table 3.1 summarises the philosophical approach that has been adopted in this thesis. The choice of the philosophical approach used here is driven by the focus of the research undertaken, which encompasses a number of disciplines, in particular geography and innovation studies. It could be argued that both disciplines, to some extent, display elements of an *interpretivist* epistemological approach to social sciences[23].

As shown in table 3.1, in terms of epistemology the study reflects an *interpretivist* assumption, based on the view that 'the subject matter of the social sciences- people and their institutions- is fundamentally different from that of the natural science' (Bryman 2001: 13). Ontologically, I position the research under the constructivist paradigm, implying that social phenomena and their meaning are 'accomplished by social actors' and that 'social phenomena and categories are not only produced by social interaction but that they are in a constant state of revision' (Bryman 2001: 18). This is pertinent to this research because the uptake of RE development is often driven by socio-political as well as physical dimensions.

Two important issues that are interconnected need to be discussed here. These relate to i) the choice of a mainly qualitative approach for the empirical work over other alternative approaches and the justification of the relative benefits derived from the chosen approach;

[23] The research conducted here refers to the issue of materiality that emerged from the 'cultural turn' in geography and the innovation systems approaches that, according to Moussavi and Kermanshah (2018), present some elements from culturalism in the epistemological foundation of the innovation systems approaches.

and ii) the implications of the methodological stance for the wider research design, choice of data gathering tools and modes of analysis.

Table 3.1 Methodological stance and assumptions of the research

Ontology	Reality socially constructed by humans via inter-subjective meanings; multiple realities are possible
Epistemology	Interpretivist/ Knowledge generated by interpreting the subjective meanings and actions of subjects according to their own frame
Research approach	Primarily qualitative methods
Research design	Case studies; comparative multiple case studies
Methods of collection and analysis	Interviews/ documents/ observations/ Thematic analysis

Source: author's elaboration from Lincoln et al. (2013) and Tsang (2014)

As argued, the conceptual framework can add theoretical clarity by investigating the meaning and interrelatedness among key concepts. As discussed below, I argue that empirically, a largely qualitative approach in terms of data and information gathering is most appropriate to this study. The research utilises case studies to investigate the spatially uneven processes of RE at the regional level with data collected to inform the various elements of the conceptual framework.

In the 1990s and early 2000s, social science and geography research was dominated by approaches influenced by *positivism*, in other words focusing on methods widely used in the natural sciences (Snape and Spencer, 2003) where concepts are tested through a hypothesis led approach. The research questions asked in this thesis, however, require an approach to research methods and data generation which is i) flexible and sensitive to the social context in which data are produced (e.g. as it asks questions on institutions and explores the socio-physical dimensions of RE) and ii) based on methods of analysis and 'explanation building' which reflect the complexity, detail and context of data (cf. Snape and Spencer, 2003: 4). In other words, the approach adopted here is *interpretivist* in nature and creates a body of evidence that is intended to allow for richer differences and similarities in RE deployment across regions to emerge than if a positivist approach were to be used.

A number of benefits can flow from utilising an *interpretivist* methodology and qualitative research methods. As Creswell (2009) points out, such an *interpretivist* methodology allows for an understanding of a particular phenomenon from individual actors' perspectives, investigating interactions among such individuals but also the way in which historical and cultural contexts influence both individual and social reality. In this sense, qualitative approaches can allow for the development of explanations rather than simply causes and respects the uniqueness of each case as well as enabling cross-case analysis. This is particularly relevant to the research carried out in this thesis, which is concerned with identifying and understanding the distinctiveness of particular case study regions and the implications of such distinctions for the differential development and deployment of RE across regions.

As suggested, quantitative approaches, on the contrary, tend to align more with natural scientific investigation, which is primarily directed at analysing the relationships and regularities between selected factors in what is considered an external and objective reality. This is not to say that quantitative and qualitative research are seen as competing and contradictory. While qualitative methods lie at the heart of this approach, in Chapter 3 and Chapter 4 the thesis also draws on quantitative data relating to the regions and their differences, combining both quantitative and qualitative approaches to address the research questions and strengthen the arguments presented. In particular, in Section 3.3.1 and Section 4.5, quantitative data are used to show how RE deployment differs across the regions and the qualitative approach allows questions to be posed about the '*why'* and the '*what'* of regional differences.

The methodological approach has, therefore, important implications in terms of the wider research design and influences the choice of data gathering tools and modes of analysis, including the transferability of the qualitative evidence and findings generated. This will, in turn, influence the reliability and validity of the research. This raises questions on how the 'meaning attached to qualitative research evidence is conceived' (Lewis and Ritchie, 2003: 263) and brings to attention the way in which the qualitative data are gathered, managed and used to generate findings (cf. Spencer et al., 2003). I will return to this issue later in this chapter, but start here with a detailed discussion of the choices made in conducting the empirical research.

3.3 Research strategy, methods and data collection

As I have argued in chapter 1, there are merits to the adoption of a case study approach that derive primarily from the research questions set. Case study research design has been recognised for its role in investigating a phenomenon in its natural context. Simons (2014: 457) defines case study as an 'in-depth exploration from multiple perspective of the complexities and uniqueness of a particular project, policy, institution or system in a real-life context'. Siggelkow (2007) suggests that not only can studies be useful in illustrating and adding to the development of theoretical concepts, but they can also be employed as illustrations to strengthen conceptual contributions.

I have argued in Chapter 1, that qualitative methods, in particular case study research, are useful when examining a contemporary phenomenon in its real-world context and to understand social complex phenomena (Yin 2014). In the geography discipline, understanding the role of *context*[24] represents a long-standing discussion. Farole et al. (2011: 59), for instance, argue that 'since social, cultural and institutional forces vary considerably across territories, the geographical context of these factors should provide critical input' and Wirth et al. (2013), similarly, contend that examining the influence of institutions is highly contextual. Moreover, Peck (2003) claims that qualitative methods provide a means of accessing and understanding multi-faceted and historically produced social phenomena, rarely amenable to quantitative empirical categorisations.

I also argue that, while case studies are helpful to interrogate, examine and tease out some of the effects of the context and of different contextual conditions, there is also a need to extend case study methods to incorporate comparative methodologies (e.g. cross-regional, multi-site and transnational fieldwork) that can aid in identifying the influence of context and the validity and transferability of research findings (cf. Peck 2003). Moreover, research also shows that this process of comparative empirical case study analysis is important to determine the influence that institutions exert on economic processes at different geographical scales. Gertler (2010), for instance, shows how a comparative approach to

[24] *Context* in the geography literature is necessarily multi-scalar and the local, it is argued, is not the only scale at which multiple enduring and contingent phenomena come together empirically (Castree 2005).

empirical case studies (between different Canadian and US cities) has yield unexpected insights into the influence of local institutions and actors in shaping economic outcomes.

For the reasons highlighted above, this study adopts primarily a qualitative research strategy that focuses on multiple-case studies of a selected sub-set of particular regions. This choice is driven by the need to understand and investigate complex and multi-faceted phenomena and the way they unfold in specific geographical contexts. This requires an intensive and detailed examination that other methods, such as those that require quantitative empirical categorisation, do not allow.

Moreover, Yin (1994) argues that for generalisation purposes, multi-case study choice is important and this research design has the advantage of allowing for 'replication logic' where the different case studies contribute similar results (literal replication), or contrasting results but for predictable reasons (theoretical replication). Multiple case studies can strengthen, therefore, the arguments made during the research and enable the researcher to derive theoretical implications and insights from the case studies (Yin 1994; May 1997; Bryman 2001). The empirical research, therefore, focuses on different regional settings, across two different national institutional contexts, that helps unpack the importance of context specificity, including the importance of natural resources, and the material dimensions of RE, and contribute major insights for the testing of framework.

3.3.1 Multiple case study selection and design

The study proposes to investigate regions that are based in two different national settings, namely that of Italy and the UK. The choice of national settings derives from the fact that, on the one hand, both countries have been subject to similar pressures from European and international regulatory frameworks and have introduced targets for RE as well as financial and legislative incentives for the promotion of RE deployment. On the other hand, a key difference is that, while the Italian central government shares responsibility for energy policies with regional governments, in the UK, energy policy is a reserved function much of which is not devolved. Yet, devolution and local government reform have allowed for the emergence of a regional and local governance for RE in the UK (see for the English regions

Smith (2007)). Additionally, recent research has shown that the UK is an interesting case to study. There are sufficient institutional differences across Wales, Scotland and the rest of the UK that open up fundamental questions in understanding the development and deployment of RE (for an example of bioenergy in the UK, see De Laurentis (2013) and for comparison between England, Scotland, Wales and Northern Ireland, see Cowell et al. (2015)).

Furthermore, the international case of Italy has been so far under-studied in RE research. This has occurred despite the fact that Italy had the world's largest national share of PV generation in 2012. The two countries also show differences in their institutional make up, as they are often considered examples of a liberal market economy (UK), and a variation of a coordinated market economy (Italy) (Hall and Soskice 2001). The analysis presented in chapter 4 of this thesis is specifically aimed at exploring and investigating the influence that the national (as well as the international and European) contexts exert on RE deployment processes.

The research adopts the regional scale as a focus of the analysis. Hence, the first task, in the identification of the likely cases to be studied, is to categorize and delineate the boundaries of the unit of analysis. As argued this is not without its challenges as the concept of the 'region' can be looked at from a variety of different perspectives, using a range of methodological approaches and this opens up a number of possibilities.

This work does not look at regions as social categories and, as argued, remains separated from the theoretical arguments about the construction of regions[25]. The choice here, as discussed in chapter 1, is to accept that, as also stated by Paasi and Metzger (2016: 23), 'many regions are actually territories deployed within the processes of governance, and are made socially meaningful entities in processes characterized by multifaceted power relations'. Nevertheless, the delineation of regional boundaries will depend, to a large extent, on the research questions and the purpose of the analysis (cf. Macleod and Jones (2007); Harrison (2013). As suggested in chapter 1, I define regions as 'territories smaller than their state

[25] E.g. how regions emerge from the co-location of people in space, through historical processes which involve the construction of regional consciousness and identities out of diverse interests and agendas (Paasi, 1991; 1996, as quoted in Cumbers et al. (2003)). Paasi and Metzger (2016) argue in the geography literature, regions are seen as social constructs that are produced/reproduced by social actors in and through variegated social practices and discourses. The region, in this sense, they argue, is understood as the outcome of contestable 'region-building' or regionalization processes.

possessing significant supra-local governance capacity and cohesiveness differentiating them from their state and other regions. Amongst the governance powers all possess, to varying degrees, are certain capacities to develop innovation support policies and organisations, though these are not their only or most important capacities or competencies', following Cooke et al. (1997: 480). Within the regional boundaries, as defined above, there will be economic and social interactions between agents, spanning the public and private sectors that characterise and shape RE deployment. Adopting a RIS approach (Braczyk et al. 1998), these are represented by the regional institutional infrastructure (e.g. policy, governance and financial resources), the specific regional networks of innovators, local clusters and research institutions, and internal and external knowledge flows that relate to the RE sector in a specific region.

As the specific aim of the multiple case studies is to test theoretical propositions, the case study design needs to take into account primarily theoretical replication cases that predict contrasting results for predictable reasons (cf. Yin 2014). It follows that case studies need to be deliberately selected in order to offer contrasting situations (cf. Peck 2003). Given the need to capture the nature and extent of spatial heterogeneity in the dynamics of transformation of the energy sector towards sustainability (focussing in particular on RE deployment), regional case studies have been selected in a way that reflects their ability to allow distinguishing characteristics to emerge.

A scoping exercise (cf. Davis et al. 2009) was conducted to investigate regional differences in Italy in RE deployment and resource endowments to aid the selection of regions. The scoping exercise was conducted by synthetizing and analysing a number of secondary-data sources (in particular to highlight the main sources and types of evidence available and to inform the choice of regions). Italy is politically divided into 20 regions and into over 110 provinces, which have quite different size, population and regional per capita gross domestic product (GDP). The country, except for the Po plain in the north, is largely mountainous, with mountain areas running from the Alps to the central Mediterranean Sea, presenting regional variations in solar radiation, orography, climate, population, area and economic conditions. This regional diversity, with the increased autonomy of action and governance capacity over energy, despite lacking control over economic framework conditions (such as subsidies and feed in tariffs), provides an interesting testbed for and illustration of the material dimensions of RE.

Figure 3.1 and 3.2 illustrate the differences in terms of wind and solar resources and table 3.2 displays the regional distribution of RE.

Apulia, in the south, was selected for its pioneering role in RE deployment, as it became the leading region in wind and solar energy production in 2012. Tuscany, in the central area of Italy, was selected for its high concentration of universities and research clusters specialising in RE and the environment, and its tradition of industrial districts. Sardinia was chosen because of its insularity and by its 'special statute[26]' condition. All three regions show similarities in wind strength and also differences and similarities in solar radiation, as figures 3.1 and 3.2 show.

In the UK, regions were selected in terms of their asymmetry of powers and ambition for RE deployment. Wales, a relatively small country of just under three million people, is located on the western periphery of the UK, and Scotland, with an estimated population of over five million, located in the north of the UK are, for the purpose of this study, both considered regions as they are situated between local and national levels with the capacity for authoritative decision making, together with a Welsh Government and an elected Assembly in Wales and a Scottish Executive and a Parliament in Scotland[27]. Furthermore, a high proportion of RE sources potential, in the UK, is situated within the territory of Scotland and Wales. Figure 3.3 and 3.4 display solar and wind resources, respectively, and table 3.3 display the distribution of RE in Scotland, Wales and the UK.

The main distinguishing characteristics among all 5 regions are summarised as following:

[26] Five out of the twenty Italian regions have been characterised by a `special statute' since the 1948 Constitution, and thus have significantly broader legislative, administrative, and financial autonomy than do ordinary regions. Among these, three are located in the North (Friuli-Venezia Giulia, Trentino-Alto Adige, and Valle d'Aosta) and two in the South (Sicily and Sardinia).

[27] Northern Ireland was not selected as the region has always had responsibility for all energy matters (except nuclear power of which it has none (Ellis et al. 2013).

- *Regions that represent a varied degree of political and administrative autonomy:* Sardinia a region with a 'special statute'; Apulia and Tuscany, both regions with an 'ordinary statute'; Wales and Scotland, both with a varied degree of devolved power;

- *Regions that are playing a pioneering role in RE deployment*: Scotland and Apulia have both experienced high success in terms of RE deployment; Apulia was the leading region in wind and solar energy production in 2012;

- *regions that display different degrees of local institutional environments*: Tuscany for instance with 3 major university clusters in Florence, Pisa and Siena, each with research centres specialised in RE and environment and its industrial districts' tradition; Wales with the research capabilities of the Low Carbon Research Institute; and Scotland with its Marine energy innovation system[28];

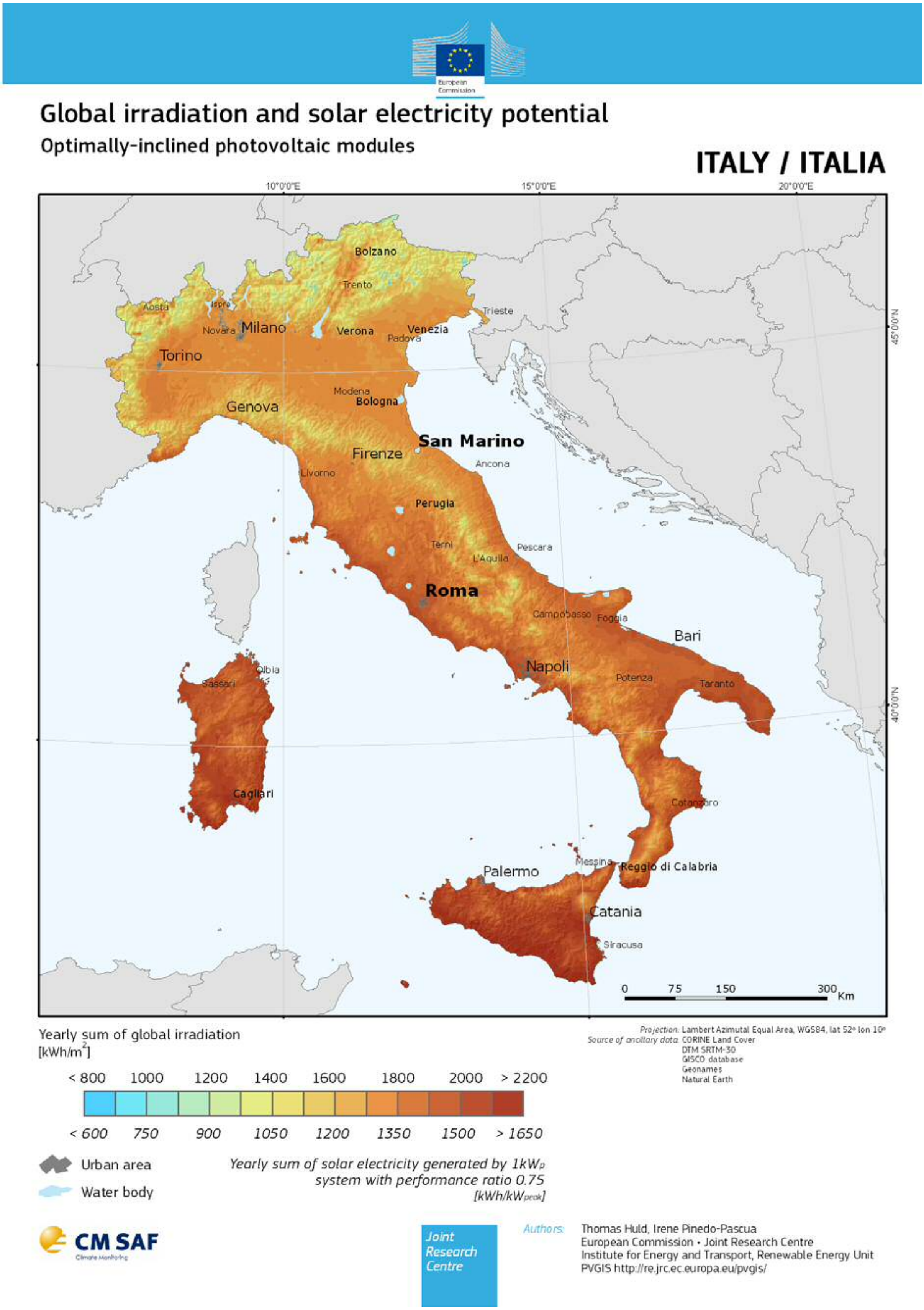
[28] The energy policy and institutional context of the Scottish marine energy innovation system is discussed in Winskel et al. (2006).

- *Regions that display a certain degree of variance in resource endowments*: the regions selected differ in terms of geographical contexts and natural resource endowments.

Figure 3.1 Italian Wind Resources: Regional Differences

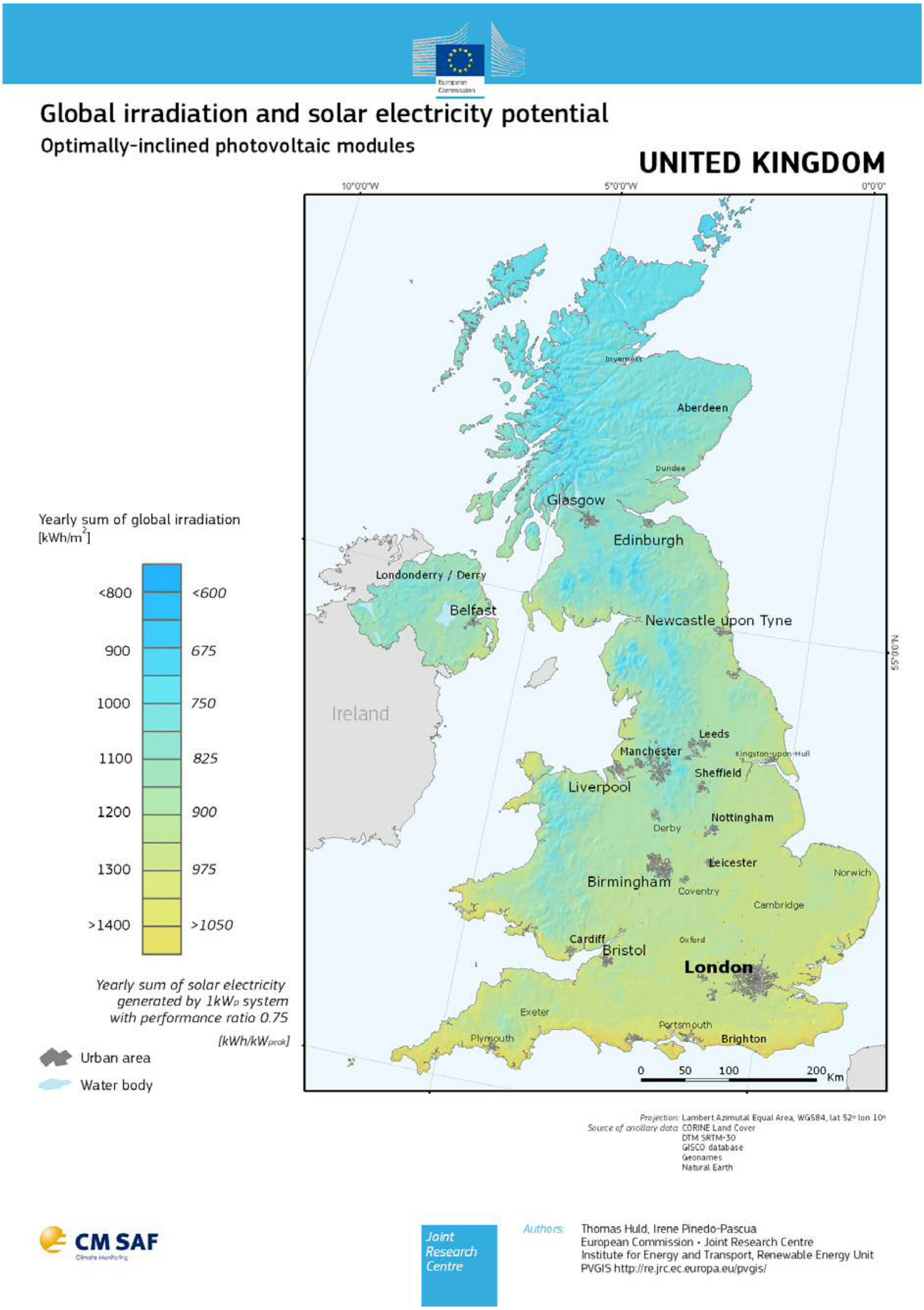
Source: This map is generated by the Global Atlas for Renewable Energy (http://www.Irena.org/GlobalAtlas) using Open Street Map (openstreetmap.org) as base map

Figure 3.2 Italian Solar Resources: Regional Differences



Source: Joint Research Centre/ European Commission
http://re.jrc.ec.europa.eu/pvg_download/map_index.html

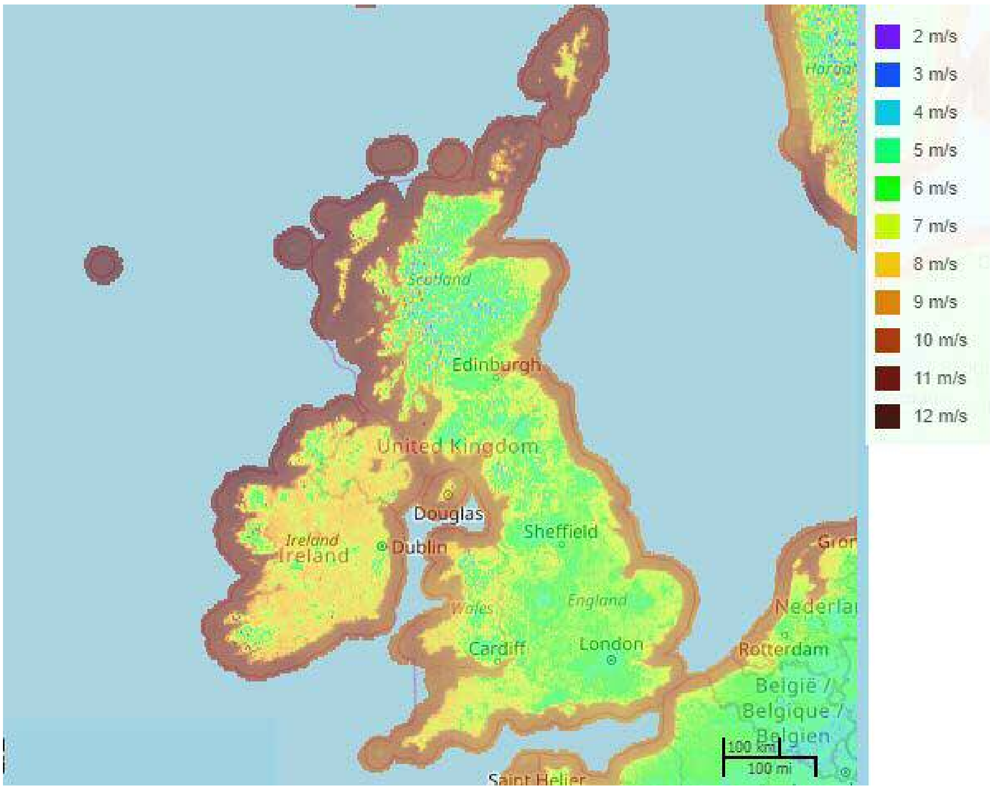
Figure 3.2 UK Solar Resources: Regional Differences



Source: Joint Research Centre/ European Commission

http://re.jrc.ec.europa.eu/pvg_download/map_index.html

Figure 3.4 UK Wind Resources: Regional Differences



Source: This map is generated by the Global Atlas for Renewable Energy (http://www.Irena.org/GlobalAtlas) using Open Street Map (openstreetmap.org) as base map

The next section details the data collection methods applied in the research. It is important to highlight that, as shown in table 3.4, the majority of face to face interviews were conducted in the three Italian regions. In fact, the main focus of the research has been on the Italian regions. This is because there has been little research on RE uptake in the case of Italy. Given the fact that the Italian government shares responsibility for energy policies with regional governments, the rapid uptake of RE deployment and the resulting regional variations in uptake all represented interesting characteristics to be assessed against the framework proposed. Yet, as suggested, it was also important to have a second national context considered to ensure that national characteristics (e.g. high subsidies for RE in Italy) were not the main drivers for the successful application of the framework. In other words, it was important to test the framework in another national context to ensure that it was transferable to other settings.

Table 3.2 Regional Distribution of installed capacity (MW) & n. of sites (2014) (Italy)

Region	n.	n. %	MW	MW %
Piemonte	46878	7.14	4,541.10	8.98
Valle d'Aosta	2082	0.32	967.70	1.91
Lombardia	95353	14.53	8,048.50	15.91
Trentino Alto Adige	22794	3.47	3,764.00	7.44
Veneto	88483	13.48	3,220.00	6.36
Friuli Venezia Giulia	28271	4.31	1,119.30	2.21
Lguria	6662	1.02	266.80	0.53
Emilia Romagna	64693	9.86	2,816.10	5.57
Toscana	34468	5.25	2,223.10	4.39
Umbria	15190	2.31	1,023.90	2.02
Marche	23310	3.55	1,339.00	2.65
Lazio	40094	6.11	1,865.10	3.69
Abruzzo	16426	2.50	1,967.30	3.89
Molise	3589	0.55	669.00	1.32
Campania	25156	3.83	2,554.10	5.05
Puglia	42155	6.42	5,219.90	10.32
Basilicata	7363	1.12	1,048.20	2.07
Calabria	20471	3.12	2,407.70	4.76
Sicilia	42385	6.46	3,265.50	6.45
Sardegna	30390	4.63	2,268.50	4.48
total Italia	656213	100.00	50,594.80	100.00

Source: GSE (2016)

Table 3.3 Regional Distribution of installed capacity (MW) & n. of sites (2014) (UK)

	n. of sites	N %	MW	MW %
England	515,947	78.08	14,766.2	59.26
East Midlands	60,310	9.13	1,499.1	6.02
East of England	71,534	10.83	2,675.0	10.73
North East	30,686	4.64	711.7	2.86
North West	56,702	8.58	1,913.9	7.68
London	16,971	2.57	331.2	1.33
South East	80,825	12.23	2,476.2	9.94
South West	92,768	14.04	1,964.2	7.88
West Midlands	47,915	7.25	882.9	3.54
Yorkshire and the Humber	58,236	8.81	2,312.2	9.28
Northern Ireland	12,695	1.92	807.2	3.24
Scotland	44,405	6.72	7,309.1	29.33
Wales	40,762	6.17	1,824.1	7.32
*Other Sites**	46,969	7.11	213.0	0.85
UK Total	660,778	100.00	24,919.5	100.00
* Other sites are sites that have not been attributed to a region so that data related to individual companies are not disclosed.				

Source: author's elaboration from BEIS (2014b, 2014a)

In the UK, there has been a lot of attention and research activities on the variance of RE uptake and the effects of devolution. Therefore, it was never the intention to undertake the same scale of primary data collection in the UK, but rather to target the case study analysis at key institutions and individuals to confirm and provide updates to material from research already conducted.

3.3.2 Data collection

Simons (2014: 457) argues that case study research needs to be 'research based, inclusive of different methods and is evidence led'. Moreover, case study research has to include a wide variety of evidence that range from documents, artefacts, interviews and observations (Yin

2014). Following this, the validity of this research relied upon the triangulation of multiple forms of evidence (Yin 2009, 2014). This helped to build converging narratives from different interviews and secondary documentation and disparities and contradictions of evidence, when necessary, have been clarified with follow-up interviews with key informants and validating data in the form of asking frequent check questions.

This research draws upon an extensive review of the academic literature, press reports and policy documents to build up a detailed picture of the theoretical considerations associated with the transformation of energy systems towards sustainability with particular attention to RE deployment at the regional level. This also helps to identify how regional actors interact with the national and international scales. This has allowed for the identification of the main actors and the different regional governance frameworks in RE sectors within the selected regions.

More specifically, secondary data collection focussed a) on the investigation of existing regional/national policy frameworks and b) on a review of RE deployment and innovation activities in the different regional settings under investigation. Adopting a Regional Innovation System approach (Braczyk et al. 1998), this review ranged from an overview of the regional institutional infrastructure (governance, the innovative capacity and financial resources), the specific regional networks of innovators, local clusters and research institutions and internal and external knowledge flows. The secondary data review also helped identify how narratives, and shared expectations, of natural resources abundance and innovation in RE are constructed and mobilised and by whom.

Table 3.4 Interviews conducted[29]

			Organisation type		
			Government	*Industry*	*Research (public or private)*
Italy	National		Ministero per l'Innovazione e lo Sviluppo Economico (MISE) (National Government Department of energy; Ministry of economic development)	ENEL Green Power (Enel Group subsidiary for renewable sources) Graziella Green, Renewable Energy Electricity producer	ENEA, National agency for new technologies energy and sustainable economic development CNR (National Research Council) institute of geosciences and earth resources ENEL Research Centre (Global Generation Division) Horizon 2020 Representative for Italy in the area of Secure, Clean and Efficient Energy
	Regional	Tuscany	Regione Toscana (Regional Government)	DTE Toscana (technological districts for Energy Toscana Region) Magma Energy Italy, geothermal 40 South Energy, marine/ wave energy	CRIBE, Research Centre for Biomass energy, Pisa university, Department of Civil and Industrial engineering Scuola Superiore Sant Anna, Innovation and Renewable Energy Research Group
		Sardinia	Regione Sardegna (Regional Government)	Confindustria Nord Sardegna, Manufacturing and services association Elianto, Renewable Energy Electricity Producer	Sardegna Ricerche, Cluster Renewable Energy

[29] The position and contact details of the interviewees have been omitted for confidentiality purposes.

		Apulia	ARTI, Agenzia regionale per la tecnologia e l'innovazione (Apulia Development Agency) Regione Puglia- Regional Government	Vestas, Wind Energy- Manufacturer Tara Renewable Energy, Energy efficiency and smart buildings	CREA, Centro Ricerche Energia e Ambiente, Lecce University Foggia University, Economics Department

			Organisation type		
			Government	***Industry***	***Research (public or private)***
United kingdom	National		Department of Energy and Climate Change		
	Regional	Wales	Welsh Government Natural Resources Wales Cardiff Council	Tidal Energy ltd Pembrokeshire Marine Energy Tidal Power Lagoon (Swansea Bay Lagoon) RWE Innogy (Wales) Wind Energy Renewable UK Cymru	Swansea University Marine Energy Group
		Scotland	Scottish Government		

The research included semi-structured exploratory interviews. Interviews, according to Creswell (2009) are highly suitable for exploratory as well as explanatory research questions with the aim being to ascertain how certain processes unfold and outcomes are achieved. Thirty-two key regional and national stakeholders have been interviewed during the research[30]. A list of organisations interviewed is presented in Table 3.4. Leading participants were identified through a scoping exercise, using the experience and knowledge of the researcher and a snow-balling technique (the initial key stakeholders may have knowledge of others stakeholders or initiatives in the area that were not covered in the initial scoping exercise; this was also facilitated through liaising with the host institution during one of the study visits, as discussed later).

As Table 3.4 shows, stakeholder participants have been chosen from different institutions and organisations involved in RE systems; these include policy makers, regional and national government representatives, institutions that supported innovation and RE development (e.g. development agency etc.), firms, and private and research institutions.

The interviews offered the opportunity to collect more detailed information about recent RE deployment and policy frameworks at national and regional levels. The interviews explored actors' activities that are often not documented and actors' perceptions of the role of natural resources and narratives developed around natural resource exploitation. The interviews were organised predominantly face-to-face and in the native language of the interviewees (English and Italian), and were recorded and transcribed.

In particular, both the interviews and the study visits (discussed in more detail in the next section) have focussed on the following:

- Identifying the relationships and shared expectations that foster RE deployment among different actors in different regional settings;
- Exploring how local/regional actors and institutions overlap and are connected with national and transnational networks;
- Identifying the role that the regional, national and international policy frameworks play in supporting RE deployment and how it differs across the regions;

[30] To some extent, some could argue that the number of interviews conducted is limited in size. I conform to Crouch and McKenzie (2006)'s suggestion that small scale interview-based research is 'intentionally conceptually generative' and aimed to 'indicate rather than conclude' (2006: 492).

- Exploring the role and influence that regional resource endowments play in RE deployment dynamics;
- Providing comparative material on the deployment of RE in different contexts of climate and endowment of natural resources.

3.3.3 Study visits

Three study visits were also conducted in Italy during the period of the research (between the 10th and the 23rd of May 2015 in Tuscany, between the 15th and the 28th of July 2015 in Sardinia and between the 22nd and 29th of October 2015 in Apulia). The first visit in the region of Tuscany was conducted under a Short Term Scientific Mission (STSM) sponsored by the Cost Action TU1104 'Smart Energy Regions'. The mission presented a valuable opportunity to conduct field work research and to gain primary and secondary knowledge on Italian regions, primarily Tuscany. During the two weeks visit, I was based at the host organisation, the Istituto di Management, of Scuola Sant' Anna, Pisa that specialises in three main areas including energy and waste.

During my stay, four meetings were set up with members of the Institute to:

- Discuss past and current trends in RE development in Italy, with an emphasis on the three regions of Tuscany, Apulia and Sardinia;
- Map the key players in RE in the region of Tuscany, including a number of players that were also contacted for an interview. A number of key players were also identified for the Apulia region;
- Reflect on the preliminary results that emerged from the interviews conducted.

The STSM allowed for the collection of evidence that included interviews, observations and documents for the Italian case study regions, allowing for the organisation of meetings with national and regional stakeholders and offering the possibility to investigate phenomena and the way they unfold in their specific geographical contexts. The visit also provided access to literature on the other two Italian case-study regions, to provide information on the main actors (including contact details) in the RE system in these regions. Additionally, the shorter visits carried out in Sardinia and Apulia allowed for the conducting of face to face semi-structured interviews with key informants in RE deployment. A copy of the *aide-memoire* used to prompt the discussion during the visits is presented in Appendix 1. Some of the firms and organisations contacted, unfortunately, were not available for a meeting during the visits and arrangements were made to conduct interviews via Skype or phone at a later date. All the three visits focussed on regional actors (firms, organisations and policy makers), the regional knowledge networks and the regional institutional infrastructure in order to identify how actors and networks mediate and influence the opportunities offered by natural resource availability.

3.3.4 Ethical Issues

The empirical fieldwork was carried out within the guidelines of the University Ethics Committee and formal approval was obtained from the School Research Ethics Committee, prior to the conduction of the fieldwork. In particular, attention was given to issues of informed consent, assurances of anonymity, and secure data storage. Participants were offered anonymity in exchange for their valued insights and I have ensured that at every stage of the research all efforts were made to maintain this anonymity. This involved password protection for documents involving all contacts and travel arrangements. All interviews were given a code number before and after transcription and are referred to in the analysis and write up with a description of the type of the organisations they work in only. This allows for anonymity of the individuals but allows for the identification of the type of organisations and the regions where they are located. All confidentiality agreements were discussed openly up front with participants; consent forms were signed and kept locked in the research office.

3.4 Data analysis

As outlined previously, chapter 5 outlines the key analytical themes of the framework developed. These were identified in an attempt to capture how RE deployment processes are shaped by a constellation of interacting actors, institutional and regulative settings and the material dimensions of RE. The analytical themes stem directly from the arguments presented in Chapter 5, drawing attention to the influence that materiality exerts on RE deployment processes, suggesting the way in which both institutions and material differences are highly context specific, and are influenced by complex place-based interactions, which occur at both local and regional levels.

The data generated from the research, both in the form of interview transcripts and secondary documents, have been organised under thematic summaries (that provide descriptive accounts of the various concepts), and combined under analytical categorisations. These analytical considerations have been developed using the interview guide (this is presented in Appendix 1) as a blueprint and include the following:

1. Regional responses to pressures, targets and existing constraints on RE deployment;
2. Renewable natural resource endowment and opportunities sought for exploitation;
3. Policy perception for RE support and geographical scale of relevance;
4. Barriers to current and future deployment of RE.

Both the key concepts and analytical categories have been derived from i) the empirical instances to map the diversity and range of contributions from the organisations and individuals interviewed as well as policy documentation and ii) the literature and the critical discussion of key concepts and issues presented in Chapter 5. In particular, the approach adopted combined a 'cross-sectional code-and-retrieve model' with a 'cross referencing system' (Spencer at al, 2003: 203). This approach has been useful to locate analytical categories from the data, linking them back to the original interview material and secondary data, to allow comparisons and connections to be made. This was particularly important because retaining links with the original data and revisiting them constantly is seen an integral part of the qualitative analysis process (Spencer et al, 2003). By conducting the analysis using this approach, I was able to identify concepts that I had not previously considered of great importance, for example the particular significance of the role of agricultural land and the role of the national state in facilitating or conditioning the activities of the regions in RE.

Due to the different languages of the transcripts and secondary documents, the themes and categories were applied manually across the whole dataset. It is important to say that the different stages of the analysis, including the analytical building block (themes, concepts and categories), were discussed with research colleagues during a research seminar, as well as with the research supervisors. The descriptive and explanatory accounts that were derived from this analytical process (the coding, extraction and evaluation of the data collected) are presented in the three empirical chapters (chapters 6, 7 and 8) and conclusion (chapter 9) of this thesis. In these chapters, the set of concepts and categories according to which the data have been labelled, organised and synthetized have been linked to the analytical constructions identified in the conceptual and analytical frame developed in chapter 5. It is important to reiterate that the aim of the empirical material has been to compare and contrast the role of the material dimensions of RE deployment at the regional level. Attention was devoted to the relationship between the analytical/ conceptual level and the empirical insights accumulated in the course of the analysis. The purpose of the analytical process, and the largely qualitative approach used, was not to identify causal relations and deterministic explanations but to clarify the nature and interrelatedness of different contributing factors and influences on RE deployment (cf. Spencer et al, 2003). The results are, therefore, presented in the form of a narrative exploration that integrates and illustrates the set of issues that have been, potentially, underappreciated in understanding RE deployment in the innovation systems and sustainability transitions debates.

3.5 Limitations of the research

All studies have inherent limitations. These were considered during the formulation and conduct of this research. In terms of the methodological approach, the choice of case studies for the research means that the study could be affected by the many challenges that are well documented in social research methods texts (e.g. external validity, researcher bias and generalisation). Nevertheless, the requirements of the research aims and the decision to use comparative and multi-case approaches can overcome some of these limitations. As the comparative research is cross-national, the issue of comparability of data collected and culture/language specificities of the national contexts selected was taken into consideration. During the research, extra care was taken in ensuring that data collected through secondary sources were comparable (both in terms of categories, data collection methods, and terminology used) and that new data collected and interview instruments were carefully translated in order not to undermine comparability (e.g. Bryman (2001).

The case studies were selected carefully, given their particular characteristics of resource endowments, RE deployment and the varying degrees of political and administrative autonomy with the aim of providing an in-depth and detailed understanding of each case study. The alternative would have been to select a larger number of case studies but this would lack the depth of analysis required to achieve the aims of the study. Notwithstanding the number of case studies selected, the conceptual and analytical framework, while providing the basis for exploring the data and the empirical material collected, is intended to be applicable to study RE deployment at the regional level and can be applied to other regions aside from those covered in the study; this is one of the key strength of the framework developed.

3.6 Concluding remarks

This chapter has reviewed the methods and research strategy adopted in the research, investigating the methodological implications of researching regions, institutions and the material dimensions of RE. As argued, the research consists of two main interrelated phases: the development of a conceptual and analytical approach and its empirical testing across 5 regions within Italy and the UK.

In this chapter, I provided an explanation of the case study approach adopted and the data collection strategy, presenting in detail the activities that were undertaken during the research to collect material and evidence to support the method of inquiry. The chapter also discussed some of the limitations and strengths of the research.

Before introducing the analytical and conceptual framework, the next chapter provides contextual information on the two countries in terms of their energy systems- in relation to RE. The purpose of what follows is to highlight the national and international frameworks for RE, to frame the regions investigated and to situate the research undertaken.

Chapter 4

Renewable energy institutions at international and national levels: Italy and the UK, differences and similarities

Summary

As explained in chapter 2, building on recent research on the importance of the institutional framework in the geography of transitions, the institutional infrastructure, at different spatial levels, can help to explain differences in the spatial patterning of RE innovation systems. Before turning my attention to the analytical framework proposed in this thesis and to the way in which the spatial unevenness of RE deployment can be explained at the regional level, it is important to stress that, as argued in chapter 2, regional governance, regional policy, and regional-specific institutions result from processes that take place at, and across, various scales. Hence, national and international institutional frameworks interact, influence, and shape organizational practices and learning processes at regional and local levels. Before introducing the regional case study work conducted in the chapters that follow, this chapter aims at setting out the national and international frameworks for RE deployment that serves the purpose of framing the regions investigated and to situate the research undertaken.

4. 1 Introduction

Chapter 1 has highlighted that there has been a renewed interest in the spatial transformation of the state that focuses the attention on the region as an emerging political-economic unit, with increasing autonomy of action both at national and international levels. Moreover, the pressures associated with tackling climate change and reducing carbon emissions, it is argued, have given rise to a rescaling of environmental governance in which the regional level is of growing significance.

Yet, an increasing number of regional scientists and innovation studies scholars (see for instance (MacKinnon et al. 2002) have argued that while national states have certainly become less self-contained as a result of economic globalisation, they retain key powers. Such powers are exerted both over their own territories and in their relations with the wider world economy. Thus, national states continue to regulate a range of important policies, such as energy. The sub-national level of the region is increasingly being articulated as a key strategic space for the management of economy-environment tensions, and as governments seek to reconcile environmental protection with multiple pressures and demands, complex architectures of political power and spaces of governing are emerging. Such complexity in governing innovation and environmental processes has been highlighted by a number of scholars, including Bulkeley (2005); Bulkeley and Betsill (2005); While et al. (2010); Bulkeley and Betsill (2013).

The work undertaken by Bulkeley and colleagues is important as it seeks to understand whether the multi-level governance perspective (Hooghe and Marks 2001) can capture the processes in place to govern climate change at an urban level. Their work examines the way in which resources, competencies and powers are distributed both 'vertically' between different levels of government and 'horizontally' through multiple overlapping and interconnected spheres of authority (Hooghe and Marks 2001). Accounts of governance, understood in terms of the re-structuring of the state, from a situation of state dominance in the management of public functions to more multi-actor forms of partnership and networks (Jessop 1995; Rhodes 1996) are useful here. This implies not only that 'governments' exist at a range of different geographical levels, but also that they are increasingly interdependent and involved in a continuing process of negotiation across a range of policy fields. It can be said that state responsibilities have moved in three directions: 'up' towards supranational organisations and institutions; 'down' towards regional and local levels, and 'out' with a stronger reliance on semi-public and private institutions (Pierre and Peters 2000).

How they have moved 'up' and 'down' is the focus of this chapter. The ultimate objective of this chapter is, therefore, to analyse the institutional structure that governs RE systems and how this is organised and distributed at the national level. The focus here is on governance and institutional frameworks – in particular the financial and legislative incentives in place for promoting and regulating RE- and the role they have played in its deployment.

In this respect, Section 4.2 briefly highlights the pressures and influences that have arisen from European and international policy and governance frameworks. The chapter then moves to review the energy systems of Italy (Section 4.3) and the UK (Section 4.4). In particular, I discuss how both countries have undergone major changes, emphasising the pressures for change and the key regulatory and support mechanisms that have been put in place to promote RE deployment. Section 4.5 looks at the regional level in the two countries, arguing that regions in Italy and Wales and Scotland in the UK have experienced increased autonomy of action in the governance of RE deployment. The chapter concludes by summarising the main points of relevance for this work, emerging from the discussion around institutions and governance at the national level.

4.2 Unfolding the landscape of renewable energy systems: European and International policy and governance frameworks

This account of the policy and governance frameworks for RE starts with a brief analysis of the pressures for change that energy systems are experiencing stimulated by institutional and governance changes at European and International levels. This analysis is necessarily selective, given that the goal is not to survey energy issues, such as energy governance and policy, in their entirety, but rather to introduce some key areas that are important for this research. In this section, the discussion examines the rising importance of climate change issues and how they have impacted on the global and European energy agenda.

4.2. 1 International policy and governance frameworks

Both energy and energy policy have traditionally been treated as a national competence as the supply of energy is a key aspect of any national economy and its competitiveness. Nevertheless, during times of crises coordination between nation states on international energy policy activities has tended to increase (Hirschl 2009). For example, the 1973-74 oil crisis led to the creation of the International Energy Agency (IEA), an inter-governmental organisation, that has become, over time, the main international energy policy advisory institution of the OECD countries (Florini and Sovacool 2009; Hirschl 2009). While the IEA was partly established in response to the perceived threat of OPEC and its 'Cartel', RE has become part of IEA's core portfolio.

Moreover, climbing oil prices triggered the gathering of a group of leading industrial countries (originally the G6, since 2006, the G8) to address common policy issues and coordinate policies, which dealt, primarily, with issues around security of supply and, in recent years, climate protection. Many argue that, increasingly, climate change and environmental protection have become persistent issues on the global energy agenda (Florini and Sovacool 2009; Hirschl 2009). Pressures for change grew after the first report of the Intergovernmental Panel on Climate Change (IPCC) published in 1990 and the ones that followed the 'Earth Summit' in Rio in 1992[31], and the adoption of the Kyoto protocol in 1997 (Langsdorf 2011). While energy and climate policies at both national and international levels have long been largely separated from each other, during the 90s, policy making in relation to energy and climate change became increasingly interconnected (Heubaum and Biermann 2015).

RE, at the international level, has been addressed within the political issues of environment and sustainability policy, becoming a separate agenda item in the negotiations of the 2002 Second World Summit in Johannesburg (Hirschl 2009). This momentum building for RE was followed, in due course, by the 'Renewables 2004' conference in Bonn, a gathering of high-ranking officials to deal exclusively with the issues of RE. This resulted in the creation of the Renewable Energy Policy Network for the 21st Century, REN21- dedicated to policy issues and policy concerns at the international level (Hirschl 2009). In 2009, the International Renewable Energy Agency (IRENA) was also officially established to advise governments and international organisations on the development of political and financial approaches to the use of RE (Hirschl 2009).

Therefore a process of international commitments for RE has been underway for some time, including the development of alternative energy scenarios (by the IEA) and the creation of a framework for investment and financing on clean energy initiatives (led by the World Bank) (Florini and Sovacool 2009). One could argue that climate change issues have slipped down the international policy agenda during the global financial crisis and its aftermath. Nevertheless, eighteen years after the Kyoto Protocol adopted legally binding emissions targets, during the Paris climate negotiations at the end of December 2015, a global climate

[31] The Summit also established the United Nations Framework Convention on Climate Change (UNFCCC) that remains the key framework for multilateral action on climate mitigation and adaptation.

agreement[32] was reached, sending 'a strong signal for countries to move from negotiation to action and rapidly decarbonise the energy sector' (IRENA 2016).

4.2.2 European policy and governance frameworks

The necessarily brief account presented above highlights that as renewable sources have become more important in global electricity provision (IEA 2014b), RE is increasingly playing a key role alongside energy and climate within the international agenda, leading to a positive impact on the international advancement of RE. The European Commission has played a key international leadership role in moving this agenda forward.

The European Union came to energy policy late in its history (Helm 2014). At the European level, a push for a common energy policy was triggered in the early 1970s as a consequence of the 1973 oil crisis, that led Member States agreeing to a declaration on energy policy, adopting guidelines concerning energy supply and demand (Kanellakis et al. 2013). Nevertheless, common energy policies usually focussed on economic objectives (e.g. the liberalisation objectives underlying the Internal Energy Market) (Langsdorf 2011). In the early '90s, when pressures for a global energy agenda amplified, a renewed series of efforts were put in place, at the European level, to implement a European framework for energy policy[33] (Helm 2014). This included a commitment to set the European Union to lead the world towards addressing climate change, resulting in the setting up of ambitious climate and energy targets and policy measures to support RE sources (Kanellakis et al. 2013).

Nevertheless, support for RE sources at the European level goes back as early as 1986, when a Council resolution highlighted the promotion of RE as one of the Community's energy

[32] The agreement is considered a "treaty" under international law, but only certain provisions are legally binding. The issue of which provisions to make binding was a central concern for many countries, in particular the United States, which wanted an agreement the president could accept without seeking congressional approval. Meeting that test precluded binding emission targets and new binding financial commitments. The agreement, however, includes binding procedural commitments – such as the requirements to maintain successive nationally determined contributions (NDCs) and to report on progress in implementing them' (see https://www.c2es.org/content/paris-climate-agreement-qa/)

[33] In other terms, in energy policy, EU law sets requirements for the member states in a wide range of areas, including electricity and natural gas markets, emissions of greenhouse gases and air pollutants, energy efficiency and RE.

objectives. RE was also recognised in the 1995 White Paper (European Commission 1995) as a factor to help achieve the main objective of improved competitiveness, security of supply and protection of the environment (Kanellakis et al. 2013). Hitherto, it could be argued that policy support for RE in Europe focussed mainly on research and development (Blok 2006). During the second half of the 1990s the focus then shifted gradually from R&D to market deployment policies[34].

It is not until the 1997 White Paper (European Commission 1997) that the first target for RE deployment was set at the European level (an indicative target of 12 % share of RE sources in total final energy consumption by 2010). This 2010 target was underpinned by two further European directives (European Commission 2001, 2003) that formulated a requirement to introduce policy measures to increase the market share of RE sources by EU member states (Klessmann et al. 2011). Nevertheless, the framework established by these Directives was considered insufficient to help achieve the 2010 targets and, shifting the focus from 2010 to 2020, the EU agreed several steps to promote an increase in energy production from RE sources, which eventually led to new legally binding national targets for RE.

The first step consisted of an EU energy strategy and action plan- 'An energy policy for Europe' (European Commission 2007), endorsed in March 2007, by the EU heads of state and governments (Langsdorf 2011). Building on this, several strategy papers have defined energy developments at the EU level, the most important ones being 'Energy 2020. A strategy for competitive, sustainable and secure energy' (European Commision 2010) and the 'Energy Roadmap 2050' (European Commission 2011). Such documents pointed towards the three major challenges for European energy policy: sustainability, security of supply, and competitiveness and to what has been renamed 'the 20-20-20 climate and energy package' (see Box 4.1).

[34] The attention towards R&D and innovation came back at the top of the agenda, more recently, following the publication of the Framework for an Energy Union (European Commission 2015).

Box 4.1 The climate and energy package targets for 2020

The three unilateral targets for 2020:

- to reduce its greenhouse gases (GHG) emissions by 20% in 2020 below 1990 levels,
- to increase the share of renewable energies to 20% in its gross final energy consumption and to 10% in transport, and
- to reduce its total primary energy consumption by 20% in 2020, relative to the 2007 projections of energy consumption in 2020

Source: European Commission (2010).

Both sustainability and climate change were the key drivers of EU energy policies at that time (IEA 2014a) and, in the eyes of the EU, a fast track programme of investing in current renewables - complemented by the world's first large scale emissions trading scheme - could yield a competitive advantage to both the EU and its members (Helm 2014).

In 2014, the European Commission published a revised package of legislation on climate and energy, proposing new targets for 2030 (e.g. 40% carbon emission reduction below 1990 levels by 2030 and an EU wide target of 27% for RE by 2030). Moreover, in the aftermath of the COP21 UNFCCC negotiation in Paris, the EU has sought to push for key climate and energy goals such as those established in the 2030 Climate and Energy Framework. However, as the 2030 targets are binding only for the EU as a whole, it is unclear what implication this might have on each member state (Froggatt and Hadfield 2015). The expectation is one that requires national plans to 'set out the direction of national energy and climate objectives and policies in a way that is coherent with delivering on the commonly agreed objectives of the Energy Union, in particular the 2030 targets' (European Commission 2015, citied in Froggatt and Hadfield (2015)).

Achieving the RE production targets in Europe has required significant investment in RE projects. This has had a two-fold effect. On the one hand, nation states are urgently challenged with achieving a significant increase in the deployment of RE; on the other, at

European level, this has given rise to a debate around the most effective and efficient way to organise policy support for RE sources (Kitzing et al. 2012). Rather than deciding on fully harmonised support systems, where the policy types are decided top-down and implemented by all Member states, a decision was made to allow all EU countries to exercise their independence in the choice of policy types and support schemes (Kitzing et al. 2012). This has led to a range of support mechanisms[35] being applied in different countries (Haas et al. 2011; Kitzing et al. 2012) (see Table 4.1). While every EU country has implemented at least one of the major instruments, in 2011 according to Kitzing et al. (2012) an economic incentive in the form of subsidies- the Feed-in-Tariff schemes (FiTs) and its variants- and investment grants were among the most popular. Although national policy support has increasingly become aligned across the EU member states, support scheme choices are often influenced by different resource endowments and national priorities etc. This is reflected in different attitudes to particular sources – for instance, nuclear and/or coal, which are important in some countries but rejected in others (Keay 2016).

Support for RE technologies fall into two broad categories: public R&D support and deployment/diffusion support (del Río and Bleda 2012; Uyarra et al. 2016). The latter includes FiTs, quotas with tradable green certificate and bidding/tendering schemes. Both types of support have been regarded important for driving innovation; nevertheless, demand-pull and technology-neutral instruments, it is argued, tend to promote the deployment of mature technologies and later stages of the innovation process.

[35] Support often entails a differentiated approach through which policy differentiation is mostly related to technology types and installation size. Moreover, countries have combined several instruments in their policy support (e.g. FITs are often used for small installations and tendering schemes for larger installation sizes) (Kitzing et al. 2012).

Table 4.1 Choices of support instruments for Renewable Energy

Major support instruments
Feed-in tariffs (FIT)
Feed-in premiums (FIP)
Tenders (TND)
Quota obligations with tradeable green certificates (TGC)
Supplementary support instruments
Public R&D
Investment grants (INV)
Fiscal measures (TAX)
Financing support (FIN)

Source: Kitzing et al. (2012)

Interestingly, at the national state level the different emphasis and relative importance of the three energy policy objectives of security, sustainability and affordability has changed over time and these policy objectives have, quite often, been joined by other objectives such as industrial development. In summary, governments intervention to support RE not only ranges from the energy, climate and sustainable development agendas, influenced by the mounting pressures at the international level, but also from growth strategies at different spatial levels, encompassing several policy domains (such as environmental, technology, and industrial policy). R&D and innovation support, and more broadly industrial policy initiatives, in the RE sectors are regarded as key in resolving the 'trilemma' of affordability, security, and sustainability of energy supply (Uyarra et al. 2016) as well as maximising opportunities to grow green economies (OECD 2011).

The way in which governments are intervening to promote the deployment of RE technologies is the subject of the next sections of this chapter, focussing on the cases of Italy and the UK.

4.3 The Renewable Energy System in Italy

4.3.1 Main characteristics of the Italian energy system and the path to renewable energy

What marks Italy, and its energy system, as different from some of its economic competitors is the nature of its primary energy sources, which highlights its vulnerability. Natural gas is the largest single source of generation, together with a low share of coal in electricity supply and it has no nuclear power deployed[36], making the country heavily dependent on imported fossil fuels and electricity from neighbouring countries[37]. This lack of considerable fossil-fuel natural stocks (Italy has limited domestic coal and moderate gas resources) resulted, historically, in the use of natural renewable resources, such as geothermal and hydroelectric, in order to maximize the self-generation quota of total energy consumption.

Since the beginning of the twentieth century, in Italy, a new geography of energy resources started. This involved the investigation of the hydrography of the peninsula (Enel 2010) and the introduction of several legislative initiatives that contributed to the creation of new opportunities for exploiting hydroelectric resources, including building hydroelectric plants, reservoirs and storage capacity. The exploitation of water was seen as a way to overcome the structural constraints on the Italian economy and its industrialization constituted by the scarcity of coal, with the water resource becoming the 'white coal', which would ensure Italy all the energy it needed for its industrial take-off (Enel 2010). Although, traditionally, hydropower has been the dominant form of renewable electricity in Italy, the country has also a long history of geothermal electricity production that started at the beginning of the 20th century. All geothermal plants in operation - there are approximately 304 production wells in operation alongside 62 reinjection wells and 125 wells used for reserve or field control

[36] Although Italy was one of the countries that had one of the earliest nuclear power programmes in Europe (IEA 2010) following an overwhelming opposition in the referendum held in November 1987, nuclear energy production was abandoned. A signal to revive nuclear energy production in 2009 occurred when the Italian government appointed a committee of experts to study the technical, economic and social implication of nuclear energy. The committee was tasked with choosing the most suitable sites and indicating the steps with which nuclear power plants can be established. The construction of new Italian nuclear power stations was planned to start in 2013. Yet a new referendum in 2011, opposed the interest and revival of nuclear energy in the country.

[37] Moreover, Italy has also some of the highest energy cost in IEA Europa (IEA 2016).

- are located in Tuscany and are owned and operated by Enel Green Power[38]. Despite the high share of RE in the electricity generation mix, growth in electricity generating capacity in the early 2000s was largely due to an increase in gas-fired production, leading to increased dependency on imported gas.

With the privatisation process[39], which started shortly after the Bersani Decree in 1999, the Italian government implemented a number of institutional reforms that led to the dismantling of the monopoly of the Ente Nazionale Energia Elettrica (ENEL), the state-owned electricity provider[40]. Although struggling during the initial stage of liberalisation and market reform of the electricity market, the Italian government has put in place the necessary institutions and market design to allow a competitive electricity market to develop, unbundling transmission and generation ownership[41].

The deployment of RE sources has been seen as one of the priorities of Italy's energy policy for some time. The growing contribution in terms of RE sources has traditionally been seen as a way to tackle the vulnerability of the Italian energy system, in terms of the limited coal and gas resources, and increase security of energy supply[42]. Yet, the overall strategy for RE has been heavily influenced by efforts to fulfil the EU's 20-20-20 commitments. Exploitation

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[38] Enel Green Power is Enel's subsidiary dedicated to international development and management of power generation from renewable sources.

[39] Energy liberalisation started in Italy much later than in the UK.

[40] Italy's electricity industry has experienced 30 years of progressive concentration of activities in the hand of the state since the creation of ENEL, the national electricity board, in 1962. Nowadays, Enel is the largest Italian electricity company operating globally in the field of electricity generation. Enel manages the majority of the Italian electricity distribution network and offers an integrated package of electricity and gas products and services to its Italian customer base. Enel, in terms of installed capacity, is still, by far, the largest owner of generation, with 31% of the market share (Edison, the second largest one, account for only the 5.2%) (IEA 2016) 2016). Enel is also the largest producer in Italy at 25% of total generation in 2013.

[41] The electricity sector was unbundled in November 2005, resulting in the establishment of a fully independent transmission system operator (TERNA), who owns 98.3% of the country's electricity transmission infrastructure. In addition there are 139 distribution operators, of which Enel Distribuzione is the largest, accounting for 85% of market share (IEA 2016).

[42] The National Renewable Energy Action Plan (MISE 2010), published in 2010, in line with Directive 2009/28/EC lists the main objectives of renewable energy policy in Italy as: increasing energy supply security and reduction in energy costs for businesses and individual citizens, promotion of innovative technology, environmental protection (reduction in polluting and greenhouse gas emissions), and therefore, ultimately, sustainable development.

of wind energy, for instance, had already began in the early 1990s and within 5-6 years a significant number of plants had been installed, mainly located in the windier southern regions (Campania, Apulia, Sicily, Molise and Sardinia). Nonetheless, it is with the Legislative Decree 387 (DL 2003) that we start seeing a step change in RE policy in Italy. This implemented the EU Directive 2001/77/EC and set out a national framework for the promotion of RE sources, aimed, in particular, at the promotion of photovoltaic plants (Carfora et al. 2017). This was followed with a National Action Plan for Renewable Energy (MISE 2010), that confirmed Italy's contribution to the 2020 RE targets[43]. Italy was set to provide 17% of Italy's final energy consumption from RE[44] (in 2005 the share of energy from renewable sources in gross final consumption was 5.2% (IEA 2010), greatly increasing the challenges facing Italian policy makers. Moreover, according to IEA (2016), natural gas, coal and oil represented 82.8% of total generation (50.3% gas, 16.6% coal and 15.9% oil, respectively) in 2005. The remaining 17.2% share consisted of RE, including hydro (12.2%), biofuels and waste (2.1%), geothermal (1.8%), wind (0.8%) and solar (0.4%).

It was clear that reaching the Italian share of the EU 2020 objectives required a consistent intensification in the mobilisation of resources available, especially wind and solar and to some extent biomass (MISE 2010; RSE 2011). This was deemed necessary, despite the significant emphasis from the national government on the mobilisation of RE for some time via a number of support mechanisms already available (as discussed later).

Slow progress characterised RE deployment in Italy in the period between 2004 and 2009[45]. Nevertheless, since the start of 2010, Italy has experienced impressive growth in the RE sector, explained in particular by the strong increase in installations that occurred between

[43] In the framework of the EU burden sharing agreement, under the Kyoto protocol, Italy committed to reduce its GHG emissions by 6.5% below base layers levels (1990). In this respect, it is worth noting that in order to achieve these climate change mitigation goals, Italy's strategy has relied on increased use of renewable energies and energy efficiency mechanisms (such as tradable white certificates in the industrial sector, tax rebate and capital funding for the residential sector and public administration (IEA 2016).

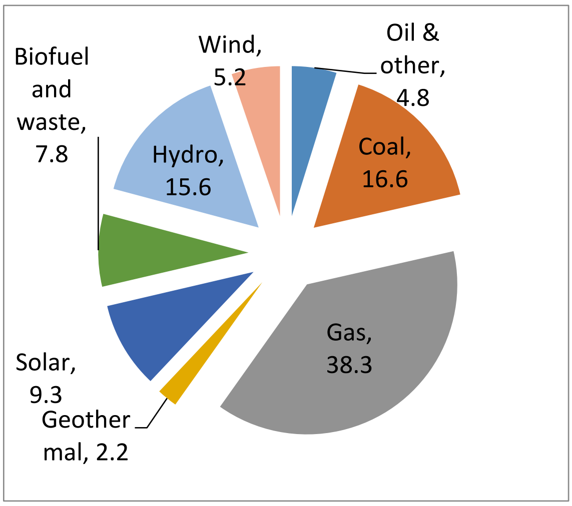
[44] A target of 26.39% by RE was established for the electrical sector and wind, biomass, and solar were the main energy sources designated to hit this target according to the National Energy Action Plan published in 2009.

[45] Bigerna et al. (2017) identify two periods of pre and post diffusion of RE in the Italian market: the period between 2004 and 2009 marked by a slow progress below 3% and the period since 2010 characterised by a constant increase in the deployment of RE sources.

2010 and 2012, most notably photovoltaics. In 2015, RE made up over 40% of total generation. Figure 4.1 shows the electricity generation by fuel type in Italy in 2015 and Figure 4.2 shows the installed capacity in RE (all sources) and its growth since 2002.

Figure 4.1 Electricity Generation by fuel type (Italy- 2015)

Electricity mix	**%**	**TWh**
Oil & other	4.8	13.5
Coal	16.6	46.6
Gas	38.3	107.5
Geothermal	2.2	6.2
Solar	9.3	26.1
Biofuel and waste	7.8	21.9
Hydro	15.6	43.8
Wind	5.2	14.6
total	100	280.7

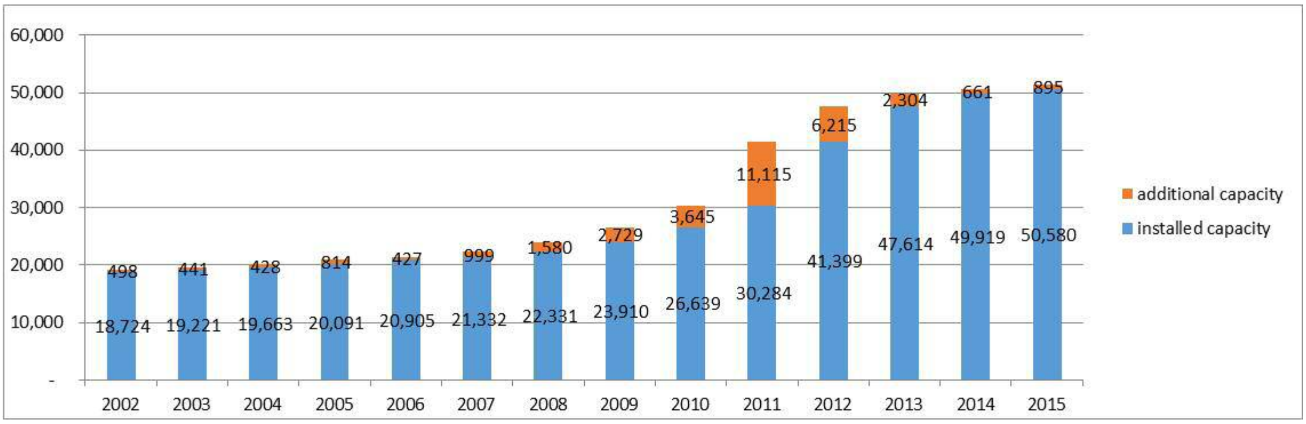


Source: IEA (2016)

It can be argued that, following pressures from European and international regulatory frameworks, Italy introduced a system of generous, uncapped incentives (subsidies and investment in RE deployment) that led it to experience, between 2010 and 2012 an impressive growth in the RE sector and an unprecedented increase in PV installation and capacity[46]. I discuss the different schemes that, some more successfully than others, supported RE deployment in the country in the next section.

[46] In 2009 the share of energy from renewable sources in gross final consumption was according to the (IEA 2010) 5.2.%, with Italy reaching the 2020 targets (set at 17% of Italy's final energy consumption), 4 years earlier than planned.

Figure 4.2 Growth of Installed capacity in RE (all sources) in Italy



Source: GSE (2015)

Note: The graph also shows the additional growth in capacity separately for each year.

4.3.2 Financial and legislative incentives for Renewable Energy

Since the early '90s, Italian governments have put in place a number of financial and legislative interventions aimed at increasing production from renewable sources (for a summary see table 4.2). The National Energy Plan of 1988 for instance set up a target of 300-600 MW of installed wind power by 2000 and several legislative requirements in 1991 provided support in the form of regional grants for feasibility studies and the establishment of RE installations. Nevertheless, it was in 1992 that a scheme of subsidised prices (CIP 6) was launched. This was followed, starting in 2002[47], by an obligation, issued on all electricity producers (and importers), to supply 2% of their power from RE sources. In order to fulfil the obligation, a market for Trading Green Certificates 'Certificati Verdi' (TGC) was created. RE operators received tradeable green certificates for their RE electricity production for a total duration of 15 years. The quota obligation was raised over the years, reaching 7.5% in 2012. However, an excess supply of green certificates required GSE (Gestore dei Servizi Energetici) to temporarily buy back the green certificates, increasing the costs of support for RE to the national government. Administrative and bureaucratic burdens and grid limitations limited the success of the scheme to increase the demand for RE and consequently to increase RE

[47] PV integrated solar have also been supported since 2001 with a '10,000 PV Roofs' initiative. According to this policy, PV systems with rated power from 1 to 20 kW received capital subsides equal to 60–70% of the total purchase, installation, and design costs.

supply (Malandrino and Sica 2011). These problems together with its excessive costs resulted in the withdrawal of the scheme by 2013.

Green certificates were issued for wind, biomass and other forms of electricity from RE sources, except solar. A specific programme for solar PV was introduced by Legislative Decree 29 December 2003[48]. This established an incentive program 'Conto Energia' (Energy Account) that provided a system of incentive tariffs for the production of electricity from solar PV plants, covering both the electricity fed to the grid and the electricity used for auto consumption. From 2005 (First Conto Energia) to 2013 (end of Fifth Conto Energia), Conto Energia provided five different legal frameworks (for a detailed review of the 5 frameworks see Di Dio et al. (2015)). They introduced feed-in and premium feed-in tariffs, with different value depending on the type of installation (e.g. integrated or non-integrated plants, such as those located on the ground on open fields) and peak power output, providing details of the classification of different type of PV installations supported and the values of the related FITs (Antonelli and Desideri 2014). While the First Conto Energia had limited success due to complex authorization procedures and inertia in the administrative processes, the Second Conto Energia, with simplified authorisation procedures for obtaining the FITs, contributed to a high growth of PV plants in Italy.

This did not occur without problems. Firstly, while the scheme (with the Second Conto Energia) foresaw a 2% reduction of the incentivised tariff between 2009 and 2010, no cap was set on the overall amount of installations and power output. Moreover, the incentive was kept constant throughout the 20 year period[49]. The incentives provided by the Second Conto Energia (that lasted until 2010) were calibrated on the Italian PV plants' costs (modules, inverters, etc.) for the year 2007 (Di Dio et al. 2015). Despite the decreasing costs for PV installations[50], a reduction of FiTs was not considered and a strong reduction of the tariffs

[48] Until then, only capital subsidies were used to support building mounted PV systems with capacity up to 20 kW.

[49] It was only the fourth and fifth versions of Conto Energia that established time-decreasing tariffs.

[50] Photovoltaic technology costs have fallen by about 70% from 2008 to 2012.

only occurred after 2011. A delay of almost two years in the FIT reduction resulted in a large uptake of PV plants and in an unbearable peak of the cost of the Italian PV FiTs mechanism[51].

The Italian government also realised that the investors market had focused on MW size plants, with several installations on open fields, while the 2008 scheme was based on the assumption that large plants were those with a power output higher than 20 kW (Antonelli and Desideri 2014). While a cap system was introduced to reduce the size of projects eligible, it was with the fifth Conto Energia that severe limitations to the access of FiTs for large scale PV facilities were introduced. This also included a cap on the support payments of €6.7 billion Euro. This was reached in June 2013 and the system has now been discontinued.

Most of the incentives reviewed here have now expired. Those remaining in force (Decree of July 6th 2012) are FiTs and premium FiTs for other renewables, such as wind, hydroelectric and geothermal, other than solar PV, and a support scheme for solar thermal electricity (Conto Termico). The Decree of July 6th 2012 included a cap on national spending for renewables incentives (set to a maximum of €5.8 billion in public funds per year), including a cap on public funds which may be used to support the refurbishment and/or rebuilding of existing plants (as wind and hydro plants reach the end of their induced term). Since the reduction in incentives, PV growth has slowed down and the only incentive available for new PV installations is a tax credit, which covers integrated PV in households. This amounted to 36 % of the cost of the PV installation in 2016.

This RE deployment success has also been supported by a number of regulatory interventions i) to distribute the national targets at the regional level under a 'Burden Sharing' principle; ii) facilitate grid access and connections and iii) to simplify the regulatory and non-regulatory barriers of administrative and planning procedures.

Under the principle of burden sharing the national targets (set under the EU commitment for 2020) have been distributed at the regional level, leaving the regions to decide on the mix of RE sources that will contribute to reach the target (DM 2012). In terms of grid access and connections (cf. IEA 2016), the Italian regulation has established that grid operators are

[51] It is argued that as FiTs are not paid via national taxes but are charged on the electricity bills, Italian energy users will be paying each year a surcharge of 9 billions euros on their energy bill (Antonelli and Desideri 2014).

obliged to give priority access to RE plants in the operation of their grids. They are also obliged to give priority dispatch to electricity from renewable sources subject to the security of the electricity systems. Moreover, plant operators can also request their grid operator to expand the grid if the connection of a plant requires this expansion or proceed to construct their own connections where works do not involve interventions on the existing electricity grid. The simplification of the authorisation process and planning procedure for building and operating all types of RE projects was supported by the Legislative Decree 387/2003 (DL 2003). The Decree introduced a simplified authorization process for new RE plants[52]. It identified a period of 180 days (from the start of the authorization process) under which the Region or another delegated authority (e.g. provinces delegated by the regions)[53], in compliance with local environmental and town planning laws, would issue or refuse such authorization[54] .

The national Government was also set to provide a set of guidelines (‘*Linee Guida’*) for the siting of the renewable plants under the principle that RE installations (and the infrastructures required for the operation of the plants) were considered of public utility, urgent and that could not be deferred. Under these Guidelines, the regions were required to indicate areas and sites unsuitable for the construction of specific types of production. However, the national guidelines were issued only in the second half of 2010 (Figure 4.3 summarises the legislative interventions and their associated timelines), seven years later than the originally planned date, leaving regions, in the meanwhile, to legislate in their absence. I will return to these three issues later in the thesis.

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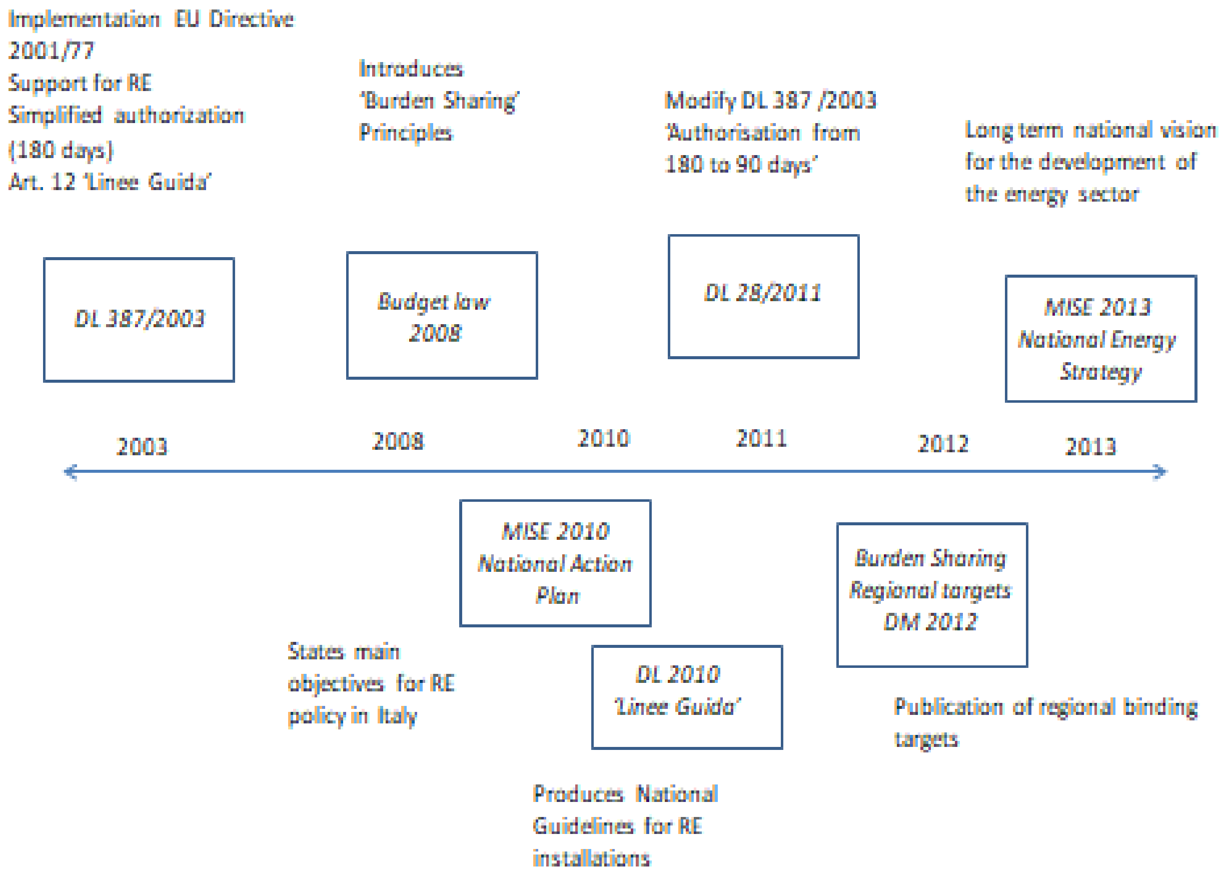
[52] New plants exceeding certain capacity thresholds, such as 20 kW for solar PV plants or 1 MW for wind farms, can be authorised through a simplified authorisation procedure, which covers permits and any environmental impact assessment.

[53] Competence for the issue of the single authorisations rests under the regional level.

[54] Decree 28/2011 further reduced the maximum duration of the procedure from 180 days to 90 days (exclusive of the timescale required for the production of the environmental impact assessment when necessary) (IEA 2016).

Figure 4.3 Timeline of Implementation '*Linee Guida*', Burden Sharing and Authorisation Procedures'



policy was marked by the absence of a clear integrated long-term vision for the development of the sector, and the exploitation of RE sources. Moreover, according to the IEA (2010), the development of energy scenarios for the country followed by their publication and open debate happened infrequently in the past. Consequently, Italy lacked a detailed road-map not only to increase the penetration of RE but also to guide Italy towards meeting its EU obligations. It is only in 2013 that the National Energy Strategy (NES) was published for consultation (and in 2017 in its finalised form), specifically 13 years after the process to liberalise the electricity and natural gas markets commenced. This characterised the support to RE. A lack of clear guidelines on energy and '*RE research priorities on which to concentrate resources*' has resulted in the inability to '*act as a system*' (Interview MISE) around major initiatives and/or hubs of excellence. This failed to provide coordination for the sector to facilitate collaboration and the more effective allocation of financial resources (MISE 2013).

Yet, the NES (MISE 2013) defined objectives, key policies, and priority measures for the energy sector for the medium (2020) and long term (2050) aiming at fostering sustainable growth by strengthening the competitiveness of the Italian economy. To some extent, introducing a stronger focus on strengthening the research and innovation system for energy (and RE) in Italy.

The next section will briefly review the energy system and the support implemented for the deployment of RE in the UK. I will return to the role of regions in both countries in section 4.6.

[55] Policy support to RE stemming more directly from the innovation and industrial policy agendas (e.g. a domestic economic policy strategy for RE that established research priorities) was lacking up until the publication of the National Energy Strategy in 2013.

Table 4.2 Main financial and legislative incentives in support of RE in Italy- Summary

CIP 6 **(a form of Feed-in tariffs)**	Programme to encourage the production of electricity from renewable and assimilated sources in the form of a scheme of subsidised prices. All the new plants submitting applications would get a contract to sell to the grid electricity produced for a period of time (up to 15 years). New RE from wind, biomass and waste was successfully deployed. It also supported cogeneration plants.	Started in 1992 and closed in 1997 with a transition to the TGC
Certificati Verdi **(Trading Green Certificates)**	Obligation on all electricity producers (or importers) to supply 2% of their power from RE sources and tradeable certificates, with exceptions for combined heat and power plants and companies generating less than 100 GWh. Banding was first introduced in 2006 and modified in 2008 in order to differentiate between RES technologies (ranging for instance from 0.8 for biogas to 1.8 for ocean energy technologies). Only wind energy and energy from waste have shown relevant growth rates. Development has been slow, even with high certificate prices ranging from 74 to 85 €/MWh between 2009 and 2012. Certificati Verdi do not support solar energy, which retains its own support scheme detailed under the Conto Energia). Main barriers identified are: slow authorisation process at the local level, high risk for investors and costly grid connections. Since the start of 2013, the RE quota scheme has been closed for access, with plants entering operation before the end of 2012 still eligible for payments under the green certificate scheme.	Started in 2002; concluded at the start of 2013. From 1 January, 2013 the quota system was replaced by a feed-in system for schemes under a given threshold and a tendering scheme for new plants (except biomass) with a capacity above the threshold.
Tariffa Onnicomprensiva	All plants except for PV plants are eligible for receiving a premium tariff. Plants with an installed power between 1kW and 1 MW (and 0.2 MW for wind farms); are entitled to choose a feed-in tariff in alternative to the premium tariff. The tariffa onnicomprensiva is an incentive tariff which is an alternative to the Green Certificates with tariffs differentiated by source.	Decree of July 6^{th} 2012 establishes a maximum of €5.8 billion in public funds which can

(All-inclusive Tariffs)	This benefit is explicitly established to incentivise small plants by easier procedures and by granting them a fixed return; this system covers all kinds of renewables for the production of electricity, excluding solar PV which is included in the Conto energia system.	be used to support renewable plants
Dedicated Withdrawal	The Dedicated Withdrawal is a simple way to place on the market electrical energy produced and fed into the grid through the intermediary of the GSE. Holders of renewable energy plants can access Dedicated Withdrawal by concluding an agreement with GSE for the withdrawal of all the energy fed into the grid. The latter pays to the producer the hourly market price of electricity in the area in which system is installed.	Decree of July 6^{th} 2012
Scambio sul Posto **(Net Metering**)	For plant's capacity lower than 20 kW (20 kW to 200 kW if commissioned after 31 December 2007). The principle of 'Scambio sul Posto' is not based on direct payments but on the balance of the energy fed in and consumed Generators who feed in more electricity than they consume do not receive any payment under the net metering scheme. If they feed in less than they consume, the difference is subject to a payment. Plant operators receive credit for electricity produced but not consumed. This credit will be available for an unlimited period of time	Started in 2009 and now regulated under the Decree of July 6^{th} 2012
Conto Energia **(Energy Account)**	**Premium FiTs** regime for Photovoltaics: a premium depending on the size and building integration of the system **All-inclusive tariffs and net metering** for smaller PV projects Second Conto Energia: permitted the PV systems that were already realized but were not connected to the grid on 31 December 2010 to use the tariffs of the Second Conto Energia, even if the Third Conto Energia was already operative. Fourth Conto Energia: sets a 23,000-MW target of PV capacity to be installed at national level. Under the scheme, feed-in tariffs are planned to be progressively reduced over time; it restrained the construction of PV plants with rated power above 1 MW and established a register of big PV;	First Conto Energia (from 2005 to 2007) Second Conto Energia (2007-2010) Third Conto Energia (2010-2011) Fourth Conto Energia (2011-2012) Fifth Conto Energia (2012- By July 2013 the expenditure cap

	With the fifth Conto Energia new rules also apply for increased tariffs under the "Made in Europe" label, which dictate that all modules and inverters must now be fully manufactured in the EU or European Economic Area and from 2012 only PV installations Integrated and PV installations with innovative characteristics Concentration PV plants could benefit. The incentive system under the fifth Conto Energia was composed of two element: a FIT for the electricity produced and fed to the grid; and a premium for the electricity produced by the PV system and used by the user for his or her own consumption. The producers could ask for FIT or net-metering for PV installations with rated power up to 200 kWp, while for rated power beyond 200 kWp, the customer could choose whether to sell the electricity produced to the local electricity provider or to use part of it for his or her own consumption. If the producer chose net-metering, he or she could also request a tax detraction equal to 50% of the total PV system cost (purchase plus installation).	(€6.7 billion) was reached and the Conto Energia V ceased its existence)

4.4 The Renewable Energy System in the UK

4.4.1 Main characteristics of the UK energy system and the path to renewable energy

The structure and governance of the energy industry in the UK has undergone profound change, with a much diminished role for the state, since 1987, and the advent of competition for most of the 90s. The advent of climate change and the return to security concerns, however, required, after the early 2000s, the need to use energy policy as the principal means of addressing green-house gas emissions, including a gradual return to some degree of co-ordination and planning (Pearson and Watson 2012; Keay 2016).

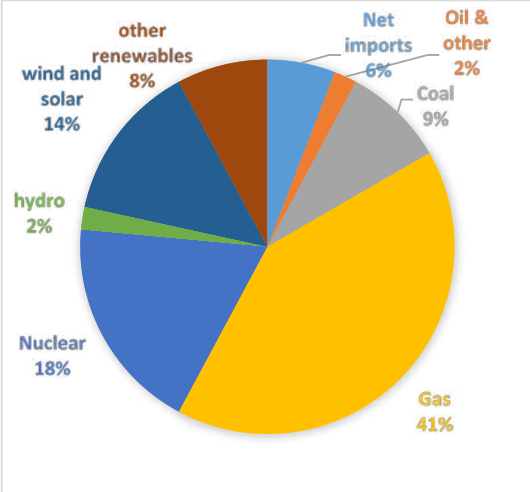
The UK was one of the first countries to liberalise and privatise its energy sector[56]. The Electricity Act (1989) laid the foundation for the privatisation of the industry, exposing the costs of coal and leading to a rapid decline of the coal industry. Some of the newly privatised power companies (particularly the so called RECs- regional electricity companies) made a '*dash for gas*', investing in combined cycle gas turbine generation, creating a huge market for gas in power generation at the expense of coal and oil. The increased exploitation of domestic gas reserves led to greatly expanded natural gas use and gas quickly become the most important fuel in the UK energy balance (Stern 2004). The UK shifted from net energy importer to net exporter and, subsequently, back again. Moreover, the 'dash for gas' also had the effect of reducing carbon, sulphur and nitrogen gas emissions as inefficient coal power plants were replaced with more efficient (and less polluting) gas-fired power plants. Whilst environmental concerns were not a central driver for energy policy at the time of the 'dash for gas', it can be argued that, according to Pearson and Watson (2012), the UK played a crucial role in the Kyoto agreement, demonstrating the UK efforts to be seen as a leader on climate change[57]. Figure 4.4 summarises the energy generation by fuel type in the UK in 2016.

[56] Gas privatisation also occurred in 1987 and coal privatisation in 1994.

[57] Similarly, at the European level, the '*UK influences European policy in what priorities they support*' (Interview DECC)

Figure 4.4 Energy Generation by fuel UK (2016)

Electricity by fuel type mix	%	TWh
Net imports	6	17.5
Oil & other	2	9.8
Coal	9	29.1
Gas	42	140.8
Nuclear	19	65.1
hydro	2	5.3
wind and solar	14	47.8
other renewables	8	26.2



Source: BEIS (2017c)

In the aftermath of privatisation, the energy systems were governed mainly by market actors and their regulators (Winskel et al. 2014). Over the past few years, policy activity has accelerated, with a succession of White Papers, consultations, Acts of Parliament, new regulatory frameworks and the creation of new policy actors. Successive governments have faced the difficult task of balancing multiple policy objectives and policy instruments, among which have been the policy 'trilemma'- ensuring competitiveness of the UK through low energy prices, securing sufficient reliable supplies of energy from national and international sources and addressing the environmental impacts of energy use (Pearson and Watson 2012). It is, however, with the 2008 Climate Change Act that the UK established a path to an ambitious low carbon plan to 2050. This consisted of a legally binding target to obtain an 80% cut on greenhouse gas emissions by 2050, it required the Government to set legally binding 'carbon budgets' [58] and set up the independent Committee on Climate Change to advise the Government on emissions targets, and report to Parliament on progress made.

Moreover, the UK was set targets under the EU Renewable Energy Directive (2009/28/EC) to meet 15% of the UK energy demand from renewable sources by 2020[59] (in 2008, the UK

[58] A carbon budget is a cap on the amount of greenhouse gases emitted in the UK over a five-year period. The first five carbon budgets have been put into legislation and run up to 2032.

[59] Scenarios for complying with the Directive entail that renewables will need to provide well over 30% of electricity produced in the UK (DECC 2009).

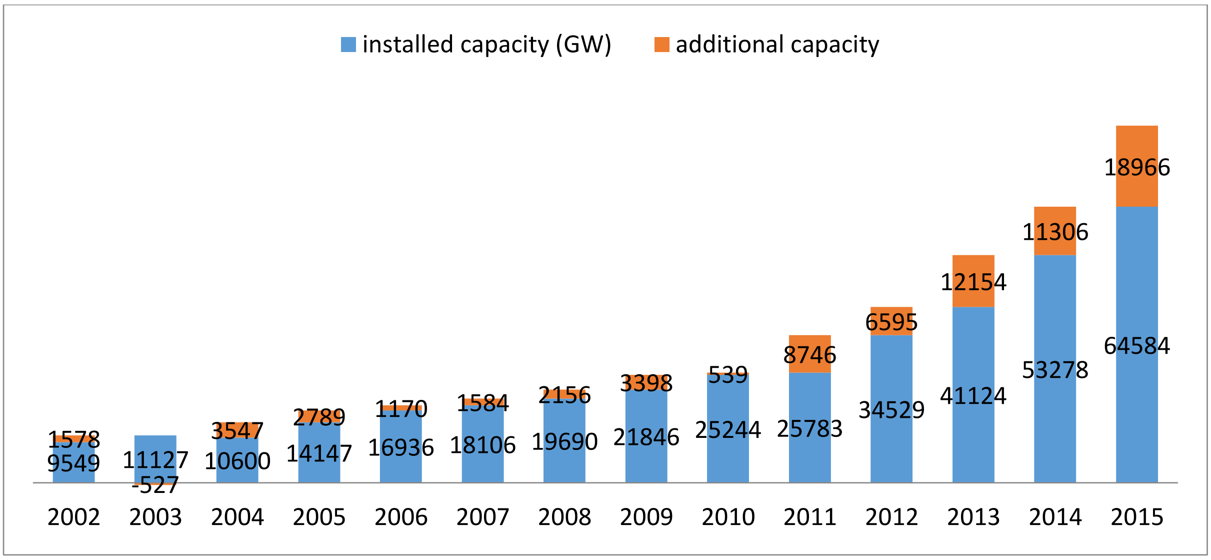
sourced about 2.3% of its energy from renewables (DECC, 2009, quoted in Woodman and Mitchell (2011)). In the same year, the UK government introduced the Low Carbon Transition Plan (2009), the Renewable Energy Strategy (2009) and the Renewable Energy Roadmap (2013-update) in order to set up a plan for policy delivery. It is with the Low Carbon Transition Plan that particular emphasis was put on the 'trinity' (Pearson and Watson 2012) of low carbon energy supply options: nuclear power, renewables and carbon capture and storage. These have also been highlighted in the Clean Growth Strategy (BEIS 2017a: 96), which has emphasised the need to continue 'bringing down the cost of low carbon generation from renewables (especially off shore wind) and nuclear power, and to ensure that the UK can deploy Carbon Capture, Utilization, and Storage at scale during the 2030s'.

These policy documents recognised a number of substantial RE resources potentially available in the UK to help meet energy and climate goals (such as wind- both onshore and offshore, marine - tidal and wave, and biomass). Nevertheless, changes to the institutional and governance settings in support of RE technologies have helped the UK to undergo rapid RE deployment and to overturn the view that the UK was a laggard in terms of deploying RE (Mitchell et al. 2006; Toke 2011). The recent development in offshore wind has contributed towards this progress. However, it has been argued, the UK is set to pay a high cost for the low carbon sources it is introducing and is doing little to secure diversity of supply (Keay 2016). Figure 4.5 shows the RE installed capacity and its growth in the UK, since 2002.

The reforms that took place to increase the share of renewables in power generation, since the early 1990s, took the shape of subsidies, institutional and organisational change, as discussed in the sections that follow. It is important to highlight that since 2010 this path to deliver ambitious low carbon targets to 2050 has been set within i) a context of austerity measures and ii) within a broader 'rebalancing' growth agenda seeking to promote sectoral diversification, overcome regional disparities and ensure a more resilient path of economic recovery and sustainable growth (Uyarra et al. 2016)[60].

[60] It needs to be noted that the package of reforms presented in these years were aimed at supporting around £110 billion investment in electricity generation and transmission by 2020, more than double existing rates of investment (Winskel and Radcliffe 2014).

Figure 4.5 Growth of Installed capacity in RE (all sources) in the UK



Source: BEIS (2016)

Note: The graph also shows the additional growth in capacity separately for each year.

4.4.2 Financial and legislative incentives for Renewable Energy in the UK

The UK has had a specific delivery programme for the generation of electricity from renewables since privatisation began in 1989. The first specific policy instrument to support renewable electricity generation (a list of the different mechanism is provided in table 4.3) was a market enablement programme, known as the Non-Fossil Fuel Obligation (NFFO) introduced in the early 1990s[61]. Although the NFFO was primarily developed to support the UK's existing nuclear industry (Mitchell 1995), it provided a means to initiate growth and support in the emergent RE industry, allowing near market technologies to reach competitiveness. The problems of the NFFO are well documented (Mitchell 1995; Mitchell and Connor 2004; Wood and Dow 2011). They mainly relate to the fact that NFFO over-optimistic bid applications, and competition drove the prices down to levels where projects become sensitive to small changes and many were not delivered. Moreover, the competitive nature of the support and the consequent need to ensure a high rate of return on investments

[61] Since the mid-1970s and up to the NFFO introduction, research and development funding and a few demonstration projects in support of RE had been the norm (Mitchell 1995).

led developers to concentrate on sites with the highest available resources, rather than trying to develop projects in areas, which may be less then optimal but might be more feasible.

The Electricity Market Reform of 2000 revised the support available, introducing the Renewables Obligation (RO), which replaced the NFFO after 2002. The RO consisted of a tradable green certificate, the Renewable Obligation Certificate (ROC), and a quota system[62] that placed a mandatory requirement on licensed UK electricity suppliers to source a specified and annually increasing proportion of electricity from eligible renewable sources.

However, the RO has underperformed, particularly with regard to set targets. Due to competition in the electricity supply market, the effort to meet the obligation focused on the cheapest available power, represented by landfill gas, on-shore wind projects and co-firing of biomass ((Mitchell and Connor 2004; Woodman and Mitchell 2011); see also De Laurentis (2013) for an account of policy support for biomass development in the UK). Less developed technologies such as dedicated biomass plants, wave and offshore wind were not deployed, as they did not receive sufficient incentive from the RO (Woodman and Mitchell 2011).

Both the NFFO and RO supported technologies that were already close to the market and favoured large vertically integrated companies over new entrants or smaller players (Wood and Dow 2011). Fine-tuning of the scheme occurred on an almost annual basis to improve its under-performance (Wood and Dow 2011; Woodman and Mitchell 2011). Changes ranged from minor and less controversial updates to more extensive ones that challenged the fundamental philosophy behind the scheme's design and the original aims of the scheme to be 'technology neutral' and to avoid 'picking winners' by prescribing certain technological choices.

Following the Energy Act 2008, the UK government introduced a Feed in Tariff for small scale renewable generation up to 5 MW that came into effect in April 2010. The tariff, differing by technology type and scale, was introduced to offer both price and market certainty to operators and to encourage the uptake of small-scale and early-stage renewables and low carbon electricity. Although the Treasury agreed a set of annual FIT budgets covering the

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[62] The proportion of renewable electricity required by suppliers to meet the obligation increased annually from 3% in 2002-2003 to 10.4 % in 2010-2011 (Woodman and Mitchell 2011).

years 2010 to 2015, following a phenomenal uptake in the first year (cf. Smith et al. 2014), a process of controversial revisions to the level of tariff provided were initiated by the then Department of Energy and Climate Change (DECC). These aimed at reducing the FIT returns in order to bring their uptake in line with planned uptake[63] and to take into account the decreasing cost of certain renewable energy technologies (such as solar and the decrease in the cost of PV hardware). While this has slowed down the development of small scale solar PV (as FiTs are available for development of projects up to 5MW), changes scheduled to the RO and the exclusion of solar from the next round of CfDs have also closed the route to market for utility-scale projects.

Despite the success of the combination of FITs for small renewables and the RO in the trend of investments and generation of output - renewable electricity generation in the UK increased from 10TWh in 2010 to almost 54TWh in 2013- government proposals on Electricity Market Reform published in late 2010 introduced a fundamental reassessment of the RO (Woodman and Mitchell 2011). This resulted in the introduction of a FIT-type mechanism (Contracts for Differences- CfDs) as the next stage in the evolution of the RO. The transition from the RO to the CfDs has represented a major change for the UK renewable electricity sector.

While RO have been phased out from 2017[64], the new policy support mechanism entered into force in 2013. Rather than introducing a premium FIT, where a fixed premium is paid on the top of the market price, the UK Government preferred the introduction of CfDs. The choice of CfDs was justified on cost grounds (as CfDs are projected to be less costly for consumers) and low carbon generators are exposed to market forces by requiring them to find buyers for their output under the CfD model (Woodman and Mitchell 2011). The CfD will eventually replace the Renewables Obligation (RO) and expands support from just renewables to include

[63] After a public consultation, and a court challenge over the proposed timetable, DECC, with changes coming into effect on the 1st of August 2012, introduced a sliding scale of returns linked to the uptake in a given three month period.

[64] Solar projects over 5MW in size will no longer be eligible for the Renewable Obligation scheme from April 2015, leaving the new mechanism, the CfDs, as the only available support mechanism.

new nuclear[65] and Carbon Capture and Storage as well. The UK Government has also introduced a cap to the overall level of spending via the ‘Levy Control Framework’ (Keay 2016). Nevertheless, it is the success of the first round of the CfDs that triggered a number of further changes, since the mechanism used an overspend within the Levy Control Framework[66].

While the introduction of CfD auctions has certainly helped create more competitive pressures, there have also been criticisms of the decisions to withdraw support from the cheapest of the new renewable sources, such as onshore wind and solar and to pay a high cost for the low carbon sources it is introducing (Keay 2016). This, to some extent, represents a step towards a broader ‘rebalancing’ growth agenda that seeks to ensure a more resilient path of economic recovery and sustainable growth.

Moreover, the problem associated with obtaining planning permission for new onshore wind, has triggered changes in the planning process, with numerous revisions of government planning guidance over the years. However, these attempts to improve the approval rate met a strong opposition in rural England, resulting in an attained greater national political salience with the election of a coalition government dominated by the Conservative Party. On the one hand, more restrictive planning approaches to on-shore wind were implemented in England, including demoting large on shore wind farms from ‘nationally important’ infrastructure status[67]. On the other hand, pressures from Conservative MPs has also informed actions with a wider spatial reach, that resulted in the scaling back of market support for on-shore wind, as mentioned above, limiting the opportunities for significant increases in onshore wind. I will come back to this point later in this chapter.

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[65] The nuclear ‘renaissance’ supported by UK politicians between 2006 and 2010 was partly driven by utilities such as EDF, E.ON and RWE, which argued in many for the UK government to promote new nuclear deployment to mitigate energy related GHG emission (Anadón 2012).

[66] These changes were set in a so-called ‘reset’ speech by the UK Energy Secretary Amber Rudd, after the 2015 Election (Rudd 2015). During the ‘reset’ speech, the Government confirmed that both onshore wind and solar would be excluded from the next CfDs allocation round, expected later in 2016. In the three months after the 2015 election, the Tories oversaw the scrapping of a tax exemption for renewable energy, the end of subsidies for onshore wind, a budget cut for DECC and the projected selling off of the Green Investment Bank.

[67] This, especially in England, signified that powers for consenting projects over 50 MW are moved away from the central government to local government, facilitating the emergence of differentiated local and social responses.

As in the case of Italy, the UK has also put in place a range of supply side instruments to directly promote research and technology development in the RE sector, such as the provision of R&D grants, loans, tax credits and venture capital (Uyarra et al. 2016) to respond to more urgent imperatives, such as that of security of supply (Winskel and Radcliffe 2014). This signals that the policy agenda for rebalancing the UK economy away from financial services and towards manufacturing has become more salient, with offshore wind becoming a key sector for the UK (cf. BEIS 2017b). Such RE resource is portrayed as a key means through which the UK can create economic added value, delivering energy security and sustainability of energy supply[68] (Toke 2011; Kern 2012; Kern et al. 2014; Wieczorek et al. 2015; Uyarra et al. 2016).

Although similar narratives have been also used to advocate other RE such as PV (see for instance Smith et al. (2014)), within offshore wind, the interest shown by large firms in combination with support from key public bodies has given offshore wind a particular weight (Kern et al. 2014). It seems, therefore, that offshore wind has become the only remaining option for large-scale RE development in the short to medium term, despite the fact that it is the most expensive, commercially available, RE technology (Keay 2016). The claim that the UK, in offshore wind, has 'better resources than anyone else proportionally' has been promoted within different government organisations, industry associations, including the British Wind Energy Association (now known as RenewablesUK) (Kern et al. 2014), contributing to its rapid success.

Interestingly, the narrative around offshore wind has also offered an opportunity to respond and rapidly deploy large quantities of low carbon electricity, when political pressures for the expansion of renewable electricity mounted. The fact that offshore arrays are authorised by central government, with local authorities having no more than a consultative role, has provided an advantage for development projects. What is important to highlight is that the narrative of producing large quantities of RE away from people's local amenity concerns was compelling enough to promote changes in the national institutional framework (cf. Kern et al. 2014).

[68] This shift also embraces other large-scale options such as nuclear power, as argued above.

Table 4.3 Financial and legislative incentives to renewable energy innovation and deployment in the UK*

Policy Instruments	Time frame	Components	RE supported	Problems/ criticism
Non-Fossil Fuel Obligation (NFFO)	From 1990-2002 (Auction mechanisms run between 1990-1998 with a total of 5 auctions)	Market enablement programme paying a premium price for electricity from near market technologies. This facilitated facilitating primarily the award of particular projects and supporting specific technologies.	Wind, landfill gas, waste and bioenergy; Renewable electricity generation grew slowly- from 2% to 3% of the UK total for the duration of the policy support; 30% of all NFFO projects reached the commissioning stage	Drove prices down to levels where projects became sensitive to small changes. Changes to sites measurements, technology selection and financial structures caused projects to become uneconomic at a later development stage. Only companies with sufficient equity were able to cope with the high uncertainty, resulting in a trend towards consolidation within the industry with mainly large utilities among the successful bidders. Whereas independent developers entered the process, they were subsequently bought up by the utility companies.
Renewable Obligation (RO)	2002- 2009	Tradable green certificate, the Renewable Obligation Certificate (ROC), and a quota system that places a mandatory requirement on licensed UK electricity suppliers to source a specified and annually increasing proportion of electricity from eligible renewable sources.	Effort to meet the obligation focussed on the cheapest available power represented by landfill gas, on-shore wind projects and co-firing of biomass	RO has not been successful in promoting diversity, whether technological or by actors involved. RO was not designed to reduce risk for investors but emphasised competition between technologies. The RO mechanism continued to favour large development companies that were able to finance projects off their own balance sheet. The choice of separating trades in physical electricity and the RO certificates presented significant transaction costs to new market entrants, facilitating vertically integrated companies that were able to trade certificates in-house among their subsidiaries.
	2009- to be phased out by 2017 and replaced by CfDs	Introduction of bands of support (a system that provided more ROCs to less developed technologies such as offshore wind); and suppliers' cap to limit renewable energy deployment for some technologies. Changes were also made to prevent a ROC price crash if the annual target of RO was met or nearly met.	To encourage the development of more emergent technologies Main policy mechanism supporting projects over 5 MW; solar projects over 5MW in size no longer eligible from April 2015, leaving the new mechanism, the CfDs, as the only available support mechanism for large solar.	Despite the success, while RO were supposed to remain the main policy mechanism supporting projects over 5 MW, government proposals on Electricity Market Reform published in late 2010 introduced a fundamental reassessment of the RO as a support mechanism for encouraging renewables deployment

Policy Instruments	time frame	Components	RE supported	Problems/ criticism
Feed-in Tariffs (FiTs)	2010- from 1st of August 2012 DECC introduced a sliding scale of returns linked to the uptake in a given three month period.	A Feed in Tariff for small scale renewable generation up to 5 MW; The tariff differs by technology type and scale and consists of two separate payments for generators (Each unit generated by micro-generators and each unit exported to the National Grid are financially rewarded by the scheme)	Domestic, commercial, industrial and community installations for solar photovoltaics (solar PV), wind, hydro, and micro combined heat and power (mirco CHP) have received support.	Although the Treasury agreed a set of annual FIT budgets covering the years 2010 to 2015, following a phenomenal uptake in the first year, a process of controversial revisions to the level of tariff provided were initiated by DECC. These aimed at reducing the FIT returns in order to bring the uptake in line with planned uptake and to take into account the decreasing cost of certain renewable energy technologies (such as solar and the decrease in the cost of PV hardware).
Contracts for Differences (CfDs)	2013-	Developers receive a long term contracted tariff for their output set above the market average price of power. A financial support mechanism for low-carbon generators in the form of a contract between the generator and a government-owned counterparty.	The first auction took place in February 2015 and 27 projects received more than £315m to provide more stable financial incentives to invest in all forms of low-carbon electricity generation expands support from just renewables to include new nuclear and Carbon Capture and Storage (CCS) both onshore wind and solar have been excluded from the CfDs allocation round, in 2016	The choice of CfDs was justified on cost grounds (as CfDs are projected to be less costly for consumers) and low carbon generators are exposed to market forces by requiring them to find buyers for their output under the CfD model; The CfD arrangements offer greater certainty for winning projects, leading to lower finance costs and the cost of projects. However, the auction does present the same risk that caused some of the NFFO projects to never get off the ground: projects where the economics are marginal become sensitive to small changes (such as lower yield from renewable energy resources or higher grid connection costs, among others) causing projects to become uneconomic at a later development stage:
				Two out of the five large scale solar projects that were successful in the allocation round in February 2015 have since collapsed after being deemed uneconomical at strike prices of £50/MWh[69]

Sources: Author's elaboration from Wood and Dow (2011); Stenzel and Frenzel (2008)

*Note: Northern Ireland is not included in the analysis as Northern Ireland has its own systems and complexities.

[69] Stoker, 2015 'Solar to be excluded from next CfD round, uncertainty remains over future allocations available at http://www.solarpowerportal.co.uk/news/solar_to_be_excluded_from_next_cfd_round_uncertainty_remains_2349

4.5 The role of regions in renewable energy governance in Italy and the UK

While the previous sections have discussed the international and national institutional frameworks in support of RE, I now turn my attention to the regional level. As the arguments presented above show, the national level, in both countries, continues to retain considerable power over energy policy. Both countries have national responsibility for the design of systems of market support and regulation. Besides this, the negotiation on energy-relevant policy, at international and European levels, also resides with central governments. Table 4.4 summarises the governance capacity over energy at the regional level, in both Italy and the UK, and I will return to this in later chapters. However, here I want to highlight that both countries have started a process of distribution of power towards the regional level.

In Italy, a process of multi-level energy governance characterises the Italian energy system. Energy production, transportation and distribution are subject to concurrent legislation between state and regions (Art.117 Italian Constitution). The constitutional reform of 2001 gave greater policy authority to the Regions for climate change and energy efficiency policies as well as infrastructure planning, development and consenting processes. The constitutional reforms provided a new framework for sharing regulatory competences between the State and the Regions, and while the national government provides an overarching framework for RE development - and the economic incentives for the promotion of RE - regions have responsibility for the areas described in the box below (Box 4.2).

The Regions and the autonomous provincial governments produce their own Regional Energy Environmental Plans (PEARs)[70]. These establish regional energy policy objectives and, while PEARs were adopted as early as 2000, provisions for RE were only made more explicit in later updates.

[70] From 2001 the Regional Energy Plans (PERs) were called Regional Energy and Environment Plans (PEARs), recognising the role that these plans needed to play for the reduction of greenhouse gases and requiring a strategic environmental assessment of the measures included in the plans. The PEAR is a reference frame for public and private agents with energy initiatives in an Italian region.

Box 4.2 Areas of responsibility for the regional level

- Formulating political objectives for regional energy and limiting greenhouse gases as envisaged by the Kyoto Protocol;
- ‘Burden sharing’
- The development and exploitation of endogenous resources and renewable resources;
- The location and construction of district heating equipment;
- Issuing of hydroelectric concessions;
- Energy certification of buildings;
- Guaranteeing safety, environmental and territorial compatibility;
- The security, reliability and continuity of regional supplies;
- Making legislative and regulatory provision for authorisation procedures and the operation of energy production plants.

Furthermore, Italian regions have a high degree of autonomy in relation to the planning and development of their own innovation and industrial support programmes. More specifically, regions have been traditionally in charge of the promotion of applied research, innovation and technology transfer programmes and projects. While basic research has often been the exclusive competence of the central government, some regions have introduced instruments to support basic research. Research and innovation policies are carried out at regional and local levels by their regional research, development, and innovation departments alone or in collaboration with regional innovation agencies and they have played a significant role in channelling EU funding (e.g. EU framework programmes for research and technological development) for energy research and demonstration grants.

In the UK, as discussed, the main policy-making powers and capacity lie in Westminster. Although none of the devolved administrations, with the exception of Northern Ireland, have full competencies over energy policy, in Scotland and Wales the competencies in this area differ (these are summarised in table 4.4 and for a discussion on the differences across the devolved administrations see also Cowell et al. (2013)). Scotland’s energy policy is ‘executively devolved’, which gives Scottish Ministers full control over major consents and planning, onshore and offshore, and some operational control over market support systems. In Wales, the Welsh Government has the fewest powers (the most relevant being planning policy and overseeing planning consent).

Table 4.4 Overview of the formal distribution of energy related powers in Italy and the UK at the regional level

		Energy Policy	Provision of Market support for RE	Planning and Consents	Economic Development spending
Italy					
	Regions*	*Concurrent Legislation*	None	Strategic planning; General planning power for RE varies across regions Provision for authorisation procedures and operation of energy production plants.	Regional innovation and industrial support programmes; EU framework programmes for research and technological development
UK					
	Wales	No Powers	No powers	onshore: partial powers over planning policy and consent for smaller schemes <50 MW** offshore: Power to determine applications up to 1 MW	Fully devolved
	Scotland	*Executively devolved*	Executive Devolution of some support Schemes	onshore: Fully devolved offshore: Fully devolved	Fully devolved

* Italy is organised into 20 Regions, including four autonomous Regions and two autonomous Provinces.
** Application over 50 up to 350 Mw to be determined by the Welsh Government under the Wales Bill 2016; over 350 MW centrally by UK government.

Source: Author's elaboration following Cowell et al. (2017)

However, all of the devolved governments have received responsibility for discretionary economic development funding for energy-related projects. Both Wales and Scotland have published RE policies, created route-maps and pathways on renewable and low carbon energy and construct future targets for RE deployment in their territory.

In both countries, regions, with the exception of Scotland, have had little control of market support systems, and these have been applied consistently, without differences at the regional level in the two countries. However, in the UK, although FiTs have operated in a consistent way across England, Scotland and Wales, in a process managed by Ofgem, the RO, was formally broken up into three separate mechanisms. One for England and Wales (with Wales having no autonomy), and the other two for Scotland and Northern Ireland. Scotland has used its power to emphasise different technologies (such as marine energy). As I will discuss later, although Scotland altered the RO for emergent technologies, this power has not been very important in shaping the overall volumes of RE deployed on the territory. Yet, Scotland benefitted from being part of an integrated, UK-wide pool of market support (cf. Toke et al. 2013). One issue is important to highlight here. With the changes in the market support mechanisms, and the introduction of CfD, Scotland has lost is power to control energy market mechanisms[71], and the UK government has now a greater role in setting future mechanism across all devolved regions (Toke 2014; Upton 2014).

The tables (4.5, 4.6, 4.7, 4.8) below show key demographic data and differences in number of sites and generating capacity by source in the regions under investigations. The arguments presented in the reminder of this thesis, I argue, can help explain the spatially uneven processes of RE in these regions.

[71] The CfD is set to finance nuclear energy and the Scottish Government has opposed this mechanism as it is taking away resources from renewables to finance new nuclear capacity (Toke 2017). Moreover, the Scottish Government's target of supplying the equivalent of 100 per cent of Scottish electricity demand from RE by 2020 seems unlikely to be achieved as financial support for onshore wind energy has been haltered.

Table 4.5 Regional differences: key demographics (Italy)

	Italy (total)	Apulia	Sardinia	Tuscany
area (km2)	301316	19358	24090	22994
population	60782668	4090266	1663859	3750511
density	201.72	211.30	69.07	163.11
KW/ GVA € Millions 2011	35.75	83.30	75.58	23.42

Sources: Istat (2012); Eurostat, authors' calculation from GSE (2014)

Table 4.6 RE in Italy: Regional differences in n. of sites and generating capacity by source (2014)

	Italy (total)		**Apulia**		**% of total**		**Sardinia**		**% of total**		**Tuscany**		**% of total**	
renewable energy	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**
hydro	3432.0	18417.5	6.0	2.3	0.1	0.0	18.0	466.7	0.5	2.5	159.0	353.9	4.6	1.9
solar PV	648418.0	18609.4	41527.0	2585.9	6.4	13.9	30222.0	715.9	4.7	3.8	34048.0	739.8	5.3	4.0
wind	1847.0	8703.1	572.0	2339.3	31.0	26.9	118.0	966.7	6.4	11.1	89.0	121.9	4.8	1.4
geothermal	34.0	821.0			0.0	0.0			0.0	0.0	34.0	821.0	100.0	100.0
bioenergy	2482.0	4043.6	50.0	292.3	2.0	7.2	32.0	89.1	1.3	2.2	138.0	186.4	5.6	4.6
wave and tidal														
total	656213.0	50594.6	42155.0	5219.8		**10.3***	30390.0	2238.4		**4.5***	34468.0	2223.0		**4.4***

*% of Total RE regional generation capacity on total Italian

Source: GSE (2014)

Table 4.7 Regional differences: key demographics for Scotland and Wales

	UK	Wales	Scotland
area (km2)	243610	20761	80077
population millions	64351200	3063456	5295000
density	264.16	147.56	66.12
KW/ GVA£ Millions 2014	15.83	34.77	61.77

Sources: ONS Population Estimate 2014; Authors' calculations and DECC (2015)

Table 4.8 RE in the UK: Regional differences in n. of sites and generating capacity by source in Scotland and Wales (2014)

	UK (total)		Wales		% of total		Scotland		% of total	
renewable energy	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**	**n. of sites**	**generating capacity (MW)**
hydro	914	7878.0	142	157.8	15.5	2.0	377	1507.6	41.2	19.1
solar PV	650309	5377.3	38914	375.8	6.0	7.0	39582	155.6	6.1	2.9
wind	7878	12987.5	468	1172.2	5.9	9.0	2736	5215.8	34.7	40.2
geothermal										
*bioenergy**	1050	4526.1	52	104.5	5.0	2.3	85	348.0	8.1	7.7
wave and tidal	12	8.7					9	7.4	75.0	85.1

** this includes: landfill gas, sewage gas and other bioenergy*

Source: DECC (2015)

4.6 Concluding Remarks

In this chapter, I have focused attention on a set of issues that are of relevance for this work. Firstly, I have highlighted the pressures and influences that have arisen from European and international policy and governance frameworks and how they have influenced and shaped RE support frameworks at the national level. This occurred, as shown, via targets and the urgency of fulfilling EU commitments to 2020 but also via the opportunities offered in playing a leading role in supporting climate adaptation and mitigation (especially with regards to the UK). National institutional and governance frameworks for RE have been developed reflecting the particular characteristics of each country's energy system (e.g. historical trends, privatisation and energy system's path-dependence), but also due to different resource endowments and the need to prioritise different national objectives.

Secondly, both countries have been subject to similar pressures from European and international regulatory frameworks, introducing systems of measures, such as subsidies, to incentivise RE deployment to achieve the EU 2020 targets. In Italy, to some extent, due to the absence of a national energy strategy and/ or a clear roadmap for RE, RE deployment occurred driven mainly by market forces, aimed at exploiting resources, especially wind and solar natural resources, favoured by support mechanisms that ensured high remuneration for large scale investments. In the UK, on the contrary, the overall design of RE support described above reflects the UK government's general approach to energy policy, with a commitment to reducing greenhouse gas emissions while minimising government intervention in markets (cf. Woodman and Mitchell 2011; Keay 2016). As shown, within the main support schemes deployed, such as the RO and CfDs, competition is seen as a key element to drive costs down.

Thirdly, as this chapter shows the two countries share, to a varying degree, responsibility for energy policies with regional governments. As shown in chapter 3, there are differences in both countries in the regional distribution of RE, despite the fact that the financial incentives for deployment have been applied consistently (except for Scotland) at the regional level, in the two countries. It is therefore necessary to investigate further the factors that can explain such spatial unevenness and regional variation in RE deployment. The remainder of this thesis aims to do so. The next chapter introduces a novel way of researching RE deployment that investigates the relationship between materiality and energy, drawing from an approach to the analysis of materiality developed in the extractive industries literature, including fossil fuels, arguing that such framework can help in identifying the factors that contributes to the uneven processes of RE deployment.

Chapter 5

Developing an analytical and conceptual framework to study renewable energy deployment at regional level

Summary

The previous chapter has highlighted how pressures for change and key regulatory and support mechanisms have supported RE deployment in both Italy and the UK. The account presented in Chapter 4 has started to highlight that the scale at which RE deployment is investigated matters and regional specific institutional structures, in both Italy and the UK, can be important to investigate the uneven deployment of RE. How these differences can be captured and analysed becomes the subject of the chapters that follow. In particular, this chapter proposes a novel way of researching RE deployment - at the regional level -by investigating the evolving relationship between energy and materiality. The chapter considers, as a starting point, the importance and role of natural resources, investigating their implicit physical and partially socially produced nature. The chapter identifies the material dimensions of RE, how they matter, why it is important to give them consideration and unpack the different ways in which they matter. The chapter concludes by providing an analytical framework and key analytical themes that can help in capturing how RE deployment processes are shaped by the material dimensions of RE. These are then tested empirically in chapter 6, 7 and 8.

5.1 Introduction

As discussed in chapter 2, the arguments presented in this thesis originated from the consideration that the deployment of RE resources presents spatial variations that are not only influenced by the resources' characteristics but also by differing infrastructure endowments and other factors, including geographical, techno-economic, institutional, and cultural factors (de Vries et al. 2007). Flows of renewable resources are thought to be immense in comparison with global human energy use (Johansson et al. 2004), yet their deployment is widely and unevenly dispersed, because of the influence of such factors and their appraisal (Zimmerer 2013). This spatial unevenness matters, has clear implications for social and spatial justice, and is integrally related to aggregate trajectories of energy decarbonisation.

Furthermore, the scale at which RE deployment is investigated matters and regional specific institutional structures, as shown in chapter 4, in both Italy and the UK, can be important to investigate the uneven deployment of RE. The arguments presented here suggest that these differences can be captured and analysed by researching RE deployment - at the regional level- in a novel way. This is by introducing and investigating the evolving relationship between energy and materiality.

The aim of this chapter, therefore, is to present an analytical and conceptual framework and several analytical themes under which the material dimensions of RE deployment can be explored. These are identified in an attempt to capture how RE deployment is shaped by a constellation of interacting actors, institutional and regulative settings - and in an effort to understand the social and physical factors that influence how and why RE technologies are dispersing geographically.

The chapter draws on an approach to the analysis of materiality[72] originally developed in the extractive industries literature, including fossil fuels. As discussed in chapter 1, most RE forms have significantly fewer material components compared with coal, oil and gas and the other extractive industries. Nevertheless, the deployment of RE, the process of turning renewable 'natural resources' into productive use as viable forms of energy through stages of energy conversion, storage, transmission and distribution through pipes, wires or other forms of transport, has material aspects like those involved in the deployment of fossil fuels. The chapter shows how understanding these aspects of RE can offer an opportunity to unpack and explain how particular RE paths come to be favoured or hampered, and yields useful insights into the spatial unevenness and variation of RE deployment at the regional level. This is also something that is under-researched, with a few exceptions such as Armstrong and

[72] As discussed in chapter 2, here materiality refers to how natural resources are both naturally endowed and socially induced. Materiality provides a way of acknowledging resources as a socio-natural phenomenon- a combination of physical and discursive practices that takes shape through interaction between the material / physical world and individual activities, institutional agendas and industrial forms of organisation.

Bulkeley (2014), Nadaï and Labussière (2012) and also Bridge et al. (2013) in their discussion of the low carbon economy.

This chapter, therefore, has three objectives. Firstly, it explains how consideration of some of the material dimensions addressed by Bakker and Bridge (2006), Bridge (2004); Kaup (2008); Bridge (2009); Kaup (2014) and others, and originally applied in the geographic resource extraction and fossil fuels literature, can help in identifying and focus on those material dimensions that particularly influence RE deployment. Secondly, it identifies the material dimensions of RE, how they matter, why it is important to give them consideration and unpack the different ways in which they matter. This is done developing 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. Thirdly, the chapter discusses how the regional level becomes an important level to study these, arguing that the regional level is an important spatial and governance level in which materiality and scale coalesce in relation to RE deployment. The scale at which RE deployment is investigated therefore matters[73], and regions can be seen as spaces that bring together the material with socio-cultural, economic and political configurations and resources in powerful ways. Moreover, I also show how the material dimensions identified can influence institutions, governance and firm decision making at the regional level, suggesting that addressing the material dimensions brings to the fore a constellation of institutional and regulative settings that have received less attention in studies of RE deployment.

The chapter proceeds as follows. In section 5.2, I discuss arguments that address how the literatures on resource geographies and non-renewable resources, especially on mineral, oil and gas exploitation, have acknowledged the role of materiality in energy development. From this brief review, I suggest a number of material dimensions that also influence RE deployment and discuss how this occurs (section 5.3). In section 5.4, I present a brief account, from recent published material on how the material dimensions identified can influence

[73] While the scale at which RE deployment is investigated matters, it also needs to be stressed that it will also depend on the nature of the source and associated technologies rather than on any single scale for all renewables (see also Stremke and Koh (2010); Smil (2017b, 2017a)).

institutions, governance and firm decision making at the regional level. I identify a number of institutions that influence RE deployment at the regional level (section 5.5). Before concluding (section 5.7), I present a number of analytical themes under which the material dimensions of RE deployment can be explored. I argue that the socio-material characteristics of RE deployment, and associated analytical themes, can be used to identify similarities and differences in RE deployment, across the regions under investigation.

5.2 Material dimensions of non-renewable energy resource deployment

Before illustrating the material dimensions of RE deployment, I draw on some selected contributions from the literatures on resource geographies and non-renewable resources[74], especially on mineral, oil and gas exploitation, that have addressed the complex material dimensions of non-renewable resources. This offers an opportunity to point towards some important material dimensions that, I argue, RE resource deployment share with fossil fuels.

As stated, most fossil fuels present broader material aspects than forms of RE. Nevertheless, the deployment of RE, the process of turning renewable 'natural resources' into productive use as viable forms of energy, has material aspects like those involved in the deployment of fossil fuels. As suggested in chapter 1, solar and wind energy, for instance, while lacking such materialities, also present material dimensions, in particular those associated with processes of energy capture, conversion, transmission, and distribution, including the physical infrastructures that support them. These material dimensions will influence RE deployment potential and interact with the ways in which these physical entities are socially constructed as exploitable energy resources through political-economic and cultural processes (cf. Calvert 2015; Bridge 2018). My argument is that through such processes these material dimensions can and do influence the geographical deployment and dispersion of RE.

[74] For reasons of space, I do not explore these debates in detail here. This discussion acknowledges but does not include important contributions such as those of political ecologists such as Huber (2015), discussion around material politics (see for instance Birch and Calvert (2015), Daunton and Hilton (2001); Barry (2013); Rutherford (2014) that have all discussed aspects of energy and materiality) and the importance of the material forms of energy consumption such as for example the social practices that constitute energy demand (see for instance (Shove et al. 2014).

Resource and environmental geographers have mostly conceptualised nature in physical terms, traditionally focussing on improving the flow of resources 'from' nature 'to' society through the design of institutional and territorial frameworks for procuring and managing environmental goods and services (Bakker and Bridge 2006; Bridge 2009)[75]. Yet, as argued in chapter 2, Bakker and Bridge (2006) suggest that what counts as a resource depends on the interaction between its physical quality and condition (e.g. the variable grade/ quality of mineral resources, for example) and social institutions. In other words, they acknowledge resources in dialectical terms as a combination of physical and discursive practices that is shaped by the interaction between the material/ physical world and individual activities, institutional agendas, and industrial forms of organisation.

Zimmerman's dynamic concept of natural resources that vary over time and space is useful here. Zimmermann (1951: 15) argues that 'resources are not, they become: they are not static but expand and contract in response to human wants and human action'. Bridge (2004: 416), in his account of the geography of mining investments, argues, for instance, that the size, location and value of mineral reserves are dynamic phenomena, products of both geological and mineralogical processes and a continual socio-economic re-appraisal of utility and value (Bridge 2009). Changes in societal demands, in market prices and/ or cost of extraction, exploration activity and/ or the introduction of new technologies can create new reserves in places where, to all practical purposes, none previously existed (Bridge 2004).

Moreover, Bridge (2008) (see also Bridge and Bradshaw (2017)) has also drawn attention to the materiality of production networks. Using the example of the oil industry, Bridge highlights the influence that materiality exerts on industrial organisations within it. He argues that the production chain of extractive industries is territorially embedded at different points. The industries' materiality emphasises that the dependency on natural production, the location relative to markets, and the existing infrastructure limit the spatial flexibility of the network. Kaup (2008: 1736) arrives at a similar conclusion, indicating that the 'material difficulties of natural gas extraction and transport have shaped the structure of Bolivia's natural gas industry'. The extraction and transport of natural gas requires much fixed capital

[75] This stands in contrast with much work in political ecology (e.g. see Bulkeley (2005); Neumann (2009); Robbins (2012)) and the production of nature thesis, in which the mutual production of 'society- nature' relations has been central to research and analysis.

and technological innovation in extraction and separation processes, pipeline construction and conversion. The requirement of capital, Kaup (2008: 1737) argues, 'has shaped the relationships between transnational extraction firms and the people and places in which natural gas is extracted'. Moreover, looking at the changing regulations and tensions surrounding Bolivia's natural gas, Kaup (2008) shows the importance of recognising how nature can be both materially manipulated and discursively constructed by a diversity of actors to disrupt and secure regimes of accumulation. He reinforces this in Kaup (2014), arguing for attention to be paid on how actors' positions within processes of capital accumulation and their differential relationships with nature can shape the ways they understand and seek to protect their interests.

The discussion above suggests, therefore, a number of material dimensions that we could explore in understanding RE deployment. These refer to:

1. The physical, technical and socio-economic appraisal of resources, their potential (or the 'quality of the energy resources') and how this interacts with their contextual conditions (e.g. land areas required and their location, land use preferences, land use ownership, land use protection and land cover);

2. The discursive constructions, the narratives and visions that actors use to promote their interests, influencing RE deployment, partly by framing or reframing debates on priorities around the deployment of new energy sources;

3. The importance of the physical characteristics of natural renewable resources and the requirement of a robust infrastructure to deliver RE can significantly influence RE deployment. This includes the pre-existing built-infrastructure in maximising or limiting RE potential, the infrastructure requirements, the transportation or distribution networks required for harnessing the renewable resource into a form of energy.

Table 5.1 shows a summary of the socio-material dimensions of RE deployment.

While I have here drawn attention to some material dimensions of fossil fuels that may enhance our understanding of RE deployment and have acknowledged that, in general, fossil fuels have significantly broader material dimensions than forms of RE, some differences are also relevant. These differences include: those between the renewable and depletable attributes of RE and fossil fuels, respectively; and the relatively low life cycle emissions of greenhouse gases and regional or local pollutants associated with some forms of RE, the social construction of which can lead to differences in the socio-political debates and contestations over fossil fuel and RE exploitation and deployment and their consequences.

This section has discussed the dimensions of materiality, as addressed by Bakker and Bridge (2006); Kaup (2008, 2014); Bridge and Bradshaw (2017), and applied in the fossil fuels geography literature, and has argued that several of these material dimensions are also relevant to forms of RE. It has shown how these material dimensions offer a way of acknowledging resources in dialectical terms - a socio-natural phenomenon that takes shape and form through interaction between the material/ physical world and specific activities, institutional agendas, and industrial forms of organisation. Moreover, a number of recent contributions (Gailing and Moss 2016; Bridge 2018) also stress the relevance of looking at resources, technical systems, and infrastructures in terms of socio-material systems as 'resources and infrastructures materialise (i.e. take form as an object of science, economy and law) as a product of social relations (Bridge 2018: 13).

Table 5.1 The diversity of material dimensions that influence RE deployment

Socio-material dimensions	RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use	Discourses, narratives and visions for renewable energy deployment

The paper by Bridge et al. (2013) on the geography of energy transition has to some extent, highlighted already the importance of investigating the socio-material dimensions of the low carbon economy, while Calvert (2015)'s paper on 'energy geographies' has stressed the importance of resources and environmental geographies to the study of emerging energy resources. They both use the concept of energy landscape to capture how different modes of energy production, distribution and use are underpinned by material relations and suggest the need to engage seriously with the materialities of renewables. Huber (2015) also reflects on how the deep cultural and political discourses are linked with the materiality of energy systems and the importance of such considerations for alternative energy futures.

As this research seeks to contribute to a better understanding of the material dimensions of RE deployment in the regions under investigation, the question I address next is how understanding the material dimensions of RE offers opportunities to unpack how specific RE resources come to be fashioned in some areas and regions and not in others and hence to help explain the spatial differential in RE deployment at the regional scale.

5.3 Exploring the material dimensions of RE deployment

The previous section noted how recent contributions on the geography of energy transition (Bridge et al. 2013; Gailing and Moss 2016) and Calvert (2015) on 'energy geographies' drew attention to the physicality of resources, the built infrastructure and narratives and visions of the low carbon economy and the relevance of resource and environmental geographies to the study of emerging energy resources, respectively. In this section, I explore further how the material dimensions just identified influence RE take up and deployment and help explain differences in its spatial distribution.

5.3.1 RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use

As suggested, the deployment of natural renewable resources depends on specific physical, cultural, economic, and technological characteristics and their appraisal. Harnessing the natural resource from the sun, the wind, a river or the sea becomes a core feature of any RE project. How natural resources get estimated and valued will influence the nature of investments and returns expected from projects that aim to recast these resources into viable, legitimate sources of energy production (cf. Armstrong and Bulkeley (2014), on community hydro in the UK). Nevertheless, although resource potentials and resource assessment procedures are often presented as 'objective', many are strongly influenced by assumptions about average values and trends that are themselves often affected by the assessments' purposes and the actors involved.

Moreover, in the exploitation and deployment of RE technologies, sometimes apparently unlikely materials, entities and sites are recast as containing the potential for RE generation (e.g. as sites for wind turbines, roof space for solar PV, fields for biomass, etc.) challenging the existing resource use (Armstrong and Bulkeley 2014). Articulating the materiality of renewable natural resources in terms of resource endowments and energy density (simply defined here as the land requirements per unit of electricity generated from the resource), influences the socio-economic appraisal of resources and their potential. This occurs via the iteration between spatial resource assessment, land use and land protection and negotiation among conflicting land use interests. I explain this below.

In the EU, the introduction of legally binding targets for the share of energy production from renewables has induced unprecedented development of RE policies and RE deployment (Banja M. et al. 2016). It has also given new impetus to the assessment of RE resource availability and hence its materiality. Member States have produced strategies and measures to meet their binding 2020 targets, resulting in scenarios and roadmaps at different spatial levels. The latter have become important tools for future planning of energy investments and supplies and helped identify targets for RE production at the European, national and regional scales. The target setting has been influenced by a sense of urgency about investment in new capacity (Haas et al. 2004; Szarka 2007). This has 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.) (cfr. Shove 1998; Nadaï and van der Horst 2010a).

The problems of this generalisation are evident given that different types of RE can be more or less space-intensive when being develop because of their different power densities (Smil 2010), and have highly geographically dependent energy production efficiency (Seager 2009; Dijkman and Benders 2010) which is often variable. For example, significant land space can be required not only for wind and PV farms but also for the construction and maintenance of access roads and buffer zones, and for transmission infrastructure (e.g. rights-of-way and high voltage power lines) if electricity is to be carried to distant urban and industrial areas (Smil 2010). The spatially extensive nature of some type of RE resource means that pursuing low carbon transitions through renewables may hold profound implications for other goods, services and values attached to the spaces concerned (see for instance Wolsink (2017) on the varied spatial claims of different RE technologies).

Land use, therefore, quickly became 'the most important environmental consideration in the development of these resources' (Pasqualetti, (1990), cited in Walker (1995)). The low energy output per unit area of wind power and the requirements of onshore sites (MacKay 2009) have created greater potential for extensive disruption of existing landscapes and the values attached to them, spurring research into the evolving relationship between landscape, energy and policy (Nadaï and van der Horst 2010b; Nadaï and van der Horst 2010a); see also Bridge et al. (2013)). Competing interests for the potentially multiple uses of land resources engage in an arena of planning systems and institutional infrastructure, socio-cultural characteristics and environmental priorities (Keenleyside et al. 2009). Nadaï and van der Horst (2010a) argue, for instance, that landscape can be understood as a multi-faceted cultural and political process in which technologies and energies are embedded into territories and local communities (Nadaï and Labussière 2009). The stimulation of RE technologies and 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 (e.g. Walker (1995)).

To sum up, this material dimension points towards the importance of the physical, technical, social, and economic appraisal of RE resources and their potential deployment via the iteration between spatial resource assessment and alternative land uses. The negotiation between turning resources into potential sources of RE and the current land resource use provides opportunities but also hindrances for RE deployment. Consequently, the devices used to frame such negotiations become highly important.

5.3.2 Discourses, narratives and visions for renewable energy deployment

While the discussion of this dimension focuses on narratives and visions for deployment, it also picks up on issues connected with resource appraisal discussed in section 5.3.1 because of their influence on the formations and character of narratives and visions. Resources can be characterised according to both their availability and attributes that relate more directly to their potential deployment. Developments in RE technologies and deployment have been accompanied by new techniques to ascertain the availability and potential of the resources, the economic costs and returns of a particular project, the science and engineering of the technology under investigation and related environmental and social concerns. 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 potential assessment imply that more careful consideration needs to be given to how these calculations happen and the actors involved. In the case of spatial planning for RE, Power and Cowell (2012) argue that some selectivity is integral to combining complex situations into a spatial map that is invariably reductionist. This highlights the need to investigate which resources do, or do not, become incorporated into spatial representations, and the extent to which these spatial representations are accepted or resisted by different actors. Research on opposition to RE development argues that much of the potential for conflict is not solely 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).

Actors, therefore, can promote or hinder appraisal of resources and their abundance through different storylines (cfr. Hajer 1995). These might narrate the reality to simplify, influence or massage strategic policy priorities (Teschner and Paavola 2013; De Laurentis et al. 2016a; De Laurentis et al. 2016b). RE resources, for instance, are often represented in terms of 'development zones' or 'opportunity areas', which can obscure or demote alternative claims on the same space.

As argued, climate change and energy security imperatives have spurred a renewed interest in RE deployment, inducing specific configurations of interests (Nadaï and van der Horst 2010a). This has led to questions about the pace and scale of RE development, including two 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 which RE-related discourses gain hegemonic status and which are marginalised (cf 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 emerging discourses in favour of RE. Lennon and Scott (2015), writing on Ireland's midlands as sites for large-scale wind, also identify how opposing and supporting discourses can be framed differently at local and national levels and are narrated via competing conceptualisations of the rural 'resource'.

Similarly, apparently abundant natural resources may lead to 'imaginative geographies' and reproduce ideas about nation-building, national identity and citizenship and territory (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 its technologies can drive the exploitation of natural resources associated with particular energy development paths (cf. Essletzbichler (2012), and Späth and Rohracher (2010)). Visions can also often work to harness particular RE resources to oppose other forms of RE (e.g. when renewables such as wind and solar are promoted to oppose nuclear new built capacity) or vice versa.

In this sense, here I draw attention to the actors, how they create differing vision(s) of identity, at different spatial levels, with the aid of, and in relation to, their appraisal and presentation of natural resource endowments. This material dimension offers the opportunity to broaden the understanding of how RE deployment can fulfil specific visions or trajectories. It does so in two ways: first, it draws attention to the discourses and coalitions that emerge in relation to using natural resources as energy sources, stressing the conflicts, powers, interests and priorities of the actors involved; and, second, it shows how different actors can organise and mobilise particular resources and shape what constitutes an accepted 'legitimate' source of energy.

5.3.3 Physical characteristics and built infrastructure requirements for renewable energy deployment

Both the physical characteristics of natural renewable resources and the requirement of a robust infrastructure to deliver RE can significantly influence RE deployment. In relation to the former, RE technologies might emerge and diffuse in one or more places where natural conditions and specific physical characteristics require testing of and learning about technical specificities – e.g. remote, difficult environments for testing sensor technologies for offshore RE. Likewise, technologies might be deployed where enhancements are required to address locally specific problems (e.g. vis-à-vis electrical load transmission capacity, balance management and storage). Managing grid capacity is a scale and site-specific problem; tackling RE resource intermittency/ variability links an inherent material property of (some) renewables to wider conceptions of how electricity networks should operate. Such activities could provide the seedbed for further targeted local, regional and national policy interventions.

Moreover, RE activities can emerge in places where the physical characteristics of the areas surrounding the natural resource make it more practical to harness the renewable source than in other places (e.g. lagoons, sheltered coastline, well-developed grid system and port infrastructure). Moreover, areas with a well-developed grid system and port infrastructure - important characteristics for the commercial success of offshore renewables - and with favourable local weather conditions and local geography, can strongly influence the exploitation of these resources (Murphy et al. 2011).

Infrastructure networks or their absence can enhance or impede RE deployment and delivery. Thus, for example, 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 any interconnections between them (a point also raised in Dahlmann et al. (2017)). Similar considerations apply to renewably produced gas or liquids. The built infrastructure, including the built environment, thus becomes an important mediating factor between 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 delayed past RE developments: see for instance Wood and Dow (2011)), constraining the feasible innovation trajectories. Moreover, areas with limited infrastructure are less attractive to global investments than those better endowed. This highlights the importance and the challenges of strategic investments in electricity transmission and distribution networks, as the number and volume of distributed RE generation connections increases.

In this respect, this material dimension foregrounds the importance of the specific physical characteristics of renewable resources, the requirement of robust, appropriate infrastructure to transmit and distribute RE electricity, gas or liquids, and how this aspect of materiality can advance or hinder RE deployment.

So far, I have discussed three material dimensions that can influence the characterisation, assessment and possibilities of RE and help explain differences in its take-up, deployment and spatial distribution. I now turn to discuss how the regional level can be seen as an important spatial and governance level in which materiality and scale coalesce in relation to RE deployment.

5.4 The material dimensions of renewable energy and their influence on regional institutions, governance and decision making

Acknowledging resources in dialectical terms as a combination of physical and discursive practices 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 an important 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, natural resources can be 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 governments' have powers to mediate exploitation of RE versus other resources, adding geographical contingency to resource 'availability'.

Moreover, 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 – as suggested, also dangles the prospect of greater autonomy and control over energy futures for regions (hence '100% Renewable Energy Region' agenda[76]). My argument here is that the regional level becomes an important 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 I argue influenced by the opportunities and constraints offered by their material dimensions, which in turn influence the different regional institutional, economic and governance contexts.

[76] See for instance the 100% Renewable Energy Cities and Regions Network instigated by the ICLEI- Local Governments for Sustainability, available at http://www.iclei.org/activities/agendas/low-carbon-city/iclei-100re-cities-regions-network.html

Firstly, I have argued for recognising how materiality is useful in stressing how the negotiation between turning resources into potential sources of energy and the current land-based resource use can provide opportunities but also hindrances for RE deployment.

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[77]. This is often concentrated on efforts that emphasised processes of resource assessment, target setting at the regional level and spatial planning. 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 (Wolsink 2007). The challenges and the processes of weighing resource potential and different environmental values against RE targets, are often articulated through deliberation between national, regional and local stakeholders (Cuocolo 2011; Cowell et al. 2015). For instance, via the construction and operationalisation of the choice of variables to be mapped spatially; in the case of spatial planning, local and regional actors can identify the nature of the challenges that renewables present for the management of land use ((cf. Cowell 2010); and Ellis et al. (2013)). While planning institutions, at national and regional levels, are often required to mobilise a dominant strategic line around the delivery of specific objectives and/ or guidance, it is the regional government (and the local authority or the municipality) that often engages with local stakeholders and can design and regulate locally tailored implementation strategies in accordance with local and regional specificities and priorities. Spatial planning therefore reflects the capacities and willingness of governments, at different scales, to render land available for RE development and manage social response (Cowell et al. 2015).

Moreover, regional and national governments are able to negotiate more (or less) stringent requirements for consenting RE projects, requesting for instance that a certain percentage of value from the development is derived from domestic content, to boost the regional/ national economies. Offshore wind in the UK provides an example, in which planning consent for

[77] I have discussed in earlier chapters how research, spanning more directly from the environmental governance literature, has also stressed how the pressures associated with tackling climate change and reducing carbon emissions, have given rise to a rescaling of environmental governance.

future offshore wind farms is set to aim for 50% of value from domestic content (Dawley 2014; Dawley et al. 2015). Regional actors can also play an important role in facilitating the dialogue between different actors at different scales. This is relevant, for instance, in the development of marine and offshore energy in the UK. The collaboration between industry, government and stakeholders at national and regional levels with the Crown Estate, responsible for leasing areas of the seabed and managing the associated seabed rights, is increasingly considered important in bringing new development opportunities to the market in the offshore and marine energy sector in the UK (Toke 2011; Kern et al. 2014).

Secondly, I have argued that 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. In many cases, regions, although they may lack control over economic framework conditions (e.g. subsidies and feed in tariffs), 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. The recent Scottish independence debate offers an example of how such imagery of natural resources, identity and RE paths can play out (cf. Dawley et al. (2015) and Toke et al. (2013)). In particular, Scottish independence 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[78]. Identity narratives linked to regional resource abundance have also played an important role in encouraging different RE path, such as offshore wind path creation in North East England (Dawley et al. 2015).

Driven by such discursive constructions, regional institutional systems can form temporary windows of opportunity for technological innovation (cf. Dewald and Fromhold-Eisebith 2015), as they set up ambitious deployment policies and support state-led projects aimed at harnessing natural resources. Nevertheless, regional 'visions' could also oppose large scale RE

[78] 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).

development aimed at harnessing natural resources, in the pursuit of maintaining a balance between energy production and landscape values (cf. Bridge et al. (2013)).

Thirdly, I suggest that 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. As RE capacity increases, the current infrastructure (e.g. grid connections, electricity distribution and transmission lines as well as regulatory codes and institutions) might represent a constraint or an opportunity for future development. Some countries have already invested, for instance, in grid reinforcement, such as Germany (Szarka 2007), and at the regional level, where the problem of grid saturation (and unavailability of new grid connections) 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). Similarly, Dewald and Truffer (2012), in their account of regional growth differentials in the German Photovoltaics market, point out the role that the built environment has played, showing how photovoltaic deployment has been more successful in rural and suburban areas than in urban areas. In this sense, the built environment, together with the established built infrastructure for the transmission and distribution of energy becomes another material mediating factor between the physical resource endowments and the institutional and governance structures, creating inertia and spatial path dependencies.

Table 5.2 provides a summary of the arguments presented here, suggesting how the material dimensions of RE might influence the institutional, economic and governance dimensions at the regional level.

Table 5.2 Material dimensions of RE and regional institutions, governance and firms decision making

Material Dimensions of RE	How the material dimensions of RE might influence regional institutions, governance and fir
RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use	The regional level often has responsibilities over regional economic development and plannin operalisation of mapping methodologies e.g. spatial planning The processes of resource assessment stimulates deliberation between regional stakeholders environmental values against RE targets Negotiation between the delivery of EU/ national and regional targets vs. land use policy trac - Limit to expansion and pressures for & regional responses to RE deployment Strategies that draw upon siting criteria to create new representation of development opport - incentivise local communities to make more sites available - Developers dash to exploit most commercially attractive locations - Attraction of inward investments Regional renewable companies might hold research or land-use permits and have the know-h planning issues
Discourses, narratives and visions for renewable energy deployment	Which characteristics of the resource become incorporated into mapping and which get exclu spatial representations) are accepted or resisted by different actors Locations as sources of inward investment ('open for business')/ simplification of legal and re ambitious deployment policies Coherent narratives provide legitimisation of a particular process of regional development an of communicating the articulation of particular RE development paths Regional actors and governance systems channel finance and support of RE technology/ prom Creation of discourses that offer opportunities to produce ideas about nation/region building and citizenship
Physical characteristics and built infrastructure requirements for RE deployment	Researchers and technology developers choose sites for testing and experimental activities ac resources. This is particularly relevant to emerging technologies Potential sites are promoted for demonstration projects and experimental platforms Existing local economic and technological structures, knowledges and competences are mobil agents resulting in the local emergence of new paths Regional governments provide funding for local infrastructure development (e.g. production,

5.5 The material dimensions of renewable energy and institutions

As suggested in chapter 1, this work remains rooted within the RIS studies and, in that literature, institutions are used as a point of entry from which to investigate certain aspects of processes of economic development (cf. Cumbers et al. 2003). My argument here is that the material dimensions of RE can help in identifying and emphasising the various components of the institutional make-up that influences RE deployment.

As explained in chapter 2, the ST and GOST literatures have already been useful in stressing the important role of the national and international institutional frameworks and their interaction with regional and local institutions. Many studies have shown how RE deployment involves a relatively strong influence of policy regulation and economic support and have analysed the role of institutions and institutional conditions for RE, such as regulatory support, the role of technological standards, and specific R&D programmes in support of RE transitions (see for instance Jacobsson and Lauber (2006) and Haas et al. (2004)). Moreover, the GOST literature has provided meaningful contributions that stress the central role of institutional variations as foundations for geographical differences in the adoption of RE. Yet, RE deployment is also influenced by specific constellations of institutional and regulative settings that are brought to the fore once we take account of the socio-material characteristics of renewable natural resources.

I suggest that giving consideration to the material dimensions of RE can help in revealing the nature of the localised institutions that might influence RE deployment, affecting the behaviour of the actors involved. In other words, the material dimensions of RE influence the institutions and institutional conditions that regulate the social, political and economic relations necessary for resource production, innovation and deployment (cf. also Bakker and Bridge (2006)). They do so in two ways. Firstly, foregrounding the material dimensions of RE deployment allows for greater emphasis to be placed on the types of institutions that matter for RE transitions and deployment and draws attention to the scale at which this happens. In the analysis presented earlier, I have shown how RE deployment and transitions are determined through the interplay between international, national, regional and local institutional conditions. Institutional scholars, particularly geographers, have shown how regionally and locally distinctive institutional architectures can and will shape innovation processes, leading to differentiated social and economic outcomes (Gertler 2010). The institutional conditions for RE energy deployment and transitions and the incentives (and or barriers) they create at any particular scale will interact, influence and are influenced by the institutional architecture at other geographical scales ((cf. Gertler (2010) and Rodríguez-Pose (2013)).

Secondly, institutions not only shape but are also shaped by place-specific institutional conditions, influenced by trust, culture, history and identity (Farole et al. 2011; Rodríguez-Pose 2013; Tomaney 2014). As argued above, these are key elements that help us to understand the influence that the material dimensions of RE exert over deployment processes (such as, for instance, in the case of narratives and visions, in influencing the meanings of landscape in land-use conflicts and mobilising actors and resources). The material dimensions of RE, therefore, help to understand how institutions are moulded by place-specific, particularly regional, informal institutional conditions.

In particular, I argue that in order to understand processes of RE deployment, following the discussion presented above, increased attention should be paid to:

- the processes by which natural resources are turned into potential sources of energy;
- the role of visions and actors' constructions and narratives in creating incentives to exploit natural resources;
- the interplay between energy and land use planning and land use ownership;
- the challenges and role of the existing infrastructure and the role of regulatory infrastructure conditions, such as connection rights, rules and transmission charges and
- how identity, trust and culture can provide meanings to particular areas, influencing visions for deployment and the social attachments to the environment and the landscape.

5.6 An analytical frame to study renewable energy deployment at regional level

What follows outlines the key analytical themes of the framework developed. These have been identified in an attempt to capture how RE deployment processes are shaped by a constellation of interacting actors, institutional and regulative settings and the material dimensions of renewable natural resources. The analytical themes stem directly from the arguments presented above, drawing attention to the influence that materiality exerts on RE deployment processes. The analytical themes proposed are the following:

1. the processes under which RE sources are seen as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use. These are influenced, at the regional level, by the following:
    i. Targets and resource assessments: their constructions and calculations;
    ii. Planning for RE and potential and different values of environmental attributes when compared against RE targets;
    iii. Availability of land/ current land- based values;
2. Discourses, narratives and visions for RE deployment, captured by an analysis of:
    i. Imaginaries and vision for RE development;
    ii. How RE are represented vis-à-vis alternative energy sources;
3. Physical characteristics and built infrastructure requirements for RE deployment:
    i. Infrastructure requirements
    ii. Formal regulatory powers and political legitimacy to shape infrastructure networks

Table 5.3 shows how the themes identified are linked with the material dimensions of RE identified earlier in the chapter. Each of these material dimensions, and associated analytical themes, will be used to analyse the case study materials and the results will be organised according to them, as shown in the table.

Table 5.3 The diversity of material dimensions that influence RE deployment

Socio-material dimensions	**RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use**	**Discourses, narratives and visions for renewable energy deployment**	**Physical infrastruc deploym**
Key themes	Targets and resource assessment: their construction and assessment Planning for RE & Potential and different values of environmental attributes when compared against RE targets Availability of land/ current land-based values	Imaginaries and vision for RE development How RE are represented vis-à-vis alternative energy sources	Infrastruc Formal re legitimac networks

Chapter 6

Chapter 7

5.7 Concluding remarks

This chapter has introduced a number of material dimensions of RE that can help us understand the spatially uneven processes of RE diffusion and deployment. They have been derived through analysis of the importance of various material dimensions highlighted through research literature from the fossil fuels sector. In particular, the chapter shows:

- why and how they matter in researching RE deployment, acknowledging the multiple processes through which turning 'natural resources' into viable source of energy is both a material artefact and discursive construct, and

- how these material dimensions might influence regional preconditions such as institutions, governance, and firms' decision making in RE deployment.

The chapters presented so far in this thesis, have highlighted the relevance of the regional level in terms of the growing competence to implement policy actions for both climate change mitigation and adaptation at this level (chapter 1 and 2). The thesis has also shown, in chapter 3 and chapter 4, that there are differences in the regional specific institutional structures, in both Italy and the UK, and that this, to some extent, can explain the uneven deployment of RE. The analytical framework presented here is, therefore, developed in order to better identify and analyse these differences. The material dimensions are identified here to capture how RE deployment is shaped by a constellation of interacting actors, institutional and regulative settings - at different spatial levels - and in an effort to understand the social and physical factors that influence how and why RE technologies are dispersing geographically. While attempting to abstract from the complexity of researching RE deployment at multiple scales, the framework focuses attention on the various relations that materiality triggers in respect to deployment processes at the regional level.

As argued, the aim of this research is not only to develop an analytical framework to study RE deployment at the regional level but also to apply, test, and refine this framework with empirical material and case study evidence from five regions. This testing, presented in the forthcoming chapters 6-8, offers the opportunity to further investigate the role of materiality in regions with distinct resource endowments, institutional settings and national contexts to ascertain how well the framework works in allowing differences in RE deployment- and the role of materiality- to emerge. The next chapters therefore adopt this analytical framework to show how the material dimensions of RE deployment have affected the spatial distribution and deployment of RE, in particular solar and wind energy, offering an opportunity to unpack and explain how particular RE paths are favoured or hampered in the regions under investigation.

Chapter 6

Renewable Energy Sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use

Summary

As argued in the previous chapter, the framework developed draws attention to the various relations that materiality triggers in respect to deployment processes and, giving consideration to analysis of materiality, can provide additional insights on how and why RE deployment realises – or fails to realise- its potential. Starting from this chapter, the attention shifts towards the testing across 5 regions - three in Italy (Apulia, Tuscany and Sardinia) and two in the UK (Scotland and Wales) - of the conceptual and analytical framework to study RE deployment at the regional level. Chapter 6 offers a number of illustrations from the regions under investigation that highlight how differences can emerge, at the regional level, by drawing from the processes under which natural resources are turned into potential sources of energy. These differences refer, in particular, to how actors construct targets and resource assessments through harnessing resources to generate energy and the challenges and negotiation between turning resources into potential sources of energy and the current land-based resource use. While the analytical framework suggests that these challenges and negotiations are an important socio-material dimension to consider when investigating RE deployment, the examples from the case studies further show how they represent themselves at the regional level and the extent to which they have affected RE deployment.

6. 1 Introduction

Chapter 4 discussed, for both Italy and the UK, the specific delivery programmes put in place for the generation of electricity from renewables resulting from a number of pressures, among which are the privatisation of the energy sector and the signing of the European Commission climate and energy package- including the 2020 RE targets. I have discussed how, in both countries, the centre continues to retain considerable power over energy policy. In both countries the design of systems of market support, the responsibility for regulating energy networks and negotiating with the EU on energy-relevant policy resides in the central governments. Nevertheless, the regional level, in both countries, has experienced an increased autonomy of action- to a varying degree in the regions under scrutiny - becoming a legitimate agent of governance in the RE field. Although the regions under investigation, in both countries, lack (or have limited) control over economic framework conditions (e.g. subsidies and feed in tariffs), they have shown an increased governance capacity over energy that encompasses the formal re-distribution of powers from the centre to the regional level. This is summarised in table 4.4, presented in chapter 4. Hence, the regions under investigation have made use of the different policy instruments available to them to promote RE deployment. This has resulted in uneven outcomes in term of rates and directions of RE deployment across the regions studied. As highlighted in earlier chapters (see tables 3.2 and 3.3 and tables 4.6 and 4.8), there is greater variety in terms of the type of RE projects (e.g. solar, wind, hydro etc.) and capacity installed across the regions under investigation. The arguments put forward in this thesis suggest that significant aspects of these differences could be explained by the influence that materiality exerts on RE deployment processes. Starting from this chapter, the attention therefore shifts towards the testing - across the 5 regions of in Apulia, Tuscany and Sardinia, in Italy and Scotland and Wales in UK of the analytical framework to study RE deployment discussed in chapter 5.

In particular, this chapter discusses how differences can emerge at the regional level, by drawing from the processes under which natural resources are turned into potential sources of energy. As suggested, this material dimension highlights the importance of the physical, technical, social, and economic appraisal of RE resources and their potential deployment via the iteration between spatial resource assessment and alternative land uses. The arguments presented here aim to show the ways in which the negotiation between turning resources into potential sources of RE and the current land resource use has provided opportunities but also hindrances for RE deployment in the regions under investigation.

The intention here is to draw attention to differences and similarities by presenting a series of vignettes that illustrate the usefulness of the key themes introduced in the framework developed (these are summarised in figure 6.1). This chapter focuses on the processes under which natural resources are turned into potential sources of energy at the regional scale and how they are influenced by:

i) the identification of potential capacity evaluating RE regional natural resource endowment and adopting targets for its exploitation,
ii) the use of spatial planning in reflecting the capacities and willingness (or the lack of) of local and regional actors in identifying the challenges that renewables present for the management of land use and to render land available for RE development;
iii) land use opportunities- and constraints- that have emerged around large-scale green energy power plants (e.g. population density and the opportunities offered by agricultural land as a 'land reservoir' for RE installations).

The chapter is structured as follows. Section 6.2 discusses the first analytical theme that illustrates this socio-material dimension. I present how national targets are distributed at the regional level and the role that targets have played in the regions under consideration (Sections 6.2.1 and 6.2.2 illustrate the case of Italian regions, Wales, and Scotland, respectively). Section 6.3 focuses on the practices that have emerged in planning and consenting processes in the case studies. The aim of this section is not to review the changes that have occurred in planning policies and practices for RE and their outcomes in each region but to focus on the challenges that have emerged around planning (and current land-based resource use) for RE development across the regions, that have influenced the rate of deployment. Section 6.5 presents some examples of how different population densities, a declining agricultural sector, and land rights have also influenced RE deployment and the type of RE projects, within the regions under investigation. The chapter concludes with a brief summary of the key issues analysed.

Figure 6.1 The material dimensions that influence RE deployment: RE sources as potentially deployable so

Socio-material dimensions	RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use	Discourses, narratives and visions for renewable energy deployment	Ph inf
Key themes	Targets and resource assessment: their construction and assessment Planning for RE & Potential and different values of environmental attributes when compared against RE targets Availability of land/ current land-based values	Imaginaries and vision for RE development How RE are represented vis-à-vis alternative energy sources	Infrastru Formal r legitima

Chapter 6

i. the identification of potential capacity evaluating RE regional natural resource endowment and exploitation;
ii. the use of spatial planning in reflecting the capacities and willingness (or the lack of) of local an identifying the challenges that renewables present for the management of land use and to renc development;
iii. land use conflicts, and opportunities, that have emerged around large-scale green energy powe contexts and the opportunities offered by agricultural land as a 'land reservoir' for RE installati

6.2 Targets and resource assessments: their constructions and calculations

As suggested in previous chapters, the introduction of legally binding EU targets for the share of energy production from renewable sources[79], coupled with a sense of urgency to trigger investment in new capacity to meet those targets, have given a new impetus to the assessment of potential RE resource availability at different spatial levels. At the national level, this resulted in member states producing strategies and measures to meet their binding 2020 targets associated with the publication of scenarios and roadmaps. These strategies have been generated via processes of evaluation and assessment of the potential of renewable sources[80] and have become important tools for future planning of energy supply developments and RE production, not only at the national but also at the regional scale (in some cases). As argued, the European Commission indicated that Italy and the UK's contribution to the 2020 EU target should be 17% and 15% of energy demand from renewable sources by 2020, respectively[81].

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[79] The focus of this work, as discussed, is on RE deployment and this section refers particularly to RE targets. Nevertheless, it is important to stress that, as argued in chapter 4, the pressures for change on the energy systems have also been driven by targets for greenhouse gas reductions at both European and International levels. These, at national level, were incorporated into the Climate Change Act 2008 in the UK and in Italy, with the through the ratification law 120/2002, which illustrated the relevant National Plan for the Reduction of Greenhouse Gas Emissions (6.5% compared to 1990 levels. Moreover, such pressure to reduce greenhouse gas reductions also drove legislation at the regional level. Examples of this are represented by the Welsh Government's Climate Change Strategy, published in October 2010, which outlined a target to reduce greenhouse gas emissions in Wales by 3% each year from 2011, relative to a baseline of average emissions over 2006-2010 and the Regional PER in Tuscany (2000) which identified the potential for RE in the region in reducing CO2 emissions.

[80] RE resource potential is often assessed utilising a combination of data from observations, estimates and mathematical formulas, generating a number of scenarios and roadmaps to quantify potentials (see for instance de Vries et al. (2007), Johansson et al. (2004); Hoogwijk and Graus (2008). These, however, sometimes can lack a well-defined approach that specifies the underlying assumptions. Although the potentials are often presented as 'objective', most of them are strongly influenced by assumptions on average values and trends that are often influenced by the purposes of the assessment and the actors involved. de Vries et al. (2007) also argue that resource assessment often requires a set of context related additional assumptions and refinements that include site-specific judgments and regional estimates. These, however, are not often widely available. Drawing a parallel with the literature on non-renewables, it can be argued that resource assessment therefore is not only the fruit of geological and natural processes but also of a continual socio-economic appraisal about utility and value of the resource (Bridge 2009). Resource assessment, in this sense, has also become a product of policy while informing it.

[81] This entails, as argued in chapter 4, that renewables will need to provide well over 30% of electricity produced in the UK and 28.97% in Italy.

The success of national policies for the implementation of RE has also depended on the number of successful projects in the areas in which renewable resources are located and on the potential associated with those resources (Wolsink 2007). This, to some extent, has influenced the way in which national targets are distilled or 'cascaded down', in both Italy and the UK, to the regional level. As discussed below, in the two countries, the approaches followed to distribute these targets at the regional level have differed.

6.2.1 Targets and resource assessments in Italian regions

I start with explaining in more detail the way in which targets have differed in Italy, at the regional level. It is important to highlight that this account is divided in two parts. Firstly, I explain how the Italian national targets have been *cascaded down* at the regional level, via a principle of *burden sharing*[82]*.* Secondly, I discuss in more detail the role that targets have played in identifying potential capacity at the regional level and whether they have played a role for future planning of energy investments in the regions.

6.2.1.1 The burden sharing principle

According to the Legislative Decree 387 (DL 2003), RE installations are considered of 'public utility, urgent and could not be deferred' and the regions are required to contribute towards the RE national objective. Moreover, the National Action Plan (MISE 2010: 4) has stressed how the national target for RE would 'be divided between the Italian regions, with shared methods for achieving this target'. Under the principle of burden sharing, therefore, the national targets have been distributed at the regional level. The calculations of the regional targets follow complex regional data processing procedures (GSE 2016) and take into account a number of issues. These include the characteristics of the territory and regional (and provincial) availability of energy resources, areas available for agriculture and forestry, and

[82] The Ministry of Economic Development states that the various regions and autonomous provinces need to contribute towards the national objective by assigning each of them specific RE objectives by 2020. Each region is also associated with an indicative trajectory in which intermediate targets for the years 2012, 2014, 2016 and 2018 are identified. In 2015, the Ministry for Economic Development approved the methodology to measure the achievement of these interim targets.

presence of urban and industrial areas, in accordance with the principles of environmental and economic sustainability. These leave the regions to decide on the mix of RE sources that will contribute to reach the target (DM 2012). The regional targets developed for 2020 - as well as the interim targets set up and monitored by the Ministry for Economic Development for 2014, 2016 and 2018- are shown in table 6.1.

Table 6.1 Regional Burden Sharing

	Regional targets by year (%)					
Region	**Reference year**	**2012**	**2014**	**2016**	**2018**	**2020**
Abruzzo	5.8	10.1	11.7	13.6	15.9	19.1
Basilicata	7.9	16.1	19.6	23.4	27.8	33.1
Calabria	8.7	14.7	17.1	19.7	22.9	27.1
Campania	4.2	8.3	9.8	11.6	13.8	16.7
Emilia Romagna	2.0	4.2	5.1	6.0	7.3	8.9
Friuli Venezia Giulia	5.2	7.6	8.5	9.6	10.9	12.7
Lazio	4.0	6.5	7.4	8.5	9.9	11.9
Lguria	3.4	6.8	8.0	9.5	11.4	14.1
Lombardia	4.9	7.0	7.7	8.5	9.7	11.3
Marche	2.6	6.7	8.3	10.1	12.4	15.4
Molise	10.8	18.7	21.9	25.5	29.7	35.0
Piemonte	9.2	11.1	11.5	12.2	13.4	15.1
Puglia	3.0	6.7	8.3	10.0	11.9	14.2
Sardegna	3.8	8.4	10.4	12.5	14.9	17.8
Sicilia	2.7	7.0	8.8	10.8	13.1	15.9
Toscana	6.2	9.6	10.9	12.3	14.1	16.5
TAA Trento	28.6	30.9	31.4	32.1	33.4	35.5
TAA Bolzano	32.4	33.8	33.9	34.3	35.0	36.5
Umbria	6.2	8.7	9.5	10.6	11.9	13.7
Valle d'Aosta	51.6	51.8	51.0	50.7	51.0	52.1
Veneto	3.4	5.6	6.5	7.4	8.7	10.3
total Italia	5.3	8.2	9.3	10.6	12.2	14.3

Source: DM 15 March 2012 ‘Burden Sharing Decree’ (DM 2012)

These objectives are binding for the regions and a system is in place to penalise the regions that are not compliant[83]. It needs to be said that almost all regions and autonomous provinces

[83] If this objective is not achieved, the region (s) may be subject to a procedure of commissioning and consequent sanctioning including monetary charges that affect the regional budget.

recorded, both in 2012 and 2014, a share of the gross final consumption of energy covered by renewable sources higher than the forecasts of the Burden Sharing Decree (DM 2012) and many regions have also exceeded the targets set for 2020 (GSE 2016). The same report attributes this to the favourable national support mechanism for RE technologies and the progressive contraction in overall energy consumption primarily due to the difficult economic situation in Italy and to the increasing diffusion of energy efficiency policies. How Tuscany, Apulia and Sardinia performed with the interim targets is illustrated in table 6.2. All three regions are among the regions that have surpassed the forecasts for the burden sharing decree, with Apulia and Sardinia reaching the targets for 2020 already in 2014.

Table 6.2 Burden Sharing: Share of final consumption of energy covered by renewable energy (%) in the regions under investigation

	Predicted 2012*	Predicted 2013*	Predicted 2020*	2012	2013	2014
Sardinia	8.4	10.4	17.8	22.7	25.3	25.0
Tuscany	9.6	10.9	16.5	14.4	15.4	15.8
Apulia	6.7	8.3	14.2	12.2	15.1	14.4

* DM 15/03/2012

Source: GSE (2016)

However, the development of the burden-sharing regional targets was not without its problems. This, as shown later, related, in particular, to the delays that occurred for the methodology for their calculations to be produced. This created a policy landscape based on a legislative and administrative framework of unclear rules, often contradictory, and one that varied across regions (RSE 2011; Giannuzzi et al. 2013). This left regions to decide how to define their own targets and whether to set targets at all. Whether or not the targets for the regions that have formulated them before the ‘burden sharing’ played any role for future planning of energy investments and influenced, to some extent, RE deployment, is addressed in the next sub-section. This also highlights some of the differences that have emerged in target calculation and identification of resource potential in the Italian regions under investigation.

6.2.1.2 How differences at regional level have emerged

The principle of burden sharing was first identified in 2003 in the Legislative Decree 387 that implemented the EU Directive 2001/77/CE. As discussed above, the PAN (MISE 2010) also in 2010 further suggested that the national targets were to be divided across regions. Yet, the proposed methodology to identify the regional share of the national target, including the parameters and the procedures that needed following, were only published in 2012 (DL 2003). This delay left the regions without any indication of how they should contribute to the national targets. In their absence, some regions set individual targets autonomously, and without coordination at the national level, in their Regional Energy Environmental Plans[84] (PEARs) or waited to upgrade their PEAR[85] in accordance to the burden sharing principle[86].

Additionally, although between 1962 and 1998 national energy plans were issued periodically, bound to the strategy of the state-owned energy providers, from 1998 to 2013 Italian energy policy was marked by the absence of a clear integrated long-term vision for the development of the sector[87], and the exploitation of RE sources. As argued in chapter 4, during this period, Italy lacked a detailed road-map not only to increase the penetration of RE but also to guide Italy towards meeting its EU obligations. Hence, many argued that the national targets, developed and published in the PAN (MISE 2010), set as reachable by 2020, were lower than the actual RE sources' potential (Gianni et al. 2012), questioning the processes under which such targets were calculated. '*The dialogue between us and the government has not been always easy (….) the communication between the technical and the political levels is not particularly fluid, it meets resistance, and anyway political decision is taken on other basis. We act as technicians to produce the models but the political bodies are*

[84] As discussed, these are produced by each region and they establish regional energy policy objectives.

[85] The DM March 2012 suggested that the regional governments had until the end of 2016 to update their PEAR in accordance to the burden sharing objectives. The delay in publishing the regional updates was also due to the complexity of the methodology envisaged, which required a number of data set that were not often available at the regional level and required new calculations.

[86] The delay and the lack of coordination might have but fortunately did not result in targets that made the PAN, and the national target, unachievable. The PAN targets were achieved for some RE sources as early as 2011. Yet some regions did not have any targets to RE deployment until their PEAR update.

[87] The NES, published in 2013, as discussed, has however reversed this trend.

selective in terms of using the data to support the message that they want to promote' (Interview ENEA[88]). For instance, the 2020 target of 8000 MW of installed capacity for PV power had already been reached before the end of 2011[89].

Some regions, including, Tuscany, Apulia and Sardinia, adopted RE targets before the identification of the burden-sharing objectives, utilising different approaches to resource potential evaluation[90] and providing different timescales (from short-term to long-term targets) for the achievement of regional targets. Some RE targets appeared in regional plans that had been in existence for a long time (as discussed, some were first published in the early 2000s). Hence, they often did not consider technological and legislative developments, thereby underestimating RE potential and opportunities (Gianni et al. 2012).

Apulia's PEAR (PEAR 2007: 133) included 'a target of 8000 GWh (about 4,000 MW of installed capacity) in the wind sector' and '200 MW in PV installed capacity' (PEAR 2007: 170). Nevertheless, although the wind energy forecasts proved to be in line with the trend recorded over the last few years, photovoltaic forecasts heavily underestimated actual outcome by more than an order of magnitude (with over 2,499 MW installed (PEAR 2014)). The favourable incentive system attracted the attention of numerous, varied entrepreneurial organisations that proposed, during the peak demand period (end of 2011) 37,000 MW of wind and 18,000 MW of photovoltaic projects (PEAR 2014). Moreover, by the end of 2012 Apulia had 78% of installed PV capacity generated by large-scale ground-based solar farms nearly twice the Italian average of 43% (Giannuzzi et al. 2013).

While Apulia '*started from a situation in 2006 where there was no (or very limited) RE and Apulia is the only region without hydroelectric power that historically constitutes the major RE source in Italy*' (Interview ARTI), Tuscany had a higher capacity of RE resources already

[88] The material quoted from the interviews is attributed to the organisation but not the respondents to protect their anonymity.

[89] Nevertheless it is this target for solar PV (and the others technologies, mentioned and published in the PAN) that were used as a basis to calculate the regional targets under the 'burden sharing' principle.

[90] Even at national level there has not been a uniform study to provide an estimate of Italian RE resource potential. This is often estimated utilising the research from Fondazione per lo Sviluppo Sostenibile (FSS 2009) the study of ENEA (ENEA 2010) and for wind resources the ANEV study on the Italian potential of Wind Resources (ANEV 2008). The estimated potential calculated by these studies is higher than the potential identified in the PAN 2010, as argued in Gianni et al. (2012).

deployed, such as geothermal and hydro. The regional government produced targets as early as 2000, and these were revised again during 2008. Interestingly, the higher capacity of already deployed renewable sources (hydro and geothermal) helped Tuscany achieve intermediate targets. Tuscany is the only Italian region with installed geothermal capacity (this accounts for 36.9% of total RE installed capacity in the region) and '*with respect to the other regions all the goals of 2020 in fact can be achieved by geothermal energy alone*' (Interview SantAnna). This to some extent has influenced the choices made concerning RE deployment and '*limited the deployment of large scale wind and ground- based solar energy initiatives*' (Interview REG Government T).

Sardinia published earlier targets for RE in the 2006 PEAR, indicating an overall target of installed capacity for 880 MW by 2010. In 2008, this target had already been reached (as the region had already 950.8 MW of capacity installed by the end of 2008). This reflects, as argued, the tendency in the regional PEAR of underestimating the RE potential of natural resources and questioning the validity of the targets set in the PEAR. Furthermore, the regional plan provided little evidence that targets could be a useful way of providing any strategic direction for RE development in the region prompting some commentators to suggest that '*the regional government lacks a coherent strategy for RE and there is no plan (or targets) in place for RE development*' (Interview Confindustria).

Targets, in the Italian regions investigated, were not seen as a specific instrument for evaluating, planning and consenting RE deployment initiatives that could help reaching those targets (cf. Gianni et al. 2012). This is in contrast with the role that targets have played in other regional and subnational contexts in other countries identifying potential capacity for RE natural resource endowment exploitation and driving RE deployment. This, for instance, is the case in Scotland and Wales, in which target setting becomes, as argued by Cowell et al. (2015) a key feature, and a policy output, of devolution, that has provided an important act of differentiation from Westminster. I discuss this in more detail in the next section.

Table 6.3 Regional targets and PEARs in Italy

Apulia	PEAR 2007 (targets to 2016)	(i) To halve, between 2004 and 2016, the growth trend of regional energy consumption with respect to the preceding fifteen years (from +19.3% to +9.9%) (ii) To increase the contribution of renewable energy as a percentage of the total regional production from 3% in 2004 to 18% in 2016; (iii) To provide electrical energy production from renewable sources of about 8,000 Giga Watt Hours (GWh) for 2016 (rather than the forecast amount of 5,000 GWh); (iv) To reach 150 MW of installed solar photovoltaic power
Tuscany	PER 2000 (targets to 2010)	- 300 MW of potential for wind installed capacity - 6 MW of potential for PV installed capacity - 1080 MW of potential for geothermal energy - 364 MW of potential for hydro energy
	PIER 2008 (targets to 2020)	(i) To reduce greenhouse gas by 20% in 2020 (ii) To create the condition to produce up to 50% of electricity through the use of renewable sources, including: a. a maximum of 300 MW of wind installed capacity; b. 700 MW of offshore wind; c. 700 MW of PV capacity d. 100 MW additional geothermal capacity (medium enthalpy systems)
Sardinia	PEAR 2006 (targets to 2010)	(i) Overall target of installed capacity for 880 MW a. Thermodynamic solar: 80 MW (to reach 100 MW by 2014) b. PV solar: 100 MW c. Wind: 550 MW d. Biomass: 145 MW e. Hydro: 370 GW

6.2.2 Targets and resource assessments in the UK: the importance of target setting for devolution in Scotland and Wales

In the UK, the distribution of targets also shows contrasting features across the English regions and the devolved administrations of Scotland and Wales. In the English regions, following the setup of regional governance around RE in the early 2000s[91], regional RE targets became

[91] Between 1997 and 2010, in England, measures were put in place to rescale governance institutions to the nine English regions, which included the establishment of a considerable network of organisations, offices and policymaking responsibilities at the regional level. Among these, Regional Development Agencies (RDAs) were set up to act as catalysts for economic development. This process was soon to be reversed with most of the landscape of regional institutions, in England, no longer in existence from 1 April 2012.

embedded into overarching economic strategies of the Regional Development Agencies and then fed back into the UK final RE strategy (Arup 2009). This was aided by regional renewable resource assessments which helped persuade the 9 English regions of the importance of RE for economic development purposes (Smith 2007). This process, in England, ensured the twofold aim of meeting the UK target - building from an evidence base - and making sure that sufficient locations for RE deployment would emerge from this process (Arup 2009).

In Scotland and Wales, on the contrary, the process of target setting was not influenced by Westminster seeking to steer the devolved organisations into delivering any specific share of the national commitments. Scotland and Wales produced their own energy strategies, which set their RE targets or aims (these are shown in table 6.4), together with their own regional visions and aspirations for RE development. Moreover, both regions have identified targets (or 'aims'/ 'aspirations' as in Wales) that exceed the UK target of meeting the 15% of RE sources by 2020. Their regional strategies were driven by regional growth agendas and, as Cowell et al. (2015) claim, they reflected mainly 'domestic' processes: such as political agenda setting, along with assessment of the resources available in each territory and projects in the pipeline. Besides, a high proportion of the potential RE resources of the UK lie within the territory of Scotland and Wales and the extent to which they are realised will affect whether UK RE and decarbonisation targets are met.

A distinctive factor that differentiates between Scotland and Wales is that Scotland has actually managed to meet a succession of its own national targets set above the UK norm, whereas in Wales targets and aims to RE expansions have often been seen as 'a wish list, rather than a concrete action plan for delivery' (De Laurentis 2012: 1992).

Table 6.4 Renewable Energy targets and aims of the devolved governments in the UK*

	Current target	Key sources
UK level	15% of energy (30% of electricity) from renewable sources by 2020	Department of Energy and Climate Change (DECC) (2011) *UK Renewable Energy Roadmap*, July, DECC: London
Scotland	Renewable sources to generate the equivalent of 100 per cent of Scotland's gross annual electricity consumption by 2020	Scottish Government (2012) *2020 Route Map for Renewable Energy in Scotland*, Scottish Government: Edinburgh.
Wales	Generating the equivalent of twice 2010 Welsh electricity consumption from renewables by 2025 Wales to generate 70 per cent of its electricity consumption from renewable energy by 2030.	Welsh Government (2010) A Low Carbon Revolution: The Welsh Assembly Government Energy Policy Statement, March. On 28 September 2017, the Cabinet Secretary for Environment Lesley Griffiths announced new targets for energy generation in Wales.

Source: Author’s elaboration following Cowell et al. (2015)
*Note: Northern Ireland is not included in the analysis.

Scotland, as shown, is well endowed with RE sources from onshore and offshore wind, to biomass, hydro and marine energy, offering a high potential of energy sources and has adopted ambitious targets to drive the exploitation of these. The setting of these targets has been a key feature of a policy agenda spanning successive governments, which gives significant prominence to the expansion of RE.

The Scottish Government was the first of the devolved government to set a RE target back in 2000 and this was achieved in 2007, three years earlier than anticipated. A detailed assessment of different renewable technologies commissioned by the Scottish Executive (Garrad Hassan 2001) provided the basis to raise awareness of the potential of the RE sector in Scotland (especially marine energy) and allowed the Government to further extend targets and plan for RE expansion (see also Winskel et al. (2014) and Cowell et al. (2013)). Targets were met and increased on a number of occasions and resulted in a revised 2020 target, with a goal to reach 100%[92] of Scotland's electricity consumption from renewables (SG 2012).

RE targets in Scotland acted as a '*positive feedback loop'* (WWF 2014: 26), based on Scotland's renewable resource endowments, raising aspirations and a vision of growth for the RE sector. Agreeing with Wolsink (2007), resource potential estimates played a key role in the co-evolution between resource assessments and efforts to promote and pave the way for development opportunities. This is certainly evident in the case of marine energy development that has become a 'distinctly Scottish political and industrial priority' (Toke 2014: 23).

In Wales, a statutory duty on the Welsh Government to promote sustainable development (Government of Wales Act 1998 Section 121) and an intense focus on environmental strategy making since 2003 provided the basis for successive Welsh governments to focus attention on energy and RE. A number of strategic documents were published by Welsh governments during the past decade to provide estimates of the potential of RE sources in Wales. The 2008 Renewable Energy Route Map for Wales (WG 2008) recognised that Wales had a natural advantage, for instance, in onshore wind due to its abundant onshore wind resource and the fact that onshore wind power is the most viable commercial technology available that will provide a high degree of certainty of meeting the 2010 target. These documents provided targets for RE deployment and indicated the role that RE could play in the region in terms of its wider economic, rural diversification and environmental agendas (Cowell et al. 2017).

Several issues are worth emphasising here. Differing from Scotland, technology specific targets that were set as early as 2005 to attain an additional 800 MW of onshore wind installed by 2010, but these were not achieved by this time[93]. The belief that fewer, larger-scale onshore wind farms represented the best means of delivery of earlier RE targets (for example the 10% by 2010) was met with the realisation that an insufficient number of

[92] The feasibility of meeting this latest target, as argued by Cowell et al., 2013, has prompted a significant level of debate; however, some authors suggest that Scotland is on track to achieve this (Scottish Government 2014 quoted in Toke (2014)).

[93] On-shore wind energy development from 2005 to 2010 fell short of the Welsh Government's 800MW target. Nevertheless, there is about 1950MW of onshore capacity under active consideration within the Strategic Search Areas, either awaiting consent of being consented and waiting construction.

locations would emerge sufficiently quickly, requiring a revision of the planning processes (Cowell 2007). Thus the sphere in which Welsh governments have done most to steer RE development in Wales has tended to be to focus on issues of planning (to facilitate onshore wind deployment) and this is discussed more in the sections that follow. Failure to achieve earlier targets motivated RE developers and investors to consider such targets as a 'wish list'[94], rather than targets that significantly drove policy action ('*Wales talks about it as much as Scotland, but has not necessarily put the budget behind it, as Scotland has. The distinctive approach is wanting to do it but not actually committing core funds*' Interview SUM).

Moreover, the recent targets, published in the Energy Policy Statement, were not mentioned in the 2012 energy strategy document 'Energy Wales: A Low Carbon Transition'. To some extent, the strategy represented a step change in energy policy in Wales. It signalled a move from '*green electricity*' and to 'd*eliver x megawatts of this and y megawatts of that*' to a more focussed attention on the '*economic, social and environmental benefits from this transition to Wales'* and to '*get more capital investment to be made through natural resources*' (Interview WG) [95].

Yet, this has also been criticised as a lack of a clear, '*strategic energy policy in Wales'*. Some commentators argued that 't*he most important lesson*' to be learnt '*from the current situation is that we need targets and a timeline. So by 2050 what proportion of our electricity do we want to come from the renewable energy sector?* (Interview RUK). Similarly, in 2016, the Environment and Sustainability Committee of the National Assembly for Wales[96] suggested that Wales should set targets to increase the production of RE in Wales and, in the context of the need to meet carbon emissions reduction by at least 80% by 2050. Following these

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[94] While Scotland managed to capitalise on the narrative around the 'legitimisation' of its resource assessment based on research conducted by UK's leading energy consultants (Garrad Hassan 2001), Wales failed to do something similar that would have strengthened the role of targets. Although earlier targets are referred to as '*Garrad Hassan's targets*' *(Interview NRW)* policy documents do not refer to research conducted by them in the same way as the Scottish government has done.

[95] As stated in Energy Wales: A Low Carbon Transition, Delivery plan (WG 2014: 13) 'the intent is to maximise economic growth in terms of jobs and wealth in Wales through policy support, supply chain and skills development and the provision of tailored flexible packages of support for the low carbon sector'.

[96] The Committee was established to examine legislation and hold the Welsh Government to account by scrutinising expenditure, administration and policy matters encompassing the maintenance, development and planning of Wales's natural environment and energy resources.

pressures, in 2017, the Cabinet Secretary for Environment Lesley Griffiths announced new targets for energy generation in Wales[97].

In summary, whilst many saw the ambitious targets of Scotland as a signal of leadership from the Scottish Government to promote RE (Cowell et al. 2013; Toke 2014; WWF 2014), the capacity and willingness of Welsh Government leaders to back targets and the supportive statements around the development of RE have been questioned. While I return on this point in the next chapter, the next section covers another important aspect that relate to the processes under which natural resources are turned into potential sources of energy.

As suggested, the material dimension under scrutiny in this chapter not only stresses the importance of the physical, technical, social, and economic appraisal of RE resources and their potential deployment, but also includes an understanding of the challenges that RE deployment presents for the management of land use and land availability.

6.3 Planning for RE and different values of environmental attributes

The attention here focuses on the practices that have emerged in planning and consenting processes, their design and regulation in accordance with local and regional specificities and priorities. The aim is not to review the changes that have occurred in planning policies and practices for RE and their outcomes in each regions but to offer an account of how similarities and differences have emerged, using the case study material as an illustration. Nevertheless, before turning the attention of the analysis to the case studies, it is necessary to stress some important features that characterise - and to some extent distinguish - the Italian and the British approaches to spatial planning governance and their implications for RE deployment.

In both countries, the issue of spatial planning has been characterised by a series of changes in governance processes, legislative reforms and attribution of competences at different

[97] Welsh Government, 'Lesley Griffiths high on ambition for clean energy, Cabinet Secretary for Environment Lesley Griffiths today announced new ambitious targets for energy generation in Wales', 28 September 2017, http://gov.wales/newsroom/environmentandcountryside/2017/170928-lesley-griffiths-high-on-ambition-for-clean-energy/?lang=en

administrative levels that have attempted to redefine the power relationship between different levels of governance.

However, in Italy, the debate on energy and RE policies, project siting and the environment has historically found little consideration in the field of planning and *vice versa* (Alberti et al. 2015), gaining importance only with the start of the liberalization process in the energy system. Moreover, as Italy's uptake of RE projects increased, the attention shifted from an attempt to intensify RE deployment to one that sought to regulate their spatial distribution, with implications for the regional governance of land-use planning and RE.

In the UK, on the contrary, there have been complex interactions between energy and planning policy over many years (McKenzie-Hedger 1995)[98]. Walker (1995: 4), introducing a special issue on land use and energy in the UK, suggested that the UK has made 'energy far more central to the land use agenda, creating pressures at national and local levels for the development of coherent policies and appropriate expertise'. Besides, up until the late '90s, the UK was generally considered, to some extent, to have a single planning system. However, since the process of devolution started, and following the changes in the political landscape occurred from 2010[99], the degree of divergence in the planning system in the UK has increased (Ellis et al. 2013). Across the devolved territories, planning arrangements, as well as targets setting, as discussed earlier, have become an important act of differentiation from Westminster. According to Cowell et al. (2013: 31) planning exemplifies 'how, under devolution, the various governments have sought to orchestrate the relationships between energy development, the environment and civil society'. In addition, in the UK, the land-use planning system has been identified by many as one of the most significant barriers to RE deployment (see for instance Wood and Dow (2011) and BWEA (2009)) and one of the main

[98] Moreover, long-standing government concerns over countryside protection have led the emergence of hierarchical planning frameworks. These were aimed to ensure that demands for that necessary infrastructure, such as housing and minerals, were met (cf. Cowell and Murdoch 1999).

[99] I am referring, in particular to: the Conservative-Liberal Democrat Coalition Government emerging from the 2010 national elections, the elections of the Devolved Administrations in 2011, the Welsh Referendum to extend the National Assembly power in 2011 and the Scottish Independence Referendum in 2014.

reasons for the failure of the UK to reach interim national targets[100]. Therefore, it is not surprising that planning policy development, in both Scotland and Wales, has become an important element in influencing RE uptake.

The remainder of this section discusses how addressing the challenges of planning and current land-based resource use differed across the regions examined and how these challenges have been critical in shaping the rate and form of RE development.

6.3.1 RE deployment in Apulia, Sardinia and Tuscany: between spontaneity and spatial planning

As mentioned previously, the issue of spatial planning in Italy has been characterised by a number of changes in the last few decades (for a review see for instance Gelli (2001); Servillo and Lingua (2014)). While there is no scope here to examine these in detail, it is important to highlight how some of these changes have had an impact on how planning for RE is regulated in Italy and its regions. The reform of the Italian Constitution of 2001 changed denomination of the field of planning competences from '*urbanistica'* (urban planning) to '*governo del territorio*' (territorial governance) and included spatial planning in the list of 'concurrent' legislative competences shared by the national and the regional levels (Servillo and Lingua 2014). This established the central role of the regional level in managing spatial planning, reduced the role of the municipal level (up until then the fundamental actor in managing urban growth and territorial change) and attempted to introduce a form of programming capacity to a planning system that has been traditionally '*urbanism'* oriented (Servillo and Lingua 2014).

Although these changes redefined the role of regions in territorial governance (see table 6.5 that illustrates the different tiers of governance, their role in relation to planning and how they compare with energy governance), two issues are of relevance here.

[100] As discussed in chapter 4, the recent development in offshore wind has contributed to overturn the view that the UK was a laggard in terms of deploying RE (Mitchell et al. 2006; Toke 2011).

Table 6.5 Territorial and Energy Planning Governance in Italy

Spatial level	Territorial planning and Governance	Energy planning and governance
National	The national state does not intervene directly and has no territorial planning or plan-control power. The central government has its own sectoral plans (such as that for energy and infrastructure), participates in the planning process via the 'Conferenze dei Servizi' and can trigger those relative to the localization of projects of public and national importance.	PEN- Piano Energetico Nazionale • 'Burden Sharing' Targets • Simplified authorisation • Linee Guida Environmental Impact Assessment (EIA) of sea water and hydroelectric plants over 30 MW and thermal plants above 300 MW
Regional	Strategic planning and 'Linee Guida' Regionali- Regional guidelines At regional level, the region has a general planning power, participates in the process of provincial and municipal plans and approves the final urban planning tools	PER- Piano Energetico Regionale Strategic direction and coordination Administrative functions for almost all types of plants relative to EIA: Size of Plants that require EIA: Wind > 60KW; Solar> 20 KW; Biomass> 200 KW; Biogas> 250 KW Regions can delegate their EIA duties to the Provinces; Regions have the option of expanding the scope of the 'simplified authorization scheme' (PAS) to power plants up to 1 MW and delegate this to municipality level (e.g. the case of Apulia)
Provincial	Provincial plan of territorial of coordination	Provincial Energy Plan (if delegated by the region) EIA Duties (if delegated by the region)
Municipality	Regulatory Municipality Plan e.g. Urban Master plan/ technical advices and procedures	Municipality Energy Plan (if delegated by the region) Guidelines for interventions to planners; Administrative functions relating to the construction, expansion, cessation, reactivation, localization and relocation of RE facilities (e.g. planning control) Provides simplified authorization schemes (PAS and Communication)

Source: Author's elaboration from GSE (2015)

Firstly, the regional reforms undermined the hierarchical organisation of the planning system and the primacy of the Piano Regolatore Generale (Land-use Urban Master Plan) at the municipal level, instituted by the national law introduced in 1942. However, the constitutional reform also called for a national reform of the planning system that would regulate the overall legal framework for the planning system, and in doing so update the 1942 national law, but this has yet to occur. The lack of a clear national planning legislative framework coupled with stronger devolution of competences to the regions resulted in a great variety of spatial planning approaches and produced a fragmented regulation that has often led to deep conflict between the different spatial levels (Gelli 2001; Servillo and Lingua 2014). Moreover, this produced weaknesses 'in implementing decisions and strategies, exposing the spatial dynamics to economic interests and speculative forces' (Servillo and Lingua 2014: 405).

Secondly, although the system of spatial governance has shown a 'withdrawal' of the State from the spatial planning dimension, there have been many cases, in periods of crises and emergencies, in which the national government has intervened in derogation from local planning instruments[101]. These issues have had a profound effect on energy and RE planning in the country. In implementing the EU Directive 2001/77/EC on the promotion of electricity produced from RE sources, the national government found itself in a situation of urgency in promoting RE deployment, leading to some extent to the strengthening of the influence of the national level over the planning sphere.

In order to accelerate the uptake of RE, the Legislative Decree 387/2003 intervened in the planning sphere simplifying the authorization and administrative processes for building and operating all types of RE projects. This Decree, as discussed previously, introduced a principle of 'Autorizzazione Unica' (Single Authorization) under which, regions or other delegated authority (e.g. provinces delegated by the regions), in compliance with local environmental and town planning laws, would issue or refuse such authorization[102], identifying a period of 180 days (reduced to 90 days in 2011) from the start of the authorization process. This not only represented an attempt by the national state to reduce the long delays caused at regional, provincial and municipal levels in authorizing RE projects, but also provided a clear indication that RE installations (and the infrastructures required for the operation of the plants) were considered of public utility, urgent and that could not be deferred.

[101] An example is provided by the 'housing emergency' and the '*condono'* derogative laws to regularize illegal constructions (Servillo and Lingua 2014).

[102] The 'simplified authorization scheme' (PAS) can be used for the authorization of RE plants below pre-set power thresholds (beyond which the Autorizzazione Unica is required, see table 6.5).

Moreover, although regions had the opportunity to set limits to the installation of RE on their territory, these limits were set around a number of national guidelines (*'Linee Guida'*). These as argued in chapter 4, represented the instrument, set at the national level[103] that informs regions about the criteria for siting of RE plants and supports them in the identification of areas and sites unsuitable for RE deployment. Whilst following the guidelines could be seen as an imposition, to a certain extent, to limit the power of regions to regulate the siting of RE plants in their territory, the Linee Guida were only published in 2010. These, it could be argued, got caught up in the Italian planning system's inertia and the lack of strong leadership from the national level (cf. Servillo and Lingua 2014). In their absence, regional laws have sought to identify criteria to regulate the siting of RE; these were however adjudged unconstitutional and abolished by the Constitutional Court.

This delay contributed to the emergence of a great variety of spatial planning approaches for RE at the regional level. Thus, some regions delegated their provinces and municipalities to i) produce provincial and municipal energy plans, ii) carry out the Environmental Impact Assessments and iii) expand the scope of the 'simplified authorization scheme' (PAS)[104] to power plants up to 1 MW. Besides, some regions in Italy become more amenable to large-scale development, while others attempted to restrict the sizes of RE projects. The differences in the regions of Tuscany, Apulia and Sardinia are represented in table 6.6.

The table emphasizes the complexity of the systems in place, considering that whereas responsibility for the Autorizazzione Unica and the Environmental Impact Assessment is shared between the regional and the provincial levels, provinces can differ further in their regulatory and administrative requirements.

[103] As discussed, the purpose of the Linee Guida was to provide a common framework for the authorization procedures and the operation of production facilities of electricity from renewable sources. The Guidelines sought to define the authorization paths to be followed for the different types of plants and the rules for proper design and integration into the landscape. In these respects, the regions can, in line with the national guidelines, articulate and adapt the content of their regulative framework to the characteristics of their territory to ensure the transparency and effectiveness of the procedures for the realization of the plants and the protection of the landscape.

[104] The 'simplified authorization scheme' (PAS) can be used for the authorization of RE plants and is submitted to the municipality at least 30 days prior to commencement of work, accompanied by a detailed report, attesting the compatibility of the project with the urban planning and existing building regulations. For the PAS, the silence mechanism is valid: after the 30 days from the PAS submission, in case of no feedback or notifications from the Municipality, the project subject to authorization can be started.

Tuscany was the '*first region in Italy to have identified a methodology, which included digital maps and geo-referenced data, to identify RE potential in the region*' with the '*aim of reducing* CO^2 *emissions' (*Interview Unisi*).* This approach, adopted as early as 2000 and published in the region's PER, not only spelt out *'the environmental implications of RE deployment*' (Interview Unisi) but was shared at the provincial level so that '*each provincial plan, following the same methodology, included efforts that could contribute to achieving regional objectives*' (Interview Unisi).

Table 6.6 Planning for renewable energy in Apulia, Tuscany and Sardinia

	Energy plans issued at:	'**Autorizzazione unica' (art. 12 Legislative Decree 387/2003**	**Environmental Impact Assessment (Valutazione di Impatto Ambientale)**	**Simplified authorization schemes (regimi autorizzativi semplificati) (PAS and Comunicazione)**	**Identification of excluded areas 'Aree non idonee'** After DM 'Linee Guida'
Tuscany	Regional, Provincial and Municipal levels	**Region/ Province** *PV: Province* *Wind: Province/ Region >1MW* *Biomass: Province* *Geothermal: Province/ Region* *hydro: province*	**Region/ Province** *PV: Province/ Region* *Wind: Region* *Biomass : Region/ Province* *Geothermal: Region* *Hydro: Province*	No difference from national legislation Comunicazione: as per national legislation with some extensions	only for PV projects
Apulia	No provinces and few municipalities produced their own energy plans	**Region** *Wind* *PV* *Biomass* *Hydro* *Geothermal*	**Region/ Province** *Wind: Province* *PV: Province* *Biomass: Province* *Hydro: Province* *Geothermal: Province/ Region*	Extended the requirement of the PAS to 1MW, for some of the RE sources (including solar and wind) Comunicazione up to 50 KW for all type of installations	PV/ Wind and Biomass
Sardinia	No province and no municipalities produced energy plans	**Region** *Wind* *PV* *Biomass* *Hydro* *Geothermal*	**Region** *Wind* *PV* *Biomass* *Hydro* *Geothermal*	Extended the requirement of the PAS to 1MW, for some of the RE sources Comunicazione: as per national legislation	PV/ Wind

Source: author re-elaboration following GSE (2015)

Apulia published its PEAR in 2007, but unlike Tuscany, no provinces and few municipalities produced their own energy plans. This created confusion as the authorisation procedures and operation of energy production plants are a regional level responsibility, whereas responsibility for the environmental impact evaluation resides at provincial and municipality levels. It also diminished the regional government's role in coordinating RE deployment. Moreover, in 2008 Apulia created a fast track approval and simplified licensing system that helped streamline the authorisation process for RE planning, project approval and installation. This provided '*a positive image of the region as an investment actuator*' (Interview ARTI). The Simplified Authorization Schemes implied that '*RE projects of up to 1MW could be authorized with a simple authorization to build issued by the municipalities*' (Interview Regional Government A)[105].

For both solar and wind energy, this led to an increased interest from RE developers and investors attracted by lucrative incentives and favourable natural resource conditions[106]. For instance, areas in the north of the region are '*less constrained by the landscape than other areas such as those in Abruzzo with its National Park, the mountains area and Tuscany'* (Interview REG government A). Moreover, the municipalities in the areas, which perform administrative functions (e.g. planning and authorisation for the construction and operation of RE plants, in coordination with the regions), played a dominant role. Some municipalities stood to gain from RE projects through the rent of the land (on average €5,000/ MW/ year) but also via generous royalties from developers (between 3 and 5% of RE generation and turnover)[107]. In Foggia, Apulia, a small municipality with 2000 inhabitants and 90 MW of installed capacity benefitted from royalties between €800,000-1,000,000 (RSE 2011).

[105] However, many larger initiatives were '*artificially fractioned into less than 1MW plants, eluding the requirements from lengthier procedures* (Interview Regional Government A).

[106] Moreover, the problems and lengthy delays in the authorisation procedures allowed for the emergence of an intermediary, known as the '*sviluppatore'*. The *sviluppatore* has local knowledge, manages the relations with the territory, proposes projects and negotiates with the local and regional governments, and acquires the authorisation, navigating through the complexity of the system. Once the authorisation is in place, they would sell the 'authorised project' to project developers who would then implement and manage the RE installations. This created a market of authorisations. The sviluppatori are in many ways seen responsible for the speculative bubble in RE deployment in Italy (RSE 2011).

[107] The Linee Guida published in 2010 prohibited this custom and introduced a system of environmental compensation mechanisms. These are defined during the Conferenza dei Servizi, proposed by the concerned municipalities, on the basis and in respect of any particular regional plans but cannot unilaterally be defined by a single municipality.

Apulia attempted to regulate RE planning and limited the development of certain areas with the approval of the Regional Landscape and Territorial Plan in 2008, a provision adjudged unconstitutional and abolished in 2010 by the Italian Supreme Court (Perrotti 2015)[18]. Although, the region's Regional Landscape and Territorial Plan was re-published (shortly after the publication of the Linee Guida), it triggered resistance to large-scale deployment, albeit after an impressive level of installed capacity had already been achieved.

In Tuscany, by contrast, the 2000 regional PER already identified the RE potential and identified the environmental implications of RE deployment. Moreover, an integral part of *Piano di Indirizzo Energetico Regionale* (PIER (2008)- the updated PER for the region) provided a map of landscape and archaeological constraints, of electric lines and of the average wind speed, to inform the spatial location and distribution of RE projects. This provided limits to, and constraints, on RE deployment, without the need for legislative intervention. Moreover, as the table shows, the Tuscan regional government did not differ from the national legislation and the negotiation between the drive towards a low carbon economic agenda and the need to protect the importance of the historical, cultural and artistic characteristic of the regional territory has represented a consistent part of the different versions of the regional energy plans (2000, 2008 and 2015). I will return to this point in more detail in the next chapter.

As mentioned earlier in this chapter, the Sardinian regional government has been slow in providing any strategic direction for RE deployment, lacking '*a coherent strategy*' or '*plan'* for the development of RE (Interview Confindustria). This is also reflected in the choices made in terms of planning for RE. For instance, in the absence of the Linee Guida, the Sardinian regional government, in order to regulate energy-environmental planning for the installation of wind power, utilised the instrument of the moratoriums[108]. The first, introduced in 2004, forbade the construction of wind farms until the approval of the regional landscaping plan, which occurred almost two years after the moratorium law. A further moratorium was introduced in 2010 to '*limit the installation of wind power plants in the regional territory*', suggesting that only wind energy plants that met the energy needs of the region can be

[108] Apulia also utilised a moratorium to oppose wind power projects in 2005. This was rejected and revoked because deemed contrary to the principle of the Legislative Decree 387/03.

authorised[109]. These moratoriums became subject of contestation (being announced, enforced, revoked, subject to litigation at administrative tribunals and eventually cancelled). Hence, they not only had the effect of delaying the realization and authorisation of new plants, but also discouraged investors, inducing them to divert their activities to other regions.

6.3.2 Spatial Planning in Wales and Scotland: a key feature and a policy output of devolution

As shown in the section 6.3, land use planning and energy-consenting has been critical for both Scotland and Wales in shaping RE deployment as these areas have offered much scope for autonomous policy development. Table 6.7 captures the differences in the planning arrangements for RE in both Scotland and Wales and how they have become an important act of differentiation from Westminster[110].

Wales follows a 'plan-led' approach to planning and the strategic document 'Planning Policy Wales'- supplemented by a series of topic-based Technical Advice Notes- sets out the land use planning policies for Wales, providing guidance on the preparation and content of local development plans and advice on development control decisions and appeals[111]. Although planning in Wales is fully devolved, planning responsibility for energy is, however, divided between the Welsh and UK governments depending on project size and location (on-shore and offshore).

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[109] The moratorium also stressed that new plants, with the only exception of small plants built for self-consumption, could only be implemented, by the region, via a wholly publicly owned company (Sardegna Energia Spa).

[110] As argued in chapter 4, the market support for onshore wind energy has been reduced and scheduled for removal. Many argue that on shore wind could provide energy at a guaranteed price of power that it is commercially viable and subsidy-free. This emphasises even more the issue of planning for significant increases in onshore wind.

[111] Planning policy guidance is a powerful administrative device for steering decisions of local planning authorities and is both used by the Welsh and Scottish governments (Power and Cowell 2012).

Table 6.7 Planning policy and renewable energy in Scotland and Wales

	Position at 1998	1998-2013	2013 onwards
Wales	Applications of 50 MW or over and major grid network proposals determined centrally, by UK Government Ministers. Applications below 50 MW determined by local planning authorities under town and country planning legislation for England and Wales. Planning policy guidance (PG22) provided criteria-based guidance (Department of Environment and Welsh Office 1993).	Applications of 50 MW or over and major grid network proposals determined centrally, by the Infrastructure Planning Commission (under Planning Act 2008), then transferred back to UK Government Ministers (Localism Act 2011), with consents issued under fast track procedures. Decisions guided by National Policy Statements. Applications below 50 MW determined by local planning authorities under town and country planning legislation for England and Wales. 2005 planning guidance (Technical Advice Note 8) institutes spatial zoning for wind farms over 25MW, within seven ‘Strategic Search Areas’. Grid network: central government applications of 132 kV or over and local panning authority for substations.	Applications over 50 up to 350 MW to be determined by Welsh Government under Wales Bill 2016. Applications over 350 MW still determined centrally by UK government ministers under Localism Act 2011. Applications from 10–50 MW to be determined by Welsh Government, under the Developments of National Significance (Wales) Regulations 2016. Applications below 10 MW determined by local planning authorities under town and country planning legislation for England and Wales and Planning (Wales) Act 2015.
Scotland	Applications of 50MW or over and major grid network proposals determined centrally, by UK Government Ministers (Secretary of State for Scotland), managed by central Scottish consents unit, under Sections 36 and 37 of the Electricity Act 1989.	Applications of 50MWor over and major grid network proposals determined by Scottish Ministers, managed by central Scottish consents unit. Nine-month time target for determining applications introduced post-2007.	No significant changes introduced

	Applications below 50 MW determined by local planning authorities under town and country planning (Scotland) legislation. Planning policy guidance issued in 1994 gave criteria-based advice, and advised local authorities to demarcate in their local plans areas that would be suitable and unsuitable for wind farms	Applications below 50 MW determined by local planning authorities under town and country planning (Scotland) legislation. Planning policy guidance issued in 2006 revised and updated guidance, continuing advising local authorities to demarcate in their local plans areas that would be suitable and unsuitable for wind farms. Planning Advice Note 45 issues good practice guidance. National Planning Frameworks identify particular infrastructural schemes as 'national developments' for which there is government support.	

Source: Author 's re-elaboration following Cowell et al. (2017)

Although consenting powers rest with local planning authorities (RE projects of 50 MW or below), the Welsh Government via the Planning Policy Wales, the Wales Spatial Plan[112] and the Technical Advice Note 8: Planning for Renewable Energy (hereafter TAN 8) has set policy and provided guidance for developers and decision makers at the local level. The TAN 8, in particular, has been an important strategic spatial policy guidance tool for RE deployment, representing the sphere in which the regional government has done most to steer energy development (especially on-shore wind) within its territory[113]. TAN 8, issued back in 2005, sought to overcome the increasing public oppositions to wind farm development experienced during the mid-1990s in rural Wales (McKenzie-Hedger 1995; Cowell 2007), in order to expand renewable deployment to achieve the 2010 RE targets, containing its environmental impacts.

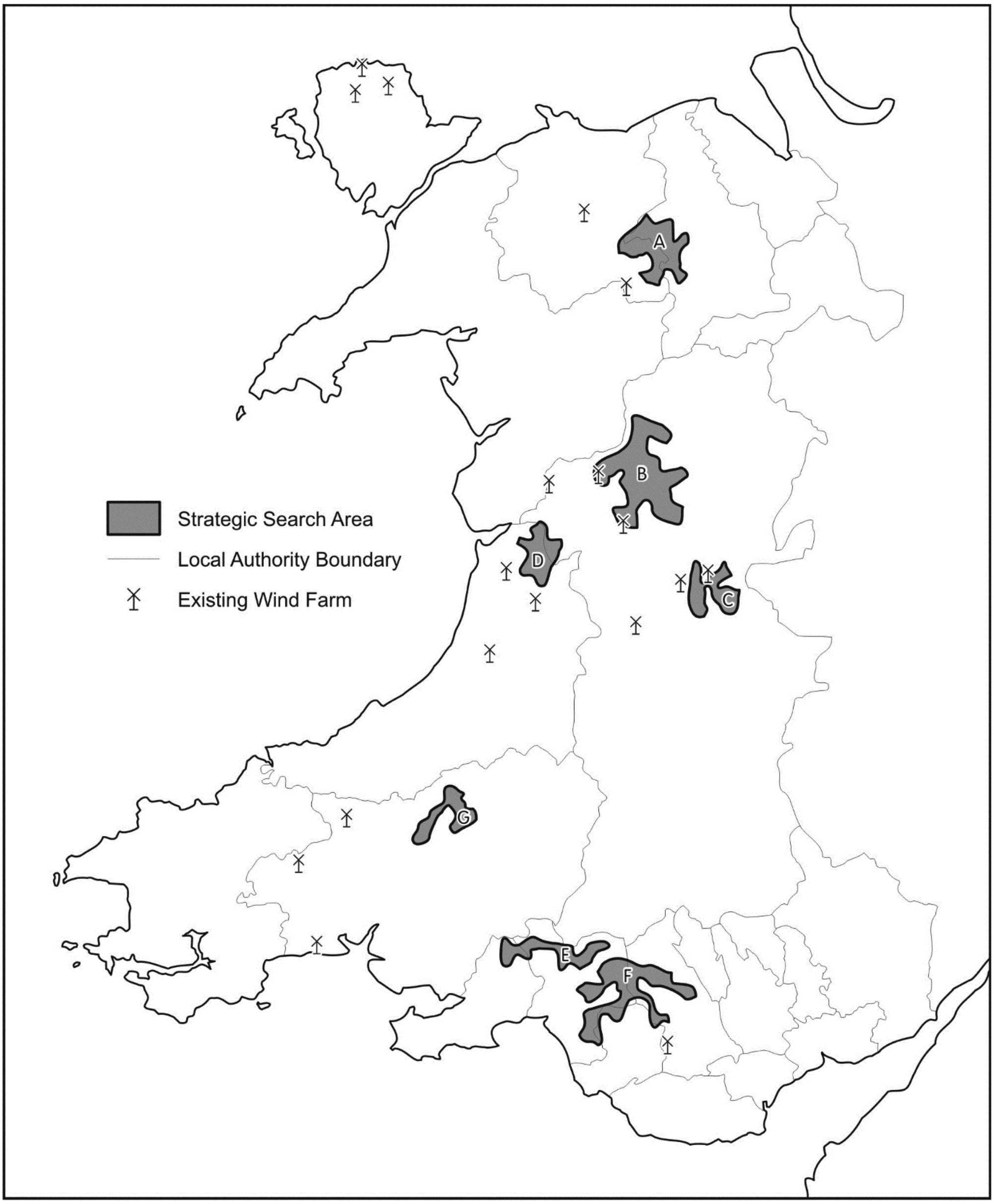
Rather than providing a criteria-based guidance, TAN 8 identified seven spatial areas, denominated Strategic Search Areas (SSAs)[114], creating a presumption in favour of large-scale (25 MW and above) on-shore wind development (the technology closer to the market at that time) within these specially demarcated areas (see Figure 6.2).

[112] The Wales Spatial Plan (2004 & 2008 Update) was once regarded as one of the key delivery mechanisms for the Welsh Government duty to promote sustainability. As part of the plan, Low Carbon Regions were identified to provide a focus for action on climate across Wales. The Wales Spatial Plan also included the requirement for each Low Carbon Region to contribute practical plans for delivery (only the South West Wales region produced such plan including a route map to map the transition towards a low carbon region, including actions for RE).

[113] Cowell and colleagues have described in detail the issue of spatial planning and energy in Wales, Scotland and the UK in general. This section summarises some of their work, but also draws on discussion with Prof Cowell on specific issues related to this research that resulted into a joint authored conference paper (De Laurentis and Cowell 2017).

[114] These resulted from an exercise with combined resource assessments, constraints mapping exercise (such as designated environmental futures, presence of radio or military constraints) and a study of the electricity network.

Figure 6.2 Strategic search Areas in Wales



Source: WAG 2005 in Cowell (2016)

This approach sought to 'accommodate at least 800 MW of new capacity to help meet the (then) 2010 RE targets' and to provide, by concentrating rather than dispersing wind farm development, 'certainty and consistency to corporate investment and planning decisions on larger wind projects across Welsh territory' (Cowell 2016: 9,10). TAN 8 acted de facto as a 'national zoning framework' (Cowell et al. 2017: 175) that not only offered a supportive policy context for wind power development but was also interpreted, by the wind energy sector[115], as a 'stabilising condition for investment' (Cowell et al. 2017). The seven SSAs attracted applications totalling over 2000MW in capacity, exceeding initial expectations. However, several wind farm applications within the SSAs have been rejected casting a shadow over the suitability of the zoning approach to yield the desired implementation targets for renewables. The installation of wind capacity in Wales has also been slower and patchier than anticipated[116]. To some extent, the spatial concentration of large-scale windfarm applications, within the seven zones, coupled with the requirement for major new grid connections, triggered protests and subsequent refusal of planning consent despite the supportive spatial policy.

The TAN 8 approach also raised questions about the capacity of the regional government to orchestrate planning centrally. Firstly, local authorities, during the TAN 8 consultation, shared industry concerns about the validity of centrally mapped wind farm locations and saw the TAN 8 as an imposition of WG direction (Power and Cowell 2012). The TAN 8 promoted the preferential siting of large-scale renewable schemes, based on resource potential and the delivery of targets and objectives (Stevenson 2009), but neglected local aspirations for the potential of other uses of the land. 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: 298). Moreover, many questioned the narrow framing of the policy problem around onshore wind at the expense of energy conservation and other renewable technologies (e.g. domestic scale technologies and offshore wind).

[115] Wind energy developers, although initially hostile to the way in which TAN 8 restricted their siting options, channelled a significant number of large scale wind farm capacity proposals towards the SSAs.

[116] Ellis et al. (2013) argue that the volume of onshore wind farm capacity consented in Wales has being less than 15 % of the volume consented in Scotland since January 2007.

Secondly, the TAN 8 supported the upsurge of wind farms applications over 50 MW. As shown in table 6.7, consenting powers, for the type of projects that the SSAs attracted[117], rested within the National Infrastructure Directorate, hence at the national UK level. This was seen as a particular source of frustration to the actors involved, and the WG in particular, providing significant ambiguity around RE responsibility.

The intensifying of the conflicts around planning responsibility become the subject of two major enquires: the National Assembly for Wales Environment and Sustainability Committee Inquiry into Energy Policy and Planning in Wales[118], and the Commission on Devolution in Wales (the Silk Commission[119]) (Cowell 2016). Further devolution of energy consenting powers was seen as a way to enable greater territorial coherence in energy governance and energy infrastructure. Nevertheless, it also highlighted the problem that devolution might not be beneficial in meeting the needs of the wider United Kingdom in achieving energy security (Cowell 2016). As highlighted in table 6.7, the Silk Commission's recommendation was to increase the thresholds for energy generation consents devolved to Wales to 350 MW, onshore and offshore, making provision for devolving electricity infrastructure consenting powers to Wales to be included in legislation (Cowell 2016)[120].

The approach to planning for RE in Scotland is less focused on the association between the identification of sites and RE development (for target achievement) than in Wales. However, Cowell et al. (2013: 31) argue that 'planning approval rates for onshore wind farms have been higher in Scotland than anywhere else in the UK' and planning is often seen 'as another

[117] As I will explain later this has now changed, following the results of two inquiries into devolution and energy in Wales.

[118] The National Assembly for Wales Environment and Sustainability Committee Inquiry into Energy Policy and Planning in Wales ran from July 2011 and reported in June 2012. According to (Cowell 2016: 11), it framed the issue in terms of 'what are the implications for Wales if responsibility for consenting major onshore and offshore infrastructure projects remains a matter that is reserved by the UK government?.' And 'how it might affect achievement of the Welsh Government's goals for renewable and low carbon energy development and greenhouse gas reductions?'.

[119] The Silk Commission, established in October 2011 and finished reporting in March 2014, was set up by the UK Government and tasked with examining the boundary between devolved and non-devolved powers and recommending improvements.

[120] Consenting for associated development like substations or grid connections, it was suggested, would be aligned with whoever has responsibility for the main project and the UK government (Cowell et al. 2015).

ingredient in Scotland's success in delivering RE, especially onshore wind'. As discussed, planning in Scotland is fully devolved and Scottish ministers have the power to issue consents for major infrastructure, which apply to all on shore RE (over 50 MW) and electricity lines. Such central decision-making has generally resulted in higher consent rates than local planning authorities and a higher proportion of wind farm capacity has been realised through this route.

Although the planning approach adopted in the first instance depended on 'criteria based guidance', since 2006, following the rapid rollout of wind energy in Scotland (and the emerging conflicts around wind energy due to cumulative landscape effects), a spatial framework for on shore wind development has been introduced[121]. Local planning authorities have been allowed to identify 'broad areas of search', where large-scale wind farm proposals (greater than 20 MW), would be supported and 'areas that will be given significant protection (e.g. National Parks and National Scenic Areas)' (SEDD, 2007, cited in Cowell (2007: 302))[122].

Importantly, the Scottish Government has also played an important role in steering RE consent approval and deployment. Firstly, it played a positive role in encouraging local planning authorities to adopt a favourable stance towards RE development. Secondly, although local planning authorities are required to draw up zones, the Scottish Government has used its power of 'strategic plan approval' to overturn local authority zone definitions if these were considered too spatially restrictive (cf. Cowell et al. 2013). Thirdly, the Scottish Government also deals with appeals on planning applications; and sometimes, decisions have been overturned in favour of wind farms deployment. Toke (2014) also argued that although there have been intense controversies about planning decisions for wind energy projects in Scotland, there has been a generally supportive and facilitative stance by the Scottish National Heritage, the body responsible for the conservation of landscape and nature in Scotland.

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[121] The Scottish Natural Heritage, Scotland conservation body introduced strategic locational guidance and efforts to map Scottish Territory according to a Natural Heritage Sensitivity zoning system. However, this guidance is not statutory.

[122] Planning authorities are required by the Scottish Planning Policy to set out in their Development Plan a spatial framework for onshore wind farms, which serves as a guide for developers and communities and identifies areas where wind farms will not be acceptable, areas of significant protection, and areas with potential for wind farm development.

Section 6.3, together with the different examples presented, shows that there are significant differences that have emerged in planning and consent, planning policy design and regulation. The examples offer an account of the differences that have occurred in organising the relationship between RE energy resources and other material factors and the challenges that RE deployment present for the management of land use. I now turn to discuss further the issue of land availability, as this has emerged as an important socio-material factor that has also influenced RE deployment.

6.4 The availability of land and current land-based values

As discussed, different approaches of planning for energy resources have provided different opportunities (and constraints) for RE energy development. While the previous section has discussed the differences in planning and consenting practices in the regions under investigation, the attention here focuses on the competing interests for land resources and the multiple uses of land and how these have rendered land available for RE installations. As already pointed out, the demand for land becomes a critical question in RE deployment and the challenges not only relate to the availability of land for realising RE targets but also to existing grid and distribution infrastructure (and the land available for their potential expansion). While I will return to the issues of grid connectivity and distribution in chapter 8, here I present some examples of how different population density, a declining agricultural sector, and land rights have also influenced RE deployment and the type of RE projects, in the regions under investigation[123] (cf. Wolsink 2007).

Apulia is mostly characterised by flat areas and small hills, with 83 % of territory being agricultural land. It is the '*availability of agricultural land'* (Interview CREA) in the region that

[123] This section does not cover the loss of land for agricultural production and the involvement of agriculture in the production of energy resources through land use for the production of biomass. All the regions under-investigation have promoted bioenergy production within their energy systems. However, a part of some few examples of imported biomass, most of the bioenergy plants are small scale and use local biomass. Therefore when talking about the use of agricultural land for the production of energy resources I refer to the use of agricultural land to produce energy other than bioenergy.

has played an important part in its RE development path. Land availability acted as a 'land reservoir'[124] for PV and wind plant installations especially since the first national feed-in tariff system was implemented in 2005 (cf. Perrotti 2015). Many interlocutors have highlighted this characteristic of the area, coupled with the availability of optimal wind speed and solar irradiation, as '*an ideal territory*' (Interview Regional Government A; Interview Uni Foggia) for the expansion or RE. The small size of farms, with the consequent fragmentation of agricultural land and the issue of generational renewal, combined with agricultural production based on arable/ wheat farming, have characterized the agriculture sector's economic crisis. RE has been, therefore, regarded as a '*financially interesting alternative income source*' (Interview Uni Foggia) and a 'major factor in thwarting economic crisis and social isolation of rural activities' (Perrotti 2015).

Both Tuscany and Sardinia, on the contrary, are characterised by an agricultural sector that uses the land for '*non intensive crops'*, supporting higher-end '*niche*' agriculture productions (Interview CRIBE) and '*livestock farming'*[125], respectively. Moreover, in Tuscany, '*the landscape discourse is fundamental and an integral part of the region*' and '*it is always difficult to have the authorizations by the responsible bodies for so many types of interventions*' (Interview REG government T). Hence, the regional energy plans (2000, 2008 and 2015) stressed that RE development and deployment in the region stem directly from the negotiation between the drive towards a low carbon economic agenda that can harness local natural resources and the need to protect the importance of the historical, cultural, and artistic characteristics of the regional territory. This provided limits to and constraints on RE deployment.

In Apulia, many energy developments also took place in hilly and mountainous areas where communities are small, or remote, with a lower economic base and characterised by demographic decline. In these areas, RE constituted an opportunity to overcome the socio-economic problems of the local communities (RSE 2011). In Apulia, and to a lesser extent in

[124] Not many official statistics are available that show the percentage of agricultural land used for RE installations; an estimate presented by ARPA Apulia shows that, already in 2009, 738,323 MW come from a total agricultural area of 2,214 hectares.

[125] The surface of Sardinia is exploited by 60% for breeding and 20% for agriculture.

Sardinia, rents/ or revenues from RE schemes represented local development opportunities for rural and farming communities, with many landowners investing in RE to benefit from the rent of the land. However, small municipalities did not often have sufficient capabilities in territorial planning and landscape governance to regulate RE deployment, as discussed, and local development opportunities translated into the ability to attract development into the areas, associating larger potential RE capacity with higher rents[126]. At the regional level, both regional governments also lacked organizational capacity (e.g. Sardinia without a strong PEAR and the inertia caused by the various moratoria and Apulia with its simplified authorization system but without a strong leadership control over the municipalities) that could promote local economic development. This to some extent contrasts with the strong organizational capacity of the Tuscan regional government, whereas RE developers, and small municipalities, resulted, to some extent, in being weak in influencing regional decision-making (cf. RSE 2011), representing another factor that contributed in limiting large-scale deployment.

One might expect that the greater presence of local farming families in the Welsh economy (in comparison to the highly concentrated land-ownership in the Scottish case) could have facilitated wind farm developments by local farmers (or local communities) or rendered more land available for development to benefit from rent/ revenue and spur local communities' development opportunities. However, many wind energy projects, by either local individual/group or multinational firms, have faced public opposition. As argued above the SSAs have sought to concentrate large-scale wind power development, aiming to protect the Welsh countryside from significant wind energy development outside these areas. Nevertheless, this has inevitably created an advantage for larger multinational companies that had the resources and expertise to challenge public opposition (cf. Munday et al. 2011; Power and Cowell 2012; Cowell 2016).

In Wales, the Forestry Commission Wales (now part of Natural Resources Wales- NRW) is the biggest landowner in Wales and its estate overlaps significantly with the SSAs. NRW played an important role in increasing the number of wind energy projects deployed, acting as an

[126] It is interesting to point out that also not many community energy developments have risen in both Apulia and Sardinia to increase the benefit of local communities. This probably is also a consequence that community benefit is a rather new practice in energy in the south and the centre of Italy. The north of Italy, on the contrary, has experienced many examples of community energy projects and has a tradition of community engagement in the hydro energy sector.

agent for the Welsh Government, in organising a preferred bidder strategy for wind farm sites, therefore '*rendering National Forest land available for wind development*' (Interview NRW). As part of this, NRW specifically asked potential developers to address community benefits in its programme to allocate the development rights and to outline plans for local purchasing and estimates of contribution to the regional and local economy in terms of gross value added generation and employment (Munday et al. 2011). The local economic contribution and community benefit provisions were seen as a means for increasing local land availability, fostering local support and potentially, therefore, as a way of expediting planning consents[127].

The lower population density and the existence of large areas of open land outside protective designations also played an important role in facilitating RE deployment in Scotland[128]. Developers found it more straightforward to gain consent for projects than in Wales (cf. Cowell et al. 2013) and to obtain planning permission for large-scale schemes in wind energy deployment. RE deployment in Scotland occurred in a context of a 'rich' wind resource, the availability of large areas of land for development, dominated by a small number of private landowners, and supported by a policy environment that encouraged developers' confidence and attracted projects. Moreover, land ownership (in the form of large private estates[129]) and the issues associated with the agenda of land reform (such as community land purchase), together with the problems of enhancement of the energy systems of Scotland's remote island communities, have also triggered the development of an agenda for community energy (Cowell et al. 2013; Murphy and Smith 2013). In order to promote this further and to contrast with raising concerns over land availability and public opposition to limit future wind energy development, community energy has become an important goal of RE in Scotland, as indicated by the Scottish Government's 'target of 500 MW of community and locally owned

[127] To some extent, many argue that this was the key to the success of the Pen-y-Cymoedd project. The project has established a benefits fund, administered by a specially formed Community Interest Company that will provide around £45 million funding over its 25-year lifetime to be distributed amongst communities in adjacent valleys.

[128] As discussed earlier, Scotland has 60% of UK's onshore wind generating capacity (RE Scotland Statistics).

[129] An article published in the Guardian suggested that on shore wind power in Scotland is dominated by a small number of private landowners and 'estate owners – where 1200 people owns two-thirds of the land, have so far benefitted the most' (Vidal, 28/02/2012 available at https://www.theguardian.com/environment/2012/feb/28/windfarms-risk-free-millions-for-landowners

renewable energy capacity operating in Scotland by 2020', making Scotland the only part of the UK to set such target[130].

6.5 Concluding Remarks

In this chapter, I focussed the discussion on how differences have emerged, at the regional level, by drawing from the processes under which natural resources are turned into potential sources of energy, via the iteration between spatial resource assessment and alternative land uses. The chapter stresses that the negotiation between turning resources into potential sources of RE and the current land resource use provides opportunities but also hindrances for RE deployment. I have shown that the devices used to frame such negotiations become highly important.

This chapter has highlighted how these processes have differed across the regions under examination, highlighting similarities and differences in the way in which they can be useful in explaining how and why RE deployment has realised its potential (or not).

The chapter has indicated that the regions under investigation have shown an increased governance capacity over energy and have made use of different policy instruments available to them to promote RE deployment. The regions have sought to organise the relationship between energy resource and other material factors, reflecting the capacities and willingness of a number of regional actors to render land available for RE development, constructing opportunities for, and barriers against, RE development. Regions have done this within broader governance structures that encompass the regional level (e.g. the influence of targets set at different spatial levels and the broader national spatial planning framework). These have influenced the power relationship between different levels of governments and helped to shape RE deployment.

The next chapter follows on from the arguments presented here. It provides specific examples of how regions under investigation have prioritised interests and re-cast resource abundance

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[130] According to the Energy Saving Trust (Flynn 2016) Scotland had already reached 595 MW of operational capacity in 2016.

in terms of their energy generation potential. It will discuss how regional actors have mobilised and promoted certain imaginaries and visions for RE development and/or used RE resources and pursued specific RE paths vis-à-vis alternative energy sources.

Chapter 7

Discourses, narratives and visions for renewable energy deployment

Summary

While chapter 6 has presented the regional differences that have emerged by drawing from the processes under which natural resources are turned into potential sources of energy, via processes of iteration between spatial resource assessment and alternative land uses, t*his chapter 7 follows on from those arguments and focuses on narratives and visions for RE deployment. This discussion also picks up on issues connected with resource appraisal discussed in chapter 6 because of their influence on the formation and character of narratives and visions. The intention here is to illustrate how different actors can construct, organise and mobilise specific natural resource endowments, creating a particular vision(s) and development path(s), prioritising interests and recasting resource abundance in terms of their energy generation potential. This chapter draws attention to the different regional discourses and narratives for abundance and opportunities that have emerged and have provided compelling visions to promote RE deployment, exploiting regional renewable resources, for the benefit of their territory. It also illustrates how RE exploitation is influenced by the identification of priorities that differ from and contrast with those set at national levels and how specific RE sources can get prioritised over other energy sources (renewables and non-renewables).*

7.1 Introduction

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. The intention here is to provide some examples of how the deployment of RE technologies has been steered and influenced at regional level via the creation of differing vision(s) and path(s) for RE deployment, with the aid of, and in relation to, their appraisal and presentation of natural resource endowments. This material dimension offers the opportunity to broaden the understanding of how RE deployment can fulfil specific visions or trajectories and highlights how priorities might differ from, and contrast, with those set at national levels, or how some energy sources might get prioritised over others (renewables and non).

Although, in many cases, regions may lack or have limited control over economic framework conditions (e.g. subsidies and feed in tariffs), they can nevertheless mobilise a vision(s) for the exploitation of their indigenous renewable resources. Such visions can then be translated into more concrete agendas that reflect the specific requirements and opportunities of particular regional contexts. This chapter unpacks how regional actors can create differing vision(s) and specific trajectories for RE deployment. It illustrates the discourses and coalitions that have emerged in the case study regions. It looks at how regional actors have promoted or hindered the appraisal of resources and their abundance through different storylines and how they have organised and mobilised specific resources and shaped what constitutes an accepted 'legitimate' source of energy. These storylines are often documented in strategies, route-maps and plans for RE deployment and get translated into visions for the exploitation of regional renewable resources and opportunities arising in particular regional contexts.

While the analytical framework suggests that the socio-material aspects addressed in this chapter are important when investigating RE deployment, the examples from the case studies further draw attention to how these aspects manifest themselves at the regional level and the extent to which they have affected RE deployment. The analytical themes, under this socio-material dimension, are articulated here in the following ways (see Figure 7.1):

i. the creation of strategies, route-maps and plans (such as PEARs) for RE deployment, that are translated into visions (in some instances shared and coherent) for the exploitation of regions' indigenous renewable resources and the opportunities offered by their specific regional contexts, and

ii. the identification of priorities that might differ from, and contrast with, those set at national levels (such as the case of opposing large scale RE development and promoting the deployment of new nuclear capacity).

Figure 7.1 The material dimensions that influence RE deployment: Discourses, narratives and visions

Socio-material dimensions	RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use	Discourses, narratives and visions for renewable energy deployment	Physical cha infrastructur d
Key themes	Targets and resource assessment: their construction and assessment Planning for RE & Potential and different values of environmental attributes when compared against RE targets Availability of land/ current land-based values	Imaginaries and vision for RE development How RE are represented vis-à-vis alternative energy sources	Infrastructure req Formal regulatory legitimacy to shap

Chapter 7

i. the creation of strategies, route-maps and plans (such as PEARs) for RE deployme translated into visions (in some instances shared and coherent) for the exploitatio indigenous renewable resources and the opportunities offered by their specific re contexts, and

ii. the identification of priorities that might differ from and contrast with those set a levels (such as the case of opposing large scale RE development and promoting th deployment of new nuclear capacity).

The chapter is structured as follows. Section 7.2 discusses the visions and trajectories promoted around RE deployment in the case study regions with Sections 7.2.1 illustrating the case of the Italian regions, and 7.2.2 those of Wales and Scotland. Section 7.3 explains how RE exploitation has also been influenced by the identification of priorities that differ from and contrast with those set at national levels, promoting some energy sources over others (renewables and non- renewables). Section 7.4 summaries the main points of this chapter.

7.2 Discourses and narratives for abundance and opportunity

As discussed in chapter 4, energy and energy policy have traditionally been treated as a national competence as the supply of energy is a key aspect of the national economy and competitiveness. Yet, the promotion of RE has often been linked more broadly to issues of environment and sustainability policy (Hirschl 2009). As pressures to adapt and mitigate the challenges of climate change have increased, RE has increasingly played a key role alongside energy and climate agendas. National government interventions to support RE have therefore emerged from the energy, climate and sustainability agendas, as they are influenced by the mounting international pressures, but also from growth strategies, encompassing several policy domains (such as environmental, technology, and industrial policy). It can be argued that, at the national level, the narratives for deploying large amounts of RE and low carbon electricity sit within the three different energy policy objectives of the 'energy trilemma' (security, sustainability, and affordability) and the opportunities RE can offer for industrial development. As environmental and economic responsibilities have to differing extents been explicitly redistributed downwards to cities and regions - as discussed in chapter 4 - RE deployment can fulfil specific visions or trajectories that might conform to, or differ from and contrast with, those set at national levels.

While chapter 4 has discussed the emphasis and relative importance of RE for fulfilling the 'energy trilemma' (Uyarra et al. 2016) and the opportunities for economic development in Italy and the UK, the next sub-sections investigate the specific visions and RE paths that the case study regions have promoted in their territory.

7.2.1 Renewable energy deployment as economic development opportunities: Apulia, Tuscany and Sardinia

In Italy, the Piano Energetico Regionale PER (later the Piano Energetico Ambientale Regionale (PEAR[131]) - Regional Energy Environmental Plan) has provided the reference frame[132] for every initiative in the energy field in an Italian region. This has become the means for determining RE priorities in fulfilment of European and national targets at the regional level. The PEARs often include a socio-economic-environmental and energy profile of the specific region, an evaluation of the potential for energy (and RE), possible actions for development and different scenarios for energy and RE development.

Despite similarities, the PEARs differ from region to region in terms of goals, methods, energy mix supported, and regional aspirations. As argued in chapter 6, the regional PEARS were published at different times; however, starting from 2015, a number of updates to the plans became available as the regions implemented the new *burden sharing* objectives. The updates adopted the methodology developed at the national level, including the presentation of 'regional energy balance' and the provision of data needed for the calculation of the burden sharing targets. This process has, therefore, homogenised the PEARs making them more comparable in their contents. Nevertheless, prior to 2015, differences emerged not only in the way in which the PEARs were presented but also in the main objectives of the regional plans. A summary of these is provided in table 7.1. The table also show how priorities and story lines have changed following the burden sharing decree (DM 2012).

[131] It is interesting to point out that the Tuscan Government has named its plan 'Piano Ambientale ed energetico', putting a stronger emphasis on the environmental side of it.

[132] Each PEAR also links with the Programme for Regional Economic Development – a strategic document that each region publishes to specify regional priorities, areas of investment and funding committed, including EU funding. All the three regions investigated had a section dedicated to the energy sector.

Table 7.1 Regional Energy and Environmental Plan (PEAR) Rationale and objectives in Apulia, Tuscany and Sardinia

	RATIONALE	OBJECTIVES	Specific Objectives FOR RE
Apulia	**PEAR 2007** The PEAR plan (2007) of Apulia identifies a series of actions and instruments that gives priority to energy saving and renewable sources and is coherent with the regional socio-economic context. The temporal reference period of the Plan is 2009-2016	(i) halving, between 2004 and 2016, the growth trend of regional energy consumption with respect to the preceding fifteen years (from +19.3% to +9.9%) (the objective of the PEAR plan is to halve the increase of consumption recorded in the 1990-2004 period.); (ii) increasing the contribution of renewable energy as a percentage of the total regional production from 3% in 2004 to 18% in 2016.	provide electrical energy production from renewable sources of about 8,000 Giga Watt Hours (GWh) by 2016 reach 150 MW of installed solar photovoltaic power by 2016
	PEAR 2015 Update Represents an update of the current PEAR and refers specifically to RE to ensure the achievement of the regional objectives of Burden Sharing; To favour the transition from large scale deployment to more sustainable projects based on energy efficiency, distributed generation, and short supply chain. To promote a more rational exploitation of resources to minimize supply chain process and maximize the energy yield and reduce impact on the territory.	To de-incentivise large scale (on ground) photovoltaic and wind power, except for the construction of PV parks limited to abandoned industrial sites To promote innovative RE technologies in the regional territory (low enthalpy geothermal, mini hydroelectric, thermodynamic solar, hydrogen, etc.) To promote built-in solutions for small-scale PV and solar thermal systems and mini wind turbines on buildings in industrial areas, To promote the sustainable production of energy from biomass To promote the energy efficiency of the existing building heritage and promote the energy sustainability of new buildings To promote supply chains and R&D for RE To promote dissemination and awareness of energy and energy saving.	Burden Sharing target of 14.2 %

Tuscany	**PIER 2008** The regional Energy Policy Plan - Pier - intends to create the conditions for renewable energy to be the engine of economic development in respect of the typical features of our territories, the environmental protection of our landscapes, our beauties Historical and artistic. The temporal reference period of the Plan is 2008-2010 Objectives to 2020	'Tuscany without oil': energy mix by 2020 that includes methane gas and renewables; Methane gas the 'driver' towards the development of RE Reducing greenhouse gas by 20% in 2020 To create the condition to produce up to 50% of electricity through the use of renewable sources	to include: up to 700 MW of offshore wind; 700 MW of PV capacity (building integrated; PV on industrial buildings, in areas affected by environmental restoration and reclamation project and Agricultural areas where PV energy production can integrated with agricultural and farm activities 100 MW additional geothermal capacity (medium enthalpy systems)
	PAER 2015 Support the transition to a low carbon economy. The green economy as a model of economic development Climate change Adaptation The temporal reference period of the Plan is 2014-2020 Objectives to 2020 (*burden sharing*)	Contrasting climate change and promoting energy efficiency and renewable energy; Protect and enhance territorial resources, nature and biodiversity; Promoting the integration between the environment, health and quality of life; Promoting a sustainable use of natural resources; Cross-cutting objectives (including R&D)	Burden sharing target of 16.5 % Promotion of 'Toscana Green Model' Priorities of the green economy are: Waste recovery and recycling supply chain (Filiera) Heat and woody biomass Smart Cities Energy Efficiency and eco-innovation

Sardinia	**PAER 2006** The Regional Environmental Energy Plan aims to foresee the development of the energy system. It sets priorities and hypothesizes scenarios on the bases of the national and European regulatory environment.	Network stability and security: Strengthening the energy infrastructures of Sardinia (Trans-European Energy Networks: the construction of a large submarine cable power; and the submarine pipeline from Algeria) Functional energy system for the productive apparatus To protect the environmental, territorial and landscape of Sardinia Structures of the energy networks Diversification of energy sources	Comply with Directive 2001/77 / EC, contributing to the development of RE and to support the maximum diversification of RE; overall target of installed capacity for 880 MW
	Renewable Energy Action Plan 2012 **Scoping preliminary plan for 2015 Pear (2012)**	These documents represented an attempt to: identify the lines of development and implementation of projects related to renewable energy , their economic evaluation and actions identify and indicate the environmental evaluation procesuders to be followed for the integration of environmental protection with the Regional Energy Planning	Burden sharing to 2020
	PEAR 2015 the PEAR is the 'planning document' which governs the development of the regional energy system and identifies the fundamental choices in the energy field to achieve the European objectives to pursue by 2020 and 2030. The temporal reference period of the Plan is 2014-2020 Objectives to 2030; burden sharing to 2020	Transformation of the Sardinian energy system towards a Sardinian Smart Energy System Energy security Increased energy efficiency and energy savings Promotion of research and active participation in the energy field Reducing CO2 emissions by 50% compared to 1990 to 2030, above European objectives;	Burden sharing target of 17.6 %

Apulia. Apulia first introduced actions and initiatives in support of RE development in the PEAR published in 2007[133], strengthening the major political commitment made to the energy sector when Nichi Vendola's government assumed office in Puglia in 2005[134]. The PEAR (2007) featured a major survey of energy consumption needs as well as an assessment of the regional potential for the production of RE. Promoting the twin goals of supporting innovation and sustainability in the regional energy sector[135], the PEAR aimed at reducing carbon emissions (and regional energy consumption) and at prioritising energy production from renewable sources and energy efficiency.

These two regional aspirations - tackling carbon emissions and increasing RE production- were justified in terms of two specific characteristics of the regional economy, the region's CO2 emissions and its net energy exporter role[136] and the position of Apulia in the heart of the Italian South – the *Mezzogiorno*.

Apulia's position in the *Mezzogiorno* signifies that the region is often considered as part of a group of chronically poor regions mired in deep developmental problems, particularly with respect to unemployment, emigration of economically active people, inefficient public

[133] Apulia was the first region to produce a regional energy plan that incorporated the environmental aspect (ARTI 2008) Tuscany on the contrary produced a Piano di Indirizzo delle Energie Rinnovabili in 2008 and a separate 'Piano Regionale di Azione Ambientale' and a 'Programma regionale per le Aree Protette' (Regional Action Plan for Environmental Action and the Regional Program for Protected Areas, respectively).

[134] The Vendola government (2005- 2015) was elected on a programme that highlighted the themes of innovation, youth employment, culture and ecologically conscious regional economic development. The 'Vendola project' was referenced as a way of re-imagining the Apulia region. Contrasting with the traditional image of a region mired in the age-old problems of the south, particularly with respect to corrupt politicians and incompetent public officials, Nichi Vendola wanted to promote a region that: (i) valorises its rich natural and cultural heritage (ii) invests in social and technological innovation and applied research and (iii) mobilises human capital, especially that of the region's youth (Altavilla and Morgan 2014).

[135] The PEAR is seen as a means to strengthen the potential synergies between environmental protection and economic and social growth (PEAR, 2007) and to provide, in the words of the President Vendola, 'a new way of land management where ecology moves along with the economy, questioning the dictatorship of fossil fuels in favour of renewables' (Schena 2007).

[136] Apulia's CO2 emissions are second only to Lombardy's, the most industrialised region in Italy. Moreover, Apulia is the Italian region with the highest energy intensity after the Valle d'Aosta. Industrial energy consumption represents nearly two thirds of final energy consumption. Apulia hosts three large power plants for electricity production (ENEL group, Edipower and EniPower) – Apulia is a net energy exporter to the rest of Italy[136]- and the region is also home to two vast industrial complexes, the Taranto steel works and the chemical plant at Brindisi. Hence, tackling carbon emissions and greening the energy systems has been a regional government priority, from some time.

administrations, *clientelistic* political systems, and a burgeoning black economy. Yet, the region has endeavoured to shed this conventional image by building a reputation as a region that sets a high premium on good governance, efficient public administration, and regional development policies.

It was made clear, since the onset of the PEAR, that the abundance of natural resources could provide a means to overcome the current patterns of uneven development. According to ARTI (2008: 12) 'for a region like Apulia, the capacity to combine local development with the affirmation of a new energy paradigm (..) would be a big opportunity for energy requalification, production reconversion and development'. Capitalising on favourable geographical conditions[137] meant that RE developments could provide opportunities to alter patterns of economic growth and development. Breaking the trajectory of fossil fuel path dependence in the region has therefore become a major goal of regional energy policy in which the public sector – through a combination of green public procurement, more permissive planning regulations (see chapter 6) and the deployment of EU funds[138] – attempted to revolutionise the region's productive structure. In other words, it was hoped and believed that the rapid adoption of RE would trigger a productive dividend through a diversification into new sectors, such as photovoltaic panel production, monitoring and experimentation, eco-tourism, and low carbon transport (cf. Altavilla and Morgan 2014).

Therefore, the PEAR became an iconic document that stated the political commitment of the ecologically conscious political administration and it was seen as an opportunity for a poor Mediterranean region to assume a leadership role in the RE stakes (see also De Laurentis et al. (2014) and Altavilla and Morgan (2014)). Strong signals in this direction were sent by the regional government's commitment to map the number of firms and research capabilities in the RE sector, re-branded 'La Nuova Energia' (see Figure 7.2). Nevertheless, most significant was the way in which the regional government assumed the role of an 'entrepreneurial state'

[137] As seen, solar radiation in the region is above the national average in large part of Apulia's territory and, overall, it has a yearly sun irradiation of 1 679 kWh/ m2 (the highest in Europe (ARTI 2008) and its wind resources are also good, although much more spatially sensitive than solar radiation. Wind resources are concentrated in the northern mountainous area in the province of Foggia, where the wind speed averages 6/7 meters per second (OECD 2012).

[138] The Apulia government was successful in channelling EUR 210 million from EU convergence funding (ERDF) (OECD 2012) to support solar energy, biomass and energy efficiency initiatives co-funded by the national government.

by streamlining and accelerating the bureaucratic procedures of license concessions[139] to fulfil this regional vision, as discussed in chapter 6. With public sector deployment and financial support for energy parks, PV installations, and large PV panel manufacture, Puglia was rapidly able to re-sell electricity to the national grid and achieve grid parity.

Tuscany. By contrast, Tuscany is often presented as an example of Italy's main weakness: that technology transfer processes from university to industry are not as intense as experienced elsewhere in Northern Europe and the US (Di Minin et al. 2006). This is despite a high concentration of universities, national, public and private, research centres and research consortia present within the region (Figure 7.3 shows the specialised R&D centres in the RE sector). The measures adopted for the diffusion of RE in Tuscany were primarily aimed at overcoming this problem, '*diagnosed as a lack of industrial leaders and projects*' (Interview DTE T)[140]. The regional energy plan PIER promoted a new model and vision for Tuscany, the '*Modello Toscana Green'*, based on an industrial strategy for RE that would stimulate interactions between companies and local institutions, knowledge and technology transfer processes and specific localisation dynamics and network relations in the RE (and energy efficiency) sector. The publication of the 2008 PIER, of the strategic programme of the RE cluster (Distretto Tecnologico Energie Rinnovabili- DTE), and the creation of the Renewable Energy and Energy Saving Innovation Pole (PIERRE) point towards a clear narrative for promoting the opportunities for the region, capitalising on its rich research expertise (see Table 7.2). Hence a vision for promoting the opportunities to stimulate networking and technology transfer activities among the local research institutes (public and private) and the small and medium firm base was emphasised.

[139] In 2008, in fact, the regional government created a fast track approval and a simplified licensing system that helped streamlining the authorisation process for renewable energy installation. Political priority was also given to the realisation of energy parks and PV installations on the roofs of public buildings. The direct deployment of RE technologies by the public sector played an important role in boosting demand and in maximising the benefits of the generous national feed-in tariff programme during its first and second rounds (2005-2010), when the regional government decided to exploit the incentives to the full by financing almost exclusively the two larger classes of panel power (20-50 Kw and 50-1000 Kw). Puglia was, then, in a very short time, able to re-sell electricity to the national grid and achieve grid parity.

[140] The strategic Programme of the Distretto Tecnologico della Toscana Energie Rinnovabili (2012) identifies areas of strength and weaknesses of the cluster: research expertise and lack of industrial leaders and projects, respectively.

Figure 7.2 New Energy Cluster in Apulia

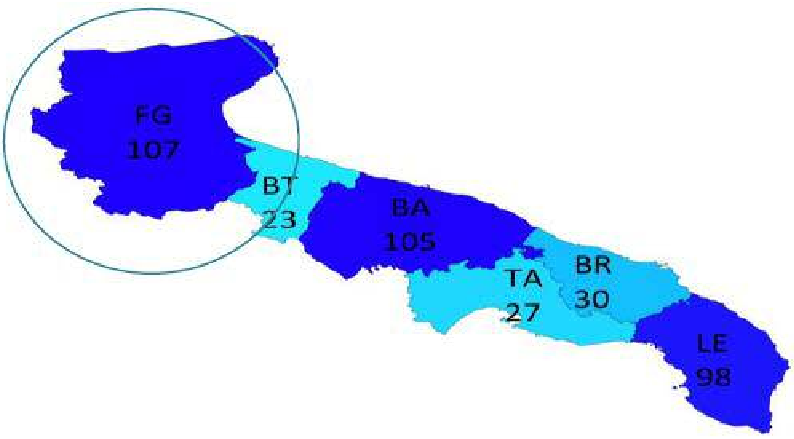
New Energy Cluster in Apulia

A study by ARTI (Agenzia Regionale per la Tecnologia e l'Innovazione), the regional development agency of Apulia, started the implementation of an energy cluster project, with the aim to evaluate and select some technological options in RE and energy efficiency, adequate for the region. The study identified that the region presents strong firms and research capabilities in RE, in particular wind, solar, bioenergy and energy efficiency. This Nuova Energia (New Energy) cluster accounts of 392 organisations: 334 firms, ranging from large to medium-small sized firms, some of which are regional and some others extra-regional (national and multinational companies). They operate in energy production, manufacturing and upstream the various solar, wind and bioenergy supply chains. Many small firms and spin offs of larger companies are also present, a sign of, as ARTI argues, entrepreneurial vitality. Firms also present in the cluster are firms that are diversifying from other related industrial sectors (construction, automotive, etc.).

Research within the cluster is often conducted in collaboration with a number of public and private research institutions and academic departments in the region: the four public universities in Puglia (the university of Bari, the Polytechnic of Bari, the University of Foggia and the University of Salento) the both public and private research centre of among others Enel, Fiat and Ansaldo) and public research centres like the ENEA centre in Brindisi and the Bari office of the Institute of Construction Technologies of the CNR (National Centre of Research). Research areas are bioenergy, solar energy, in particular solar thermal energy for heating and cooling, energy efficiency in the construction sector, environmental monitoring of the cycles of renewable sources and technologies for measuring air speed. There are also about 13 consortia from outside the region ("Romagna Energia" consortium, for example) that have offices in Puglia.

Although it is not territorially bounded, most of the renewable energy firms are located in the province of Bari (BA), Foggia (FG) and Lecce (LE) has shown below.

Territorial distribution of Apulia RE firms

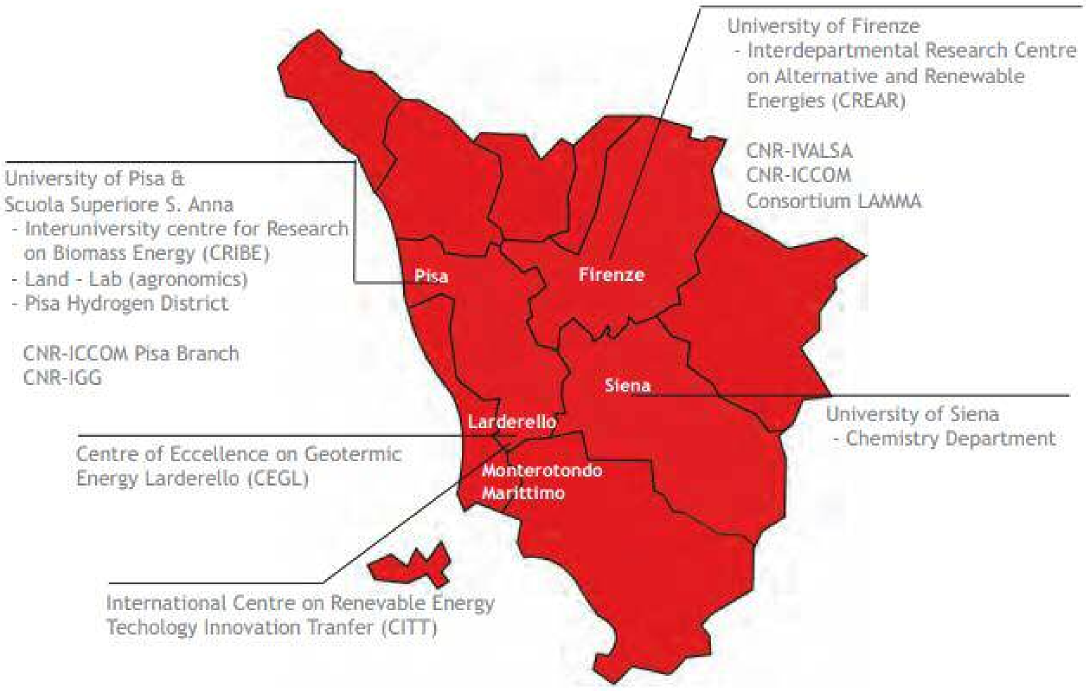


Source: author's elaboration following ARTI (2008); Gadaleta-Caldarola (2017)

Table 7.2 Clustering initiatives in RE in Tuscany

Initiative	Year	Organisations inlcuded	Funding body
PIERRE - Polo innovazione energie rinnovabili e risparmio energetico Renewable Energy and Energy Saving Innovation Pole	Established in 2011	Includes 300 firms	Funded by Regione Toscana to promote innovation and firms' collaboration- an association to promote R&D within industry; provides services to firms in the DTE cluster
Distretto Tecnologico Energia (DTE) Energy Cluster	Established in 2012	Includes RE firms and 3 universities of Tuscany (Siena, Florence and Pisa), Sant'Anna university and IRPET (the Institute for economic development of the region)	The DTE Toscana (Distretto Tecnologico Energia della Regione Toscana) is one of 5 technological districts identified by the Regione Toscana.
COSviG Consorzio per lo Sviluppo delle Aree Geotermiche (Consortium for the Development of Geothermal Areas)	Establish in 1988	Geothermal	The DTE Toscana, Polo Pierre and CoSviG aim at actively involving all the different actors in the region, in order to develop synergies between firms, research centres and technology transfers centres in the region in the area of renewable energies, energy efficiency and development in the green economy.

Figure 7.3 Regional research expertise (public and private) in Tuscany



Source: ARSE (2008)

Accordingly, the PIER identified targets for each RE source relevant to the region and the measures put in place to achieve them. Moreover, the PIER made it clear that RE development and deployment in the region stem directly from the negotiation between the drive towards a low carbon economic agenda that can harness local natural resources and the need to protect the importance of the historical, cultural and artistic characteristics of the regional territory (PIER 2008). Here it is important to stress that although generation from RE has developed thanks to local resource availability, clear policy commitment, and the presence of specific regional incentives[141], electricity generation from solar, wind, and biomass resources is still limited. Another characteristic that has influenced RE deployment in the region is also

[141] These for instance concentrated on the building sector, particularly new buildings including the solar PV roofs on buildings (a programme to install solar PV roofs on 130 public building and low income houses with asbestos removal issues; public hospital interventions (for solar PV roofs) and solar PV for 1.000.000 families.

that Tuscany is the only Italian region with installed geothermal capacity. The importance of this for RE deployment vision is analysed later, in section 7.3.

Sardinia. The peculiarities of Sardinia's energy system, devoid of natural gas[142], with 94% energy dependence on mainland Italy[143], and characterised by a lack of large energy infrastructures (see chapter 8) have had an important effect on RE deployment narratives. As table 7.1 shows, regional priorities in the different editions of the regional PEAR have emphasised the need to strengthen the energy infrastructures of Sardinia. Two major infrastructure projects have *de facto* dominated RE discourses in the region: the construction of a large submarine cable power to connect Sardinia with Tuscany; and the submarine pipeline that would allow the transportation of gas from Algeria (the GALSI pipeline). While I will return to these points later, with regards to Sardinian's vision for RE deployment, it could be said that '*the region did not stand out for entrepreneurial capacity and dynamism'* (Interview SA). This influenced the outcome of the different attempts by the regional government and the Sardinian public research organisation 'Sardegna Ricerche' to promote the project 'Cluster Energie Rinnovabili' (RE cluster), building from the research competencies and skills developed within the public and private research centres and the entrepreneurial base (see Figure 7.4). As the figure shows, the initiative attracted a limited number of actors (35 organisations including regional businesses, universities, research bodies and local authorities); a much smaller number of similar initiatives were launched in Apulia and Tuscany.

For this reason, it has been argued that there is still an untapped RE sources potential in the region. Thus Sardinia is considered one of the territories where prospective development is higher for RE deployment *'unlike Tuscany and Apulia*, *Sardinia has been and is still the most virgin region that still has plenty of opportunities on which to build something' (*Interview SA*)*

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[142] Sardinia is the only region excluded from a process of methanization, which has characterised the rest of the country. The island is in fact without a pipeline system, except for urban distribution networks in some cases still under construction and provisionally using propane or other mixtures other than methane. This peculiar condition is considered to be one of the causes of the current socio-economic condition of Sardinia and high energy prices.

[143] Within the region indigenous energy sources are represented by a small amount of coal production in the area of the Sulcis and the contribution of RE, particular hydro and wind energy.

(see also Corsale and Sistu (2016)). How this potential can be exploited is, however, influenced by the available infrastructure for the transmission and distribution of electricity in the region.

Figure 7.4 RE clustering initiatives in Sardinia

Piattaforma Energie Rinnovabili (*Renewable Energy Platform) was created in 2007 by the Sardinia regional government to provide R&D support to businesses and research organisation in the areas of RE, energy management and energy efficiency;*

Energy Cluster *Initiative was developed around the expertise and technological facilities of the Renewable Energy Platform. It consists of 35 regional organisations (enterprises, universities, research bodies and local authorities) aimed at developing, implementing and experimenting innovative solutions around the following themes:*

- *integration and management of RE sources in local electrical systems;*
- *analysis, monitoring and development of intelligent and autonomous micro-networks electrical mobility and integration;*
- *Solar photovoltaic;*
- *biofuels and biomass*
- *thermodynamic solar (with concentrated solar energy);*
- *energy accumulation (electrochemical, thermal, mechanical, hydrogen);*
- *efficiency and energy saving systems for businesses*

7.2.2 Past experiences in the energy sector and indigenous resources: Scotland and Wales

Scotland and Wales have each produced energy strategies that stress their own regional visions and aspirations for RE development. As a high proportion of the potential RE resources of the UK lie within the territory of Scotland and Wales, these visions and aspirations have often been associated with: i) the abundance of indigenous renewable resources, ii) the comparative advantage that their exploitation can provide and iii) the opportunities that past experience in the energy sector could offer- namely in the oil and coal industries[144], respectively. Boxes 7.1 and 7.2 highlight for Scotland and Wales, respectively, how the narratives for abundance have been mobilised in early strategic documents.

[144] Wales has a long industrial history, and with the development of its coal and iron and steel industries can arguably claim to have led the global transition to a carbon economy in the 18th Century. Indeed in the early years of the 20th Century the world price of coal (effectively the world energy price at that time) was set daily in Cardiff (WG 2010). However coal output in Wales peaked in 1913 at 57 million tonnes, and with 65% of that exported (Jenkins 1975).

What follows in this section describes the differences that have emerged in how the vision(s) for the exploitation of Scotland and Wales' indigenous renewable resources have influenced the variations in the rate of RE deployment across the two regions.

Successive Scottish Governments have positioned RE expansion as central to Scotland's national economic and environmental future, with a sustained emphasis on green jobs, economic growth and international competitive advantage, developing an ambitious strategy for the development and deployment of RE technologies.

Box 7.1 Narratives for abundance in early strategic documents (Scotland)

Scotland

'*We possess 10 per cent of Europe's wave power resources and 25 per cent of its offshore wind and tidal resources. Scotland's extraordinary natural marine energy resources and leading position in the development of wave and tidal energy technologies provide a unique platform to establish a world leading position in this vitally important sector. Scotland is becoming the Silicon Valley of marine energy worldwide' (Scotland First Minister[145], 2012)*

'Scotland is already taking a leadership position Europe-wide on renewables, and that is a position we are setting out to bolster' (SG 2009: 11)

'the natural advantage given to us by the North Sea from oil and gas can be maintained and secured for the long term by the natural advantage which the North Sea also offers for the storage of carbon dioxide, providing the EU's largest offshore storage capacity for carbon emissions – greater than the Netherlands, Denmark and Germany combined (SG 2010)

[145] Scottish First Minister's speech at the Commonwealth Club of California on the 20th of June 2012

Box 7.2 Narratives for abundance in early strategic documents (Wales)

Wales

'Wales has significant assets in virtually every energy source – we have significant wind resources, both onshore and offshore; significant wave and tidal energy potential; one of the best solar resources in the UK; scope for more biomass and hydro; and existing nuclear sites and expertise in the nuclear industry. We also posses the key infrastructure to make the most of the energy opportunity in terms of our roads; railways; deep ports and electrical and gas grids'. (WG 2012: 9)

'In Wales, we are determined … to seize the opportunity of being a global showcase for clean energy …' (WG 2005 Annex A, para 4)

'Having provided much of the coal that drove the industrial revolution, we believe Wales can once again take the lead in working to create a low-carbon sustainable society'. (Climate Change Commission for Wales cited in WG (2009)

As much of the renewable resources in the UK are situated in Scotland[146], the Scottish Government has been able to exert influence over the deployment of RE through its devolution arrangements, gaining control over financial income streams and bargaining with Westminster for further support in order to exploit Scottish RE resources[147]. Examples of this are for instance: the high proportion of the Scottish Renewable Obligation that has been reserved for wave and tidal stream power; Scotland was the first region of the UK to adopt technology-specific support measures (higher renewable obligations for wave and tidal[148]);

[146] It is worth highlighting that as far as offshore wind development is concerned, material constraints are to some extent limiting its development in the Scottish water. Scottish licenced areas tend to be in deeper water and this makes the exploitation of the offshore wind resource in the coast of Scotland more expensive. This represents a critical factor that is shaping project realisation especially as the UK energy policy agenda has increasingly emphasised on cost reduction, as discussed in chapter 4. Consequently, offshore wind energy development remains concentrated in the English North Sea and Liverpool Bay (bridging England and Wales), where the shallow seas allow for development cost reduction.

[147] The delivery and rapid expansion of RE has given the Scottish Government 'important hierarchical and political resources for negotiation in UK-centred networks with Westminster', in particular as the UK seeks to fulfil its requirement to deliver on EU RE targets (Cowell et al. 2017: 175).

[148] Emerging wave and tidal stream power were allocated 5 and 3 ROCs/MWh respectively. This different support only operated between 2008 and 2011, until the UK governments extended the higher bandings to England and Wales. Cowell et al. (2017: 174) suggested that this 'first mover' action in Scotland contributed to the greater growth of commercialisation and testing facilities for these technologies.

and further funding from the UK Treasury allocated to Scotland to promote RE, signalling Scotland's influence over national energy policy (Toke et al. 2013).

Energy issues and RE development have been central to the Scottish National Party's agenda for many years (Cowell et al. 2013). Many authors agree that such political will - together with the commitment of the Scottish government - have underpinned the rapid development of renewables in Scotland (Cowell et al. 2013; Toke et al. 2013; Dawley et al. 2015). Significantly, this political vision of harnessing the comparative advantage of Scotland's natural resource potential[149] benefitted from cross- party support. Moreover, a number of major energy businesses (such as Scottish Power and Scottish and Southern Energy), the presence of a long standing regional development agencies (Scottish Enterprise and Highlands and Islands Enterprise) as well as a trade association for RE- Scottish Renewables - not only have all been supportive of the Scottish Government's aspirations for RE, but they have also possessed financial and other resources for project delivery.

These interests have been brought into the energy policy-making process via the Energy Advisory Board (that acted as an important arena for discussion among actors), the Forum for Renewable Energy Development in Scotland[150] and the Intermediary Technology Institute for Energy (ITI Energy) to sponsor innovation across the energy sector. Cowell et al. (2013) suggested that this shared interest among a critical mass of actors has helped the Scottish Government to use its available powers assertively to facilitate the implementation of projects and overcome significant conflicts about the wider land use and environmental consequences especially those associated with projects related to on-shore wind and grid enhancement. I will return to this in chapter 8.

Interestingly, the abundant natural resources of Scotland and the growth of RE have become central to the narrative of Scotland's economic future and as an important dimension of an independent Scotland, with it being seen as a means for industrial renewal and modernisation (SG 2012). Post-1998 Scottish independence debates[151] offer an example on how the Scottish

[149] RE development was supported in opposition to nuclear new-build, as I will discuss later on.

[150] An expert advisory group tasked with monitoring the delivery of RE policy targets.

[151] A referendum on Scottish independence took place on the 18 of September 2014, to deliberate on Scottish independence from the UK.

National Party, and its leadership, has regarded energy development- and RE- as part of the imagery of an independent Scotland (cf. 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 RE has been considered an extension of the key objective of gaining control over 'Scotland's oil' (Toke et al. 2013).

It could be argued, that similarly to Scotland, the Welsh Government, in particular from 2003 onwards, have also expressed strong support for RE and promoted a political vision based on harnessing the region's plentiful natural resources as key for the mobilisation of a RE development path[152]. On the one hand, Welsh governments have sought to 'act' on energy as an integral part of their wider economic and environmental agendas[153] and, on the other hand, to 'maximise the potential for RE in Wales' to attract significant new investment, as detailed in WG (2010, 2012). In terms of leadership, for instance, Jane Davidson, the Minister who held the environment and sustainability portfolio from 2007-2011, was seen, by many, as an instrumental actor in forging new, clear strategies for RE and raising the profile of climate change[154]. She had a desire to encourage RE development in the region providing a firmer policy context for investment ('*she released a policy statement that set out quite articulately the potential for RE and the actions that should be taken to progress that agenda*' (*Interview* TL)).

Yet, as RE policy, between 2007 and 2011, was closely tied to climate change policy, this created a disconnection and a lack of focus on the economic development thinking in the industry. Furthermore, ministerial responsibility for the energy portfolio has not been clear and '*energy has been played around and kicked around all sort of places around the Welsh*

[152] Chapter 6 highlighted that the major outcome of this process is arguably the creation of a spatial strategy to provide the main guidance for plan making and decision making in RE in Wales- the TAN 8.

[153] As discussed, in chapter 6, a key distinguishing dimension of the Welsh Government, since its creation at the end of 1990s, has been its commitment to fostering sustainable development in its founding constitution.

[154] Between 2007 and 2011, a close conjunction was forged between RE and climate change mitigation.

Government' (Interview TL)[155]. This is emphasised by the fact that while the current first minister Carwyn Jones attempted to make energy part of his portfolio (in 2012), the energy portfolio was then split between two ministers (the Economy Minister[156] and the Natural Resources Minister). This signalled a level of confusion over the RE priority within the region ('*it took a fair amount of time to work out who was supposed to be doing what*' (Interview WG).

Moreover, the lack of backing of the supportive statements made about RE in the face of public dissent, only increased the scepticism around the capacity and willingness of the Welsh Government leaders to demonstrate leadership on driving the RE agenda forward and perpetuated the view that there has been a tentativeness regarding the 'visions' for RE deployment in Wales. Wales also lacked the industry presence and support[157] that was evident in Scotland and elite consensus has been more difficult to maintain (Cowell et al. 2017). Although many recognised the support that the Welsh Government provides to RE energy in Wales, concerns about a lack of joined up thinking, conflicting messages about future priorities and a lack of a strategic vision hampered the process of RE deployment in the region. In the words of some interviewees: '*so we kind of have good energy support but completely devoid of thought of Wales as a constituent country that may need to have a strategic oversight*' (Interview RUK) and '*it still feels like you need some kind of direction for renewables*' (Interview TLS)).

Yet, it is perhaps with the Energy Wales Strategy (WG 2012) that a step change in energy policy has become more evident, moving from '*green electricity*' to focus more on the opportunities to maximise economic benefits for Welsh businesses and communities, thus focussing the attention on the economic development opportunities that RE can deliver to Wales. In particular, the vision(s) for RE in Wales shifted towards '*a couple of areas where (…) Wales had some level of traction: i) smarter living, reflecting on the Low Carbon Research*

[155] RE in Wales has been the interest of three ministers: the First Minister, the Economy Minister and the Natural Resources Minister.

[156] The Economy Minister is responsible for green growth and capital development.

[157] Few major energy businesses have headquarters in Wales, and the staffing capacity of UK-wide energy trade associations in Wales was minimal (consisting of one officer until 2012).

Institute, the work of SPECIFIC and the Sustainable Building Envelope Centre and marine energy'. Some argue that tidal lagoons in Wales '*is the only big game changer in the marine RE sector (…) large scale marine RE deployment*' (Interview RUK). The narratives and actions around the promotion of marine energy in Wales, are focussing on tidal stream devices, such as those planned for demonstration in the Anglesey and Pembrokeshire areas (the '*Welsh Government is making a particularly strong support for this sector which is not tidal lagoon because that is what they can influence more' (*Interview RUK)[158].

7.3 How RE are represented vis-à-vis alternative energy sources

Narratives and visions around RE, as discussed above, have mobilised resource abundance and resource availability to promote particular deployment paths. The argument made in this section stresses that the regional paths chosen are sometimes constructed around a broader, pragmatic approach to energy development per se that embraces not only major nuclear and fossil investment but are also influenced by the presence of alternative RE sources. In order to explain how these have influenced RE priorities at the regional level, the next sub-section provides some examples of:

- how RE deployment in Apulia and Scotland has been supported by an increased opposition to new nuclear capacity and the effect that this has had on the chosen regional RE path;
- how the lack of gas has dominated RE discourses in Sardinia and how priorities for RE development and deployment have been influenced by alternative RE sources and interests as in the case of geothermal energy in Tuscany.

I discuss these in turn, in what follows.

[158] The Welsh Government has offered support to the Swansea Tidal Lagoon project, as emphasised here http://gov.wales/newsroom/firstminister/2018/180110-First-Minister-offers-further-support-to-kick-start-Swansea-Bay-Tidal-Lagoon/?lang=en

7.3.1 Opposing new nuclear in Scotland and Apulia

As discussed earlier, Scotland's RE development path has been influenced by the centrality of energy issues, and RE development, to the Scottish National Party's agenda, also benefitting from cross-party support and a high level of business engagement. RE development has also been supported by a coalition of interests that opposed an increase in nuclear capacity and nuclear new-build. Although the Scottish Government's own preference for RE over nuclear power provided a compelling narrative for promoting RE expansion[159], this contrasted with the UK Government's determination to support the development of new nuclear generation.

The changing nature of UK government policy has had a twofold impact for Scotland. Nuclear is costly and, as it needs to be subsidised, the argument against it is that less funding will be available to meet Scottish RE targets. When funding for RE was organised via the renewable obligation it could be argued that, to some extent, RE funding was not in competition with nuclear. However, the changes brought in under the Energy Market Reform (and the Contract for Differences) not only has meant that both RE and nuclear are now competing for a smaller 'pot' of money, but it has also *de-facto* limited the Scottish Government's ability to further promote its area of interest such as marine RE as these technologies have not received the same priority from the national government.

On the contrary, in Wales, to some extent, the decision of the Welsh Assembly officials and many politicians, to identify all energy development- including new gas power stations[160] and new nuclear[161]- in terms of their investment and employment benefits to Wales, was seen as evidence of the already *tentative* strategic vision for RE (Cowell et al. 2015, 2017).

[159] Existing nuclear power stations contribute over a third of electricity capacity, nevertheless, the devolved Scottish government opposes building new nuclear reactors and is committed to ambitious renewables targets. Scotland's two operational nuclear power stations (the 965MW Hunterston B and 1190MW Torness) are due to cease generating within 10 years.

[160] These include: a new gas CHP plant at South Hook in Pembrokeshire (500 MW), a new nuclear plant at Wylfa B (2,600 MW), a new CCGT plant in Wrexham (1,200 MW) and a gas-fired power station with a nominal generating capacity of up to 299 MW in Hirwaun (NAW 2013).

[161] See for instance http://gov.wales/newsroom/businessandeconomy/2015/150407-nuclear-capability/?lang=en

In the region of Apulia too, the RE development path received more favourable consensus following the debate over the re-introduction of nuclear capacity. In 2008, the Italian government's policy towards nuclear changed and a substantial new nuclear build programme was planned, aiming to generate 25% of the country's electricity from nuclear power by 2030 (later overturned in the 2011 Referendum that rejected nuclear energy). As legislation progressed to identify a framework for siting nuclear plants, the possibility that regions like Apulia might be identified as suitable for the new nuclear plants attracted objections. The Apulia regional government was the first to vote against new nuclear plants and banned, by regional law, the construction of new nuclear reactors in its territory. The region, by '*rejecting nuclear power with a regional law, has shown that it has an enlightened vision of its future energy*' and as Apulia already '*largely contributes to the Italian energy needs, we want to become leader in renewable energy production'* (Interview REG government A), emphasizing the distinct nature of its vision for the region.

7.3.2 Natural Gas in Sardinia and the role of geothermal resources in Tuscany

As highlighted, the energy system of Sardinia is peculiar due to the region's insularity and the endowment of (or lack of) energy infrastructure. Until the new submarine cable SAPEI came into operation in 2011, the region found itself in a condition of *energy isolation* (Corsale and Sistu 2016)[162]. In this sense, the *methanization* of Sardinia - and the opportunity offered by the construction of a gas pipeline connecting Algeria to the Italian mainland passing through Sardinia (the GALSI National Project[163]) - was originally conceived as a *win-win* solution. This would i) have guaranteed the natural gas supply to the region[164] and ii) have helped the

[162] As discussed in Chapter 8, an HVDC connection of limited capacity connected Sardinia with its neighbouring Corsica.

[163] The GALSI project envisaged the import of about 8 billion smc / year of natural gas from Algeria through a single dorsal of about 900 kilometers, including 600 offshore with a maximum depth of 2,800 meters, with specific infrastructure that would connect the Italian peninsula(in Tuscany) via Sardinia.

[164] The distribution to end users had to be realized through 'local distribution networks'.

national government to deliver a more secure energy system[165]. Nevertheless, the project has come to a standstill for both commercial and administrative reasons and its achievement remains uncertain[166]. Furthermore, the arguments raised around the opportunities of natural gas had the effect of dominating RE discourses in the region (‘*energy discourses in Sardinia in the last few years have been underwritten by an investment argument that could provide the main solution to the national energy security problem’* Interview SA) and influencing the vision for renewable energy (and the energy mix for the region) as presented in the regional energy plans published in 2006 and 2015.

While Apulia ‘*started from a situation in 2006 where there was no (or very limited) RE and Apulia is the only region without hydroelectric power that historically constitutes the major RE source in Italy’* (Interview ARTI), Tuscany had a higher capacity of RE resources already deployed, such as geothermal and hydro. Tuscany, as shown in chapter 4, is the only region in Italy with installed geothermal capacity and geothermal sources already account for 35.6% of the total regional electricity production and to 79.6% of the total electricity production from renewables (PAER 2015). In Italy, the geothermal resources are mainly used for electricity generation and all of the plants in operation are located in the two ‘historical’ areas of Larderello-Travale and Mount Amiata. Whilst development of new geothermal capacity has been limited[167], the presence of geothermal renewable sources has led some key respondents to point to the fact that ‘*with respect to the other regions all the goals of 2020 in fact can be achieved by geothermal energy alone*’ (Interview SA). This, to some extent, has influenced the choices made concerning RE deployment and ‘*limited the deployment of large scale wind and ground- based solar energy initiatives*’ (Interview REG Government T).

[165] Natural gas import in Italy comes from mainly Eastern European countries, particularly Russia and Ukraine, axis that has had criticisms from a geopolitical point of view.

[166] Although some discussion on the project is still ongoing, the Sardinian PEAR 2015 suggests a number of options to be considered for the *methanization* of Sardinia (a pipeline from the Tuscany Region; the provision of a mini gasifier positioned in an industrial-port area or coastal deposits (Small Scale LNG), that would supply distribution networks by truck and / or container.

[167] New exploration activities have only interested adjacent areas to the existing one (concentrating on exploitation of medium-high enthalpy fluid) and to the upgrading of the current 34 plants for efficiency gain managed by Enel Green Power, the Enel Group subsidiary dedicated to the international development and management of power generation from geothermal, which manages Tuscany’s geothermal complexes.

7.4 Concluding remarks

In this chapter, I have focussed attention on the way in which regional actors have promoted resource abundance to simplify and influence strategic policy priorities around RE deployment.

Both Chapter 4 and Chapter 6 have highlighted that the regions under investigation lack or have limited control over economic framework conditions (with the exclusion of Scotland that operated different support systems, between 2008 and 2011, for wave and tidal sources). Yet, this chapter has shown that the regions under investigation have mobilised different narratives and vision(s) for the exploitation of their differing indigenous renewable resources. Some of the regions have mobilised discourses around the opportunities offered by RE deployment that involved the promotion of clustering activities to foster economic development and innovation within their territory; some have seen RE deployment as an opportunity to promote networking and knowledge transfer across many actors involved and others have mobilised RE deployment as an opportunity to foster regional identity and independence. The chapter has stressed that regional strategies, route-maps and plans for RE deployment have promoted concrete agendas that reflected the specific requirements and opportunities of particular regional contexts. The examples provided therefore have shown that this material dimension is an important element in understanding spatial difference in RE deployment. Different deployment rates and RE paths have been pursued in order to fulfil specific visions and trajectories, showing how specific RE sources can get prioritised over others energy sources (renewables and non-renewables).

The next chapter will examine the influence in the case study regions of the final socio-material dimension identified. It discusses how the current infrastructure for transmission and distribution of electricity has been able to further affect the level of RE deployment across the regions.

Chapter 8

Established Infrastructure Networks: Barriers and Opportunities

Summary

This chapter discusses how the exploitation of potential RE sources is influenced by the established infrastructure networks. The analytical framework identifies that as RE capacity increases, the current infrastructure, and the relationship that regions can establish with those who own, operate and regulate it, can influence RE deployment. The case study material is used here to show how RE deployment can be influenced by differences in infrastructure endowment and how these differences put pressure on regions and regional actors to upgrade infrastructure in order to achieve regional targets and aspirations. In particular, the discussion also focuses on the formal regulatory powers and political legitimacy (or the lack of it) at the regional level that shape existing and future infrastructure networks.

8. 1 Introduction

The analytical and conceptual framework presented in this thesis suggests that the physical characteristics of natural renewable resources and the requirement of a robust infrastructure in place to deliver RE can significantly influence RE deployment. The process of turning renewable 'natural resources' into productive use as viable forms of energy requires the stages of energy capture, conversion, storage, transmission, and distribution. This, as argued in chapter 5, foregrounds the importance of the pre-existing built infrastructure that can realise or limit RE potential. The requirement of robust, appropriate infrastructure to transmit and distribute RE electricity becomes an important aspect of the material dimensions of RE that can advance or hinder RE deployment. The presence, or absence, of infrastructure networks can enhance or impede RE deployment and delivery and becomes an important mediating factor between physical resource endowments and institutional/ governance structures, creating inertia and path dependencies. Here, in this chapter, the purpose is not to look at infrastructure at regional or national levels, but to understand how it can constrain or enable RE deployment.

The move towards energy systems that incorporate a far greater use of RE technologies raises many challenges for energy transmission and distribution. The network infrastructure has traditionally played a crucial role in supplying energy to consumers: large scale electricity generation sources are connected to a high voltage transmission network (the 'grid'), which in turn is transported to supply-points of medium and low voltage distribution networks, and then delivered to the end-users. The geographical shift in the location of major sources of electricity generation to utilise low-carbon sources, often situated at a distance from energy users and in remote rural or coastal areas, together with the nature of renewables sources, including wind and solar, that are variable and fluctuate during the course of any given day or season, has given rise to congestion and load management problems. Hence, the deployment of RE, due to its distributed nature, has serious implications for the electricity infrastructure[168].

The capital intensive nature of the electricity network infrastructure presents characteristics of a natural monopoly. In this sense, the transmission and distribution networks are normally subject to governance via public ownership or some form of economic regulation which reflects the fact that the electricity infrastructure delivers wider social benefits. Among these social benefits, a new and upgraded energy transmission and distribution infrastructure is seen as necessary to deliver and ensure long-term energy reliability and security. Drivers for infrastructure renewal, therefore, not only reside in connecting new low-carbon RE sources to the existing grid but also include the import/ export of energy to other countries[169], the goal of an integrated electricity market and an increased focus on security of supply (Ritchie et al. 2013; Sataøen et al. 2015). For these reasons, the energy network infrastructure has become a strategic concern in many countries and is subject to special decision-making procedures from central governments at the national level, often resulting in increased investments in upgrading and developing transmission and distribution lines (Sataøen et al.

[168] Although variability (and the balance of supply with a variable demand) is not new to electricity systems, as the share of variable renewables supply increases, it puts pressure on power systems, giving rise to congestion and requiring increased flexibility to respond to balancing issue (requiring more flexible generating capacities (e.g. gas and hydro power plants) but also interconnections, storage (e.g. with pumped-hydro plants), and/or load-management (via for instance smart grids) (cf. OIES 2017).

[169] Cross border distribution of energy adds to the legislative complexities; however it has become apparent that governments are considering this type of upgrade to the grid systems through interconnectors and expansion of existing networks to support renewable energy distribution (Ritchie et al. 2013).

2015). Investments in transmission and distribution networks have increasingly become a 'national sustainable development priority' (Cotton and Devine-Wright 2013: 1226), as shown by the number of policy strategies promoted at the national level for future transmission and distribution network developments. These strategies are often characterised by moving from short-term efficiency and cost reduction aims to an approach driven by national strategic goals (Sataøen et al. 2015).

Electricity infrastructure renewal is complex, with several institutions involved and, although the national level plays an important role, connecting RE sources to the existing electricity transmission and distribution networks has required both the construction of new lines and the upgrading of current networks. Managing grid capacity and infrastructure upgrades becomes, therefore, a site-specific issue that questions the role of the region in steering infrastructure requirements, and this includes planning approvals. Network infrastructure renewals have often faced constraints and resistance at the regional and the local governance levels (Balta-Ozkan et al. 2015; Sataøen et al. 2015)[170]. Thus, it can be argued that the global, national and regional power and infrastructure networks become intimately connected through the materially embedded transmission and distribution networks within specific territories (Hiteva and Maltby 2014) and the interconnections between them. Furthermore, most challenges surrounding energy infrastructure provision and governance simultaneously involve various spatial levels (see for instance Goldthau (2014)).

The attention in this chapter focuses therefore on the existing infrastructure and plans for upgrade in the two countries, and how transmission and distribution network development are governed in them, underlining differences and similarities in the opportunities, actions, and constraints in infrastructure development. The aim is to understand how the regions under consideration have participated in, and supported, decision-making processes for infrastructure renewal and the type of conflicts that have arisen between interests and objectives at the different spatial levels.

[170] Public opposition to new energy infrastructure is the area that often gets covered in research, leaving a void in existing research that studies the challenges and opportunities related to electricity infrastructure development, including associated processes of siting, planning and consenting network infrastructure (see for exception Murphy and Smith (2013); Ritchie et al. (2013); Sataøen et al. (2015); Cowell (2016); Tenggren et al. (2016).

The arguments in this chapter focus on the differences that have emerged at the regional level in:

- The status of existing and planned infrastructure investments for transmission and distribution grids, and
- the challenges that governing infrastructure presents at the regional level, including the regulatory powers and political legitimacy (or the lack of it) that allows for shaping existent and future infrastructure networks to accommodate RE.

Figure 8.1 summarises the key themes identified in relation to the framework.

The case study material is used to ascertain:

i) how RE deployment is influenced by the differences in infrastructure endowment;

ii) how these put pressure on regions and regional actors to influence infrastructure upgrades to achieve regional targets and aspirations and

iii) to identify whether the regions under investigation have (or are lacking) the formal regulatory powers and political legitimacy to shape existent and future infrastructure networks.

Figure 8.1 The material dimensions that influence RE deployment: Established infrastructure networks

Socio-material dimensions	RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use	Discourses, narratives and visions for renewable energy deployment	
Key themes	Targets and resource assessment: their construction and assessment Planning for RE & Potential and different values of environmental attributes when compared against RE targets Availability of land/ current land-based values	Imaginaries and vision for RE development How RE are represented vis-à-vis alternative energy sources	In Fo leg

i. The status of existing and planned infrastructure investments for tran grids, and

ii. the challenges that governing infrastructure presents at the regional l regulatory powers and political legitimacy (or the lack of it) that allow and future infrastructure networks to accommodate RE.

8.2 Established infrastructure and the challenges of RE deployment in Italy

In Italy, after the process of liberalisation began, transmission and generation ownership was fully unbundled, resulting, in 2005, in the establishment of Terna (previously known as Rete Nazionale Elettrica SPA) as the national transmission system operator. Terna is responsible for the transmission and dispatching of electricity. It owns and operates the largest high-voltage network (transmission lines of 132 kV – 400 kV) in Europe, with more than 63 500 km of transmission lines (IEA 2016). The country's electricity transmission infrastructure is shown in Figure 8.2.

Whereas Terna has sole responsibility for the transmission system, about 139 distribution operators (IEA 2016) operate at the municipal level. These are of uneven size, with Enel Distribuzione (now known as e-distribuzione) as the main distributor, serving around 85% of the Italian market (over 30 million customers connected to the distribution network), followed by A2A Reti Elettriche (4%), Acea Distribuzione (3.4%) and Aem Torino Distribuzione (1.3%) (Benedettini and Pontoni 2013).

Distribution operators manage the medium and low voltage lines and connect not only final customers, but also producers. According to IEA (2016) Italy has the second-largest low-voltage network in Europe, after France, with 852 835 km of lines, and the third-longest medium-voltage network, after France and Germany, with 387 730 km. While traditional distribution systems have been designed to distribute electricity top-down from generation connected to the transmission level to end consumers, they have also been built to provide enough capacity to cope with changes in electricity demand and network power flows.

Although Italy has followed a 'fit and forget' principle[171] allowing RE generators to feed energy directly into the grid, as already been pointed out, they have also benefitted from priority of

[171] With the introduction of RE, local resources have been admitted into the systems and they share access to the distribution networks. With *the fit and forget* approach, the distributors will approve network connection without restriction. Nevertheless, as the number of RE connections increase, a fit and forget approach becomes less economically viable as eventually it requires increased capacity to deal with every load. While some network connections from RE sources have been denied because the network lacks the capacity to allow access or require costly networks upgrades, in some countries, such as in the UK, the approach of *connect and manage* has been introduced. This allows for distribution networks operators to manage the capacity in the network, allowing for restricted connections (following a non-firm access). For further details, see Gharehpetian (2017).

dispatch[172]. In other words, distribution operators are required by the regulatory framework to give priority access (both in terms of priority of connection and access to the grid) to RE generators. The electricity distribution networks play an important role in electricity emergency response planning, supporting the transmission operator when a problem (a 'network-crisis') occurs. As the proportion of variable renewables in the electricity mix grows, the distribution networks, in Italy as well as in other countries, have increasingly needed to be capable of exchanging signals with different distributors, generators[173] and the transmission operator, Terna.

The rapid increase in the penetration of variable sources that occurred in Italy between 2010 and 2012, has required changes both at transmission and distribution levels, ranging from dispatch operations (to increase system efficiency) to the introduction of mechanisms to better measure and enhance the performance of frequency regulation and the construction of new lines (IEA 2016). Terna has significantly upgraded the transmission network with the explicit goal of reducing congestion and reversing the general flow of electricity from the historical north-south direction to a south–north flow (IEA 2010).

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[172] In the UK on the contrary, grid connection is non discriminatory and RE operators benefit from guaranteed access but without priority of dispatching (Pérez-Arriaga 2013).

[173] As the number of distributed generators increases, the principle of '*fit and forget*' is questioned, needs monitoring but also requires the ability to exchange signals among operators to maintain voltage and current standards, adequate performance in case of relevant incidents and, in general, the security of the Italian power system.

Figure 8.2 Map of Italy's Transmission electricity infrastructure

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: IEA (2016)

At the distribution level, system operators have also needed to become more active in network management, requiring a number of changes in the current regulatory framework, which since 1997, is the responsibility of an independent regulator, the Autorita' Garante per l'Energia Elettrica e il Gas. In this regard, Benedettini and Pontoni (2013) argue that the Italian regulation, to some extent, has lacked a unified approach. While this is a consequence of the significant number and heterogeneity of Italian distribution operators, there is a legal constraint, set in Italian law, which regulates capital expenditures and operating expenses.

This has influenced and shaped the level of investments in infrastructure networks, often with different mechanisms[174].

Nevertheless, although transmission congestion, or constraints on the local network, have often caused RE curtailment[175] (Bird et al. 2016), the rates in Italy have been relatively low (1.5% for wind and 0 % for solar PV (IEA 2016)), a sign that illustrates that both the transmission and distribution networks have been able to absorb current RE deployment levels[176]. The reasons for this are threefold. Firstly, although it is true that in the event of problems and congestion of the network RE operators are forced to intervene, following a limiting dispatch order from Terna, by law Terna is now required to limit conventional plants and combined cycles before limiting RE plants. In other words, the priority of dispatch guarantees RE plants priority over conventional plants and combined cycles and these are restricted / disconnected before RE plants[177].

Secondly, at the transmission level, Terna is required by law (Legislative Decree 1 June 2011, n. 93) to provide a National Electricity Transmission Grid Development Plan, which lays out expected grid investments over a ten-year period[178], which is updated every year. The Plan takes into account:

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[174] For a review of the current Italian regulations for the electricity distribution networks see Benedettini and Pontoni (2013).

[175] Curtailment here refers in general to the use of less wind or solar power than is potentially available at a given time (Bird et al. 2016).

[176] Although more recently, curtailment rates have been reduced, it needs to point out that during the early uptake of RE projects, especially wind, the Italian electricity system suffered from inadequate grid infrastructure, which led to frequent curtailment to avoid congestions. Grid problems affected projects in Campania, Apulia, Basilicata and Sardinia. In 2009, a number of wind farms operated at 30% less than their normal capacity due to this issue. In some cases, wind farms were limited by over 70%, while others were shut down completely (RSE 2011).

[177] Conventional plants can lose 20/30 % compared to a loss, for example, of 7% for wind power, (RSE 2011). In Italy, there is no explicit capacity limit for grid connection: work required for the integration of an additional unit is automatically considered during the connection application process. As a result, grid operators cannot reject connection requests (REKK 2013)

[178] Moreover, Terna and the distribution companies that have at least a primary substation, must define and publish on their websites atlases related to networks (in high- to very high voltage) and primary substations (at medium- to high voltage) to provide up-to-date qualitative information in relation to the available network capacity and the identification of the critical lines and critical areas.

- energy demand and forecast;
- the need to strengthen interconnection networks with foreign countries;
- the need to minimize congestion, based on forecast demand and requests to distribution network operators[179].

The Plan[180] is submitted to the Minister of Economic Development, which approves it and consults the regions. As discussed in more detail later in this chapter, the development and construction of new facilities (for example, transmission lines, substations and power plants) requires permits mandated by state and regional legislation to ensure environment protection and compatibility with existing infrastructure. This has allowed for significant grid investments by Terna, designed specifically to accommodate wind power[181], which is concentrated in the south of Italy.

Thirdly, since 2000, Italy has deployed smart meter technologies extensively with about 32 million smart meters installed across the country in homes and businesses. Enel Distribuzione has led the deployment of smart meters which, among other uses, has helped to support the integration of variable renewables (IRENA 2013). The main driver for smart meter deployment, at the distribution level, has been to improve services and cost reductions (IEA 2016). Hence, distribution operators have used smart meters to manage supply contract ratings, as they restrict the maximum amount of power that flows to the customer base, according to their tariff class[182]. Smart meters have also allowed for greater visibility of

[179] Development plans have also aimed at reducing the significant transmission constraints between northern and southern Italy, and the lack of connectivity to the two main islands, Sicily and Sardinia. In 2014, for instance transmission improvements between north and south and to Sardinia (the SAPEI Interconnector) were aimed at bringing electricity wholesale prices in line with those of northern Italy. Prices in Sicily remain higher, though a new interconnection (the 'Sorgente-Rizziconi' connection between Sicily and the Italian peninsula) is currently under development (Meneguzzo et al. 2016).

[180] The most recent development plan included EUR 5.1 billion of expenditures on system improvements and new transmission lines over ten years (IEA 2016) However, it needs to be stressed that Terna's investments up to 2004, were in the order of hundreds of thousands of Euros. It is only in recent years that the level of investment has increased following the deployment of RE (Gianni et al. 2012).

[181] The transmission grid, on the other hand, has been capable of absorbing PV capacity that is more evenly spread throughout the country (IEA 2016).

[182] For historical reasons, standard household electricity contracts can vary from 3.0 kW rating (the base) or ratings at 1.5 kW, 4.5 kW and 6.0 kW. Similarly, standard non-household electricity supply contracts come at different power ratings.

demand patterns, specific network limits and reverse flow, allowing more accurate forecasting and network responses to demand changes. Moreover, smart meter technologies have also been deployed at transmission level by Terna to help manage energy flows and to predict variable renewable generation.

Nevertheless, network and congestion problems have been felt differently across Italian regions[183]. RE capacity is often concentrated in regions that are distant from the main consumption centres and where grid development has not kept pace with the spread of production facilities. This creates local over-production problems under certain conditions (for example strong solar radiation and strong winds combined with low consumption), with high risks to the balance and security of the grid and the distribution network, to which a growing proportion of generation from renewables is connected (MISE 2013). I will discuss this in more detail in the next section.

8.2.1 The challenges of RE deployment on the established infrastructure in Apulia, Sardinia and Tuscany

Congestion problems have become more evident in Southern Italy as production and consumption sites do not always coincide and are often far from each other. As discussed in chapter 6, Apulia is the second biggest electricity producer in Italy (after Lombardia) and a net electricity exporter. The region's electricity network was historically configured for the long-distance transmission of major electricity flows from the Brindisi area, where conventional plants are located and where electricity is sent to the north (via Bari) and to the south (Salento region). Nevertheless, with the increase of RE deployment, Apulia presents many large areas where '*reverse flows*' exist – in the form of electricity flowing from the distribution network

[183] Frequent network congestions translate in wind power reductions intervention and while across Italy they have been low, as argued earlier, in some areas they have reached higher percentages. The most affected lines are Andria-Foggia, Campobasso-Benevento and Benvenuto-Montecorvino, areas where wind energy production can reach 1500 MW. Moreover, According to Terna (2017), critical areas in the distribution networks, that limit wind production, are concentrated in the major islands and in the South, in particular along the 150 kV AT lines between Puglia and Campania. Similarly, in Sicily, in 2014, the existing 1000 MW experienced congestions for most part of the year, limiting, for example, the possibility to export the surplus of RE during holydays and weekends (Meneguzzo et al. 2016).

to the transmission grid. These are the areas where a higher concentration of renewable sources is installed (Foggia and Salento areas). This has had an important impact on the transmission and distribution grid, amplifying transportation needs and multiplying congestion occurrences as transmission and distribution capacity is lacking in many of the more remote municipal areas in which renewables have been deployed. Apulia's regional network capacity relies especially on old 150 kV lines, which do not allow the dispatch of all the power produced[184]. Moreover, small municipalities show high electricity reverse flow among the regional primary substations, with Troia[185] among the highest (62%)[186]. Congestion problems are also common in the interconnection with the neighbouring Campania region[187].

Thus, the overwhelming number of RE initiatives in Apulia resulted in negative effects on the national electricity system that were not appropriately covered by the National Renewable Energy Action Plan of 2010 and increased the pressure, at the regional level, to overcome the impact of the plants and their connection to the wider energy network. In 2009, for instance, a significant number of wind farms operated at well below capacity, while others were shut down completely. Moreover, areas of optimal wind resources (along the Foggia-Benevento area) attracted installations without the relevant connection permits, resulting in further network congestion. In Apulia, pending connection requests relate to about 30,000 MW of wind power plants and about 6,000 MW of photovoltaic systems. They represent almost 50%

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[184] Only since 2005 have 132/150 KV networks been included in the national transmission network and so in the transmission system operator's network planning (Gianni et al., 2012) and therefore can be included in Terna's National development plan.

[185] Troia is a small municipality (7.000 inhabitants) in the province of Foggia, characterized by the presence of several big wind farms and PV plants, connected to medium voltage network.

[186] INGRID (High-capacity hydrogen-based green-energy storage solutions for grid balancing) Project details: http://www.arti.puglia.it/progetti-internazionali/ingrid

[187] This prompted Terna to invest in a number of projects to strengthen the network and the inter-regional connections (with an authorization process that started in December 2006 and lasted over 4 and a half years and with an expected completion date of December 2018). In particular these included a new 380 kV 'Foggia-Benevento' power line, and related connections; new electricity station east of Benevento and related connections, and a new 380 kV 'Bisaccia-Deliceto' power line; 150 kV connections to the 380/150 kV power station in Troia, including storage facilities, for collecting production from renewables in Puglia and Campania.

of the entire national figure, 3-4 times larger than those of other southern regions and significantly above the national average (BURP 2014).

While Tuscany has been affected to some extent by infrastructural issues[188], the 2014 Development Plan of Terna shows that against the two interventions necessary in the north and in the centre of Italy, Apulia required 12, 3 of which were for new interregional interconnections and the remaining 9 related to the development of 380 kV high-voltage collection stations.

Similarly, Sardinia provides an interesting example of how the established energy infrastructure has influenced RE deployment. Sardinia has a relatively confined electricity grid with limited interconnection to the Italy mainland (prior to the construction of the SAPEI undersea connection with Tuscany). The electrical system of Sardinia is also characterized by a very limited thermoelectric park, that limits the flexibility and reliability of the electricity transmission (hence RE integration) and a reduced energy demand following the closure of some important industrial companies in the region in recent years (Terna 2017). Moreover, according to Purvins et al. (2011), the network infrastructure presents some distinctive features that are considered bottlenecks and weaknesses of the energy system. The transmission system comprises lines at 380-220-150 kV. These are represented by:

- a 380 kV line, that crosses the island from the south to the north-west, connecting two areas with the biggest power plants;
- a further 150 kV grid in the north east and
- 220 kV lines in the south of the region.

However, these are weakly '*meshed*' (it is worth noting that the meshing of the 380 kV network is non-existent) causing line overloads and voltage problems, in particular in periods of high demand (such as during the summer months). Moreover, while the electricity transmission between Sardinia and the mainland was guaranteed through the SA.CO.I (a high voltage direct current link) via the neighbouring Corsica, the development of two interconnectors (SARCO- Sardinia- Corsica and the SAPEI) has improved the isolation of the

[188] It is also worth noting that Tuscany has also a number of hydropower stations that can help with the integration of RE in the region as they can provide energy storage.

electricity system. These have contributed to the security of the electricity system and increased the capacity to export thermoelectric and RE power production to the mainland. Nevertheless, the limited transmission capacity of the local network (its reduced capillarity) does not allow it to fully benefit from the connection with Corsica (SAR.CO) (Terna 2017). The peculiarity of the energy system infrastructure has reduced the opportunities for connection and export of energy, therefore making the energy infrastructure subject to a more severe control from the transmission operator and more liable to limiting dispatch orders (in particular due to the large deployment of wind power) (RSE 2011).

These physical constraints have been seen, by regional actors, as a limiting factor to capture the opportunities offered by the plentiful regional resource endowments: '*in Sardinia the last problem we have is that of production. That is, the problem of production is solved. We have so much photovoltaic and wind energy already that from the point of view purely with respect to the energy demand that there is on the island, we are fixed! The problem we have is that of the impact of renewables on the wider electricity network*' (Sardegna Ricerche Interview). A feasibility study commissioned by the regional government identified that the installed capacity of 1500 MW of wind power was the maximum limit that the current infrastructure in the region could accept (further capacity could alter the continuity and stability of the electricity service and generate a negative effect reducing the productivity of current installations (Regione Sardegna 2012)). Further studies show that following the infrastructure upgrade completed in recent years (including the SAPEI project), the limit of installed capacity can be increased to 2000 MW (with a curtailment rate of 17.4 %[189]) (Benini et al. 2011). Clearly, this had the effect of i) influencing how targets and the burden sharing were applied to the region and ii) provided an opportunity for dissenting voices to raise concerns around the uptake of RE, especially large scale wind deployment, due to the rising costs of infrastructure renewal, often paid for by customers via the energy bill, and the high environmental impact of new lines and network upgrades.

Although both Apulia and Sardinia have experienced higher levels of congestion due to the physical constraints of their respective local transmission and distribution networks, these limitations have also offered the opportunities to become key regions for the

[189] If the installed capacity reaches 2500 MW, this rate could reach peak of 40 % (Benini et al. 2011).

experimentation of innovative technologies and electrical infrastructure. This will be discussed in more detail later in this chapter.

8.3 Established infrastructure and the challenges of RE deployment in the UK[190]

As discussed in chapter 4, the UK was one of the first countries to liberalise and privatise the energy sector to separate or unbundle ownership of electricity networks, supply, and generation. These processes resulted in a privatised and regulated electricity system with separate licensed roles for suppliers, for generators, for the transmission networks, for the national balancing system, and for the regional distribution networks[191]. The on-shore transmission networks, which facilitate bulk power transport at high voltages, are owned and operated by three companies: National Grid Electricity Transmission (part of the wider National Grid group) which covers England and Wales, Scottish Power Transmission Limited, and Scottish Highland Transmission Limited[192]. The transmission system consists of high voltage electricity wires that extend across Britain, and include 400kV, 275kV and 132kV, extending to offshore waters. These transmission systems are connected to each other by a series of interconnectors, which allows the export and import of electricity to and from the National Grid and the Scottish systems (extending also to neighbouring international countries). Whilst the ownership of the transmission system is split between different companies, a single system operator, the National Grid System Operator, carries out the operation of the transmission system for the whole of Britain, including Scotland. The National System Grid Operator has responsibilities for ensuring the stable and secure operation of the whole transmission system - including the operation of balancing generation with demand in real-time to maintain system security and through the dispatch of transmission assets. As an effective monopoly, the transmission system is closely regulated

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[190] The discussion presented here does not inlcude Northern Ireland as Northern Ireland has its own systems and complexities with reference to energy infrastructure.

[191] Electricity networks for the transmission and distribution of electricity are operated by private entities under license and regulated by an independent sector specific energy regulator (OFGEM).

[192] Since the deployment of offshore wind, Ofgem has run competitive tenders to appoint offshore transmission owners to construct (where a generator chooses not to do so itself) and operate offshore transmission assets. The holders of the offshore transmission licence are: TCP Robin Rigg OFTO Limited; TC Barrow OFTO Limited; TC Gunfleet Sands OFTO Limited; and Blue Transmission Walney 1 Limited (IEA 2012). These have been granted via competitive tenders in 2011 (IEA 2012).

under the Electricity Act 1989 (and amendments), by the transmission licence and the grid code[193] and has statutory duties to 'maintain an efficient, co-ordinated and economical electricity transmission system and to facilitate competition in generation and supply'[194]. The National Grid also has a statutory duty to ensure the maintenance and long-term development of, and investment in, the transmission system. Figure 8.3 shows the electricity transmission system in the Great Britain, excluding Northern Ireland.

The electricity distribution network is governed as a separate entity within the energy value chains since the unbundling of supply from distribution in 1997 (Lockwood 2014; Lockwood 2016). There are 14 licensed distribution network operators (DNOs), owned by six different groups[195], and each is responsible for a regional distribution services area. Distribution networks are regulated by the Office of Gas and Electricity Markets[196] (OFGEM) and have a statutory obligation to connect any customer requiring electricity within an area and to maintain that connection.

The upgrade of the transmission and distribution networks has often been seen as a crucial concern for the increase of RE deployment and for the successful integration of renewable power (Tenggren et al. 2016). Nevertheless, to some extent, the degree and the speed at which the electricity transmission and distribution networks have been upgraded, reinforced or replaced in the UK has been unsatisfactory. Wood and Dow (2011) argue that the national grid infrastructure in the UK was among the main 'external failures' that characterised the ability to deliver targets at the national level and limited the success of early support mechanisms to RE deployment.

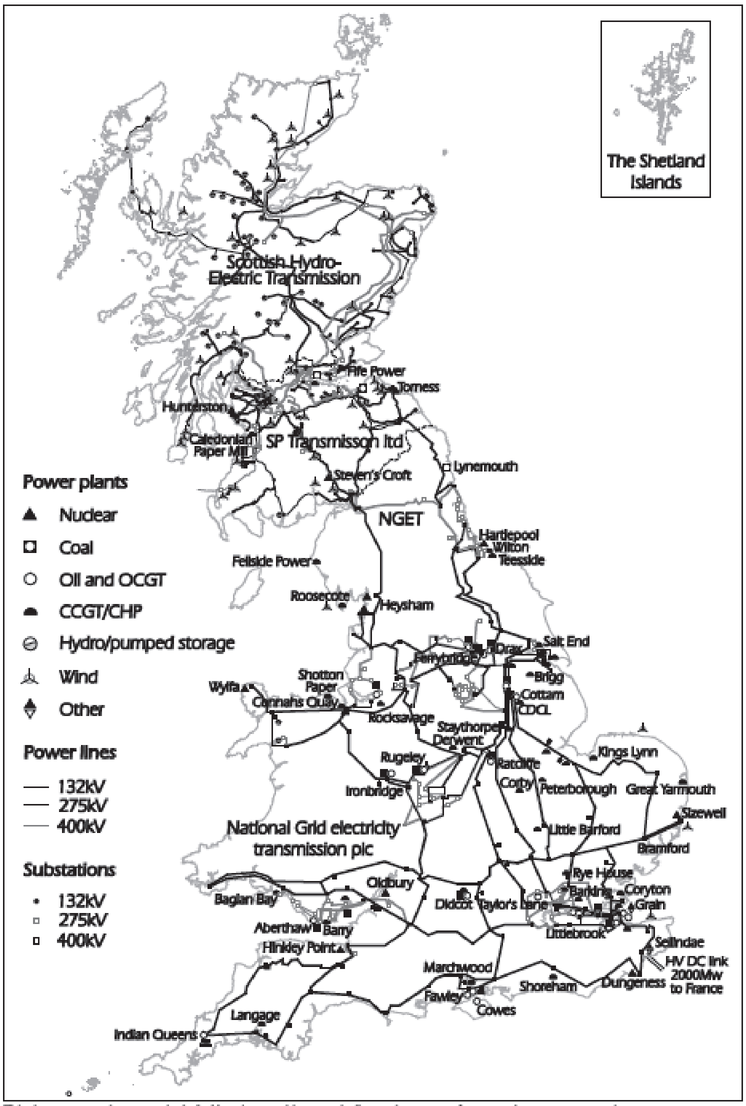
[193] Electricity codes form the framework and rules for operating the British electricity transmission network. Each of the codes focuses on a different area of the industry, see https://www.nationalgrid.com/uk/electricity/codes

[194] Electricity Act 1989 c. 29, Part I, Licensing of supply, Section 9.

[195] These are: Southern Power Energy Networks, Electricity North West, Northern Power Grid, Western Power Distribution, Scottish and Southern Energy Distribution and UK Power Network. Southern Power Energy Networks and Western Power Distribution are the distribution network operators for Scotland and Wales, respectively.

[196] 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.

Figure 8.3 The Electricity Transmission System in Scotland, Wales and England



This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA (2012)

They argued that one of the problems that RE deployment has faced in the UK is concerned with the demand for network capacity exceeding supply, especially in areas where the network is already heavily constrained (e.g. Scotland).

The already aging infrastructure (the central grid was almost fully developed before WWII and the distribution network dates back to the 1950s and 1960s), it has been argued, could have provided an opportunity for undertaking a programme of network upgrades and replacements (Woodman and Baker 2008). Nevertheless, the regulatory framework[197] has not been able to encourage the long-term strategic development necessary to stimulate investments and infrastructural upgrade (Woodman and Baker 2008). The reasons for this are manifold.

Since the privatisation of the electricity industry the main drivers for infrastructure upgrade have been efficiency and minimisation of operating cost (Sataøen et al. 2015). Although, efficiency improvements have driven electricity prices down (prices fell by 50 % between 1990 and 2010 (Sataøen et al. 2015)), adequate investment in infrastructure development has been lacking. Transmission owners propose which projects should be developed and present detailed proposals and funding requests to OFGEM which, in turn, judges them in terms of efficiency and the interests of consumers (Lockwood 2014).

Nevertheless, the construction of energy markets and the presumption in favour of competition (that has characterised the energy system in the UK[198] (Woodman and Baker 2008) has promoted infrastructure renewal largely driven by demand, with new grid elements or upgrades being added as producers wish to connect to the grid. Yet, some authors argue that the extent of upgrading the land-based grid does require a more strategic approach that goes beyond the single project and the 'response mode' to grid connection for electricity generation adopted in the UK (Cowell et al. 2013)[199].

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[197] Investments in the transmission and distribution networks have been regulated via a series of successive five-yearly price control economic regulation regimes. Grid reinforcements are proposed and reviewed during this price control processes. These also determine how much distribution network operator companies are allowed to raise to cover operational and capital expenditure in the price control period and via connection charges (Lockwood (2016) for the UK and for a review and differences between the Italian and the UK system, see Benedettini and Pontoni (2012)).

[198] As the IEA has pointed out, "the UK is among those countries that most rely on market actors, responses to price signals and private participation" (IEA/ OECD 2007: 9).

[199] In 2009, the cost of upgrading the grid to achieve the 2020 target was estimated at around £4.7 billion (Electricity Networks Strategy Group (ENSG 2009).

Furthermore, although transmission and distribution operators have not had the right incentives to construct adequate capacity in time for generators to connect, they have traditionally been (and been seen as) risk-averse, rather than proactively responding when required to by users seeking to connect, or by the regulator (Lockwood, 2014). While UK regulation has sought to overcome these problems, via a reform of price control, where revenues and investments are explicitly linked to different output targets[200], a further problem that has affected RE deployment relates to the existing regime for transmission and distribution access.

Before May 2009, the connection of electricity generators to the grid was done on a first-come first-served basis, on an 'invest then connect' principle, meaning that generators had to wait until any necessary reinforcement to support their connection had been completed and join an access 'queue'. This led to an extensive queue of prospective new projects, with some plants offered connection dates as late as 2025 (IEA 2012). In order to address this problem, in May 2009 OFGEM approved the introduction of a 'connect and manage' regime that was aimed at facilitating connection of new RE generation. The connect and manage approach has allowed new generators, regardless of size or type, to connect to the network by simply carrying out the required local upgrades (around the point of connection) without waiting for any wider transmission network upgrades that might be required. This has accelerated connection of projects (especially wind projects).

According to the IEA (2012), the connect and manage approach has provided a means of overcoming the problem of accessing the grid that has, to an extent, limited early progress in

[200] OFGEM has developed a new approach for setting price controls that applies to the transmission operators from 2013 to 2021. The previous approach to regulation (RPI-X) focused on reducing costs and achieving efficiencies. The revised framework (RIIO) involves OFGEM setting a number of wider delivery outputs (with incentives/penalties attached). This new approach is aimed to ensure that energy networks are able and willing to meet the changing network challenges, including playing a more active role in upgrading the infrastructure to meet renewable energy targets and the goal of security of supply. OFGEM has already approved around GBP 4 billion of investment under the current extended transmission price control period which runs from 2007 to 2013 (IEA, 2012). Nevertheless, this new approach is challenging, as it requires the regulator not only to define a consistent set of coherent and easily measurable outputs, but also to define proportionate, fair rewards and penalties, which have to avoid remunerating or punishing DSOs for situations, which are beyond their control (Benedettini and Pontoni 2012). Further steps to improve network performances are also set in the 2017 'Upgrading our energy system: Smart Systems and Flexibility Plan', published by OFGEM, and includes facilitating competition on new types of network flexibility, such as storage and demand-side response and other solutions, as well as further interconnection and network infrastructure improvements.

the achievement of the 2020 deployment targets. However, the increase in RE generation capacity has caused many parts of the grid to become 'closed to new connections'[201].

The closure and congestion problems on the network are distributed unevenly across the UK. This is caused, in particular, by the geographical shift in the location of the UK's major sources of electricity generation to utilise RE sources and a legacy of past infrastructure development. I discuss this in the next session.

8.3.1 The challenges of RE deployment on the established infrastructure in Wales and Scotland

Power from RE generation from onshore and offshore wind farms in the north of Scotland and, to some extent, marine renewables, is increasingly flowing towards the south of the country (Scotland and GB), adding to a network system that is already operating at its maximum capacity (ENSG 2012). The Electricity Generation Policy Statement (SG 2013), published by the Scottish Government, highlighted how, in order to achieve targets and maximise the potential for renewable resources, Scotland will have an 'excess generation capacity that can be exported through existing and planned export links' (2013: 35). In other words, due to the large distances between urban zones, wider linkages are needed for grid upgrades and reinforcements to enable electricity distribution from the north of Scotland energy sources to English demand centres. As discussed in earlier chapters, areas that are resource rich in terms of wind yield and land are also areas of low population density (and low levels of electricity demand)[202] and this surplus of generation requires a suitable infrastructure to allow renewable electricity to be exported across the distribution and transmission networks.

A number of investments and upgrades are expected to take place in Scotland, both onshore and offshore, in order to overcome the network's congestion problem and to facilitate

[201] 'UK electricity grid holds back renewable energy, solar trade body warns', Farrell, S., 10th of May, 2015, Guardian, https://www.theguardian.com/business/2015/may/10/uk-electricity-grid-renewable-energy-solar-trade-association

[202] For instance, in the area of South West Scotland where peak demand is around 177MW Scottish Power Networks have managed to connect 310MW of RE, that needs exporting via the distribution and transmission network (see https://www.spenergynetworks.co.uk/userfiles/file/SPEN%20DSO%20Vision%20210116.pdf).

integration of renewables. These include a number of improved interconnectors from Scotland to England, across the North and Irish Seas and to support intra-regional connections to solve regional transmission issues between the main islands of the Western Isles, Orkney and Shetland. Box 8.1 provides a view of the extent of the upgrade required as indicated by the Electricity Networks Strategy Group in their Vision 2020 report, updated in 2012 (ENSG 2012)[203]. In Scotland, as discussed, the responsibility for electricity infrastructure renewal, concerning ownership and investment, lies within the two transmission networks (Scottish Power Transmission and in Scottish Hydro Electric Transmission Limited)[204]. Details of the planned reinforcement, development and investment in the Scottish network are therefore presented in the two transmission operators' business plans (the most recent covers the price control period of 2013-2021), the findings of which are designed in compliance with the investment model of the regulator OFGEM, which, prioritise them in terms of efficiency and best interests of consumers. Yet, in order to boost capacity, OFGEM announced in January 2012 the fast tracking of Scottish Power Transmission and Scottish Hydro Electric Transmission plans, including investment for £7 billion in Scotland's high voltage transmission network by 2021. This provided a strong signal towards the national significance of the activities necessary to reinforce and develop the UK electricity infrastructure to deliver on the country's low carbon electricity aspiration.

Arguably, one of the most significant pieces of grid investment that has occurred in recent years in Scotland has been the reinforcement of the transmission line that goes from Beauly to Denny, in which a higher capacity 400 kV line replaced the existing 132 kV line (Cowell et al. 2013). While this development was seen as the beginning of 'a staged infrastructural programme across the UK designed to distribute energy from key sites that are rich in renewable natural resources' (Ritchie et al. 2013: 316), this investment- and the associated

[203] The ENSG is jointly chaired by the Department for Business, Energy and Industrial Strategy (BEIS) and OFGEM and aims at identifying and coordinating key strategic issues that affect the electricity networks. At the end of 2016, following the publication of the Smart, Flexible Energy Call for Evidence, the ENSG and the Smart Grid Forum have been merge to create the Smart System Forum group. This also signals a steer towards a focussed attention to flexibility, storage and the smart grid.

[204] Both areas of the north of Scotland and the central and south of Scotland are expected to experience an increase in renewable generation capacity. These are represented, among others, from offshore wind farms by the Crown Estate Round, marine generation in the Pentland Firth and Orkney waters and numerous onshore wind farms within Scotland (ENSG 2012).

delays in its completion[205]- revealed important issues regarding the steering of infrastructure renewal. As I will discuss in more detail later, the project attracted considerable media attention and controversy, stressing the importance of spatial infrastructure planning and the political decision making and steering of infrastructure renewal, at different spatial levels.

Infrastructure challenges are also present in Wales. Cowell et al. (2013: 38) argue that 'Wales provides an object lesson of the importance of sufficient grid capacity to promote renewable energy generation[206]. On the one hand, both onshore and offshore wind generation connections in Wales, together with the potential connection of a new nuclear power station, raise a number of regional connection issues. In particular, problem areas have been identified in North Wales and in mid Wales, where the capacities of the transmission and distribution networks in the area were not sufficient to accommodate generation, without investment in the system (ENSG 2012). On the other hand, during the process of identification of strategic zones for onshore wind development (the strategic spatial planning guidance TAN8; see chapter 6) sufficient grid capacity was considered in determining these areas; yet strategic zones were also identified in mid-Wales due to their wind potential, despite a lack of suitable grid connections. The mid-Wales national grid infrastructure did not contain capacity for large-scale wind developments (Ove ARUP 2010) and significant network infrastructure investments were needed in the area to unlock the wind resource potential. Furthermore, the infrastructure challenges, in mid-Wales, also relate to the distribution network, which although capable of supplying local customers, proved to be technically constrained when accepting new generation capacity (National Grid 2008). Improvement to the infrastructure[207], therefore, has not only required a review of the utilisation of existing

[205] The planning application for upgrade was presented in September 2005. The Scottish Government issued consent in January 2010 and the link was fully competed between 2015/2016.

[206] Ofgem suggested that in 2015, there was already 2GW of distributed generation connected to the network with a 3 GW, contracted but not yet connected, against a demand of 2.8 GW, suggesting that network constraints and congestion on the network are likely to occur (Maxine Frerk, OFGEM, speaking at the Policy Forum for Wales: Priorities for the Energy Sector in Wales, Investment, infrastructure and devolved powers, Cardiff 3/12/2015)

[207] The terms of connection access, as suggested, requires that generators carry out local upgrades for grid connection, however problems around the mid-Wales transmission and distribution networks meant that a small hydro company seeking to connect 18kw in the area was asked to cover a £5.5 million grid connection cost and wait 6 years for the connection to be available (Chris Blake, speaking at Forum for Wales: Priorities for the Energy Sector in Wales, Investment, infrastructure and devolved powers, Cardiff 3/12/2015). This is also something that affected some developments in the Western Isles of Scotland, as explained by Murphy and Smith (2013).

transmission assets, but has also involved the investment in new overhead lines and substations. Again, this attracted considerable media attention and controversy[208], questioning the capability of the Welsh Government to steer infrastructure renewal. I will return to this point in the next section. Moreover, a renewed attention for grid development was also stressed in the recent Energy Policy statement that introduced new RE targets for Wales as stated in chapter 6. It is argued that the 'right flexible and affordable grid infrastructure is a fundamental enabler to connect the new generation that Wales needs for a prosperous low-carbon future'[209].

Box 8.1 Potential transmission network reinforcements in Scotland and Wales by 2020

A number of potential network reinforcements were identified in both Scotland and Wales by the ENSG's Vision 2020 report (ENSG 2012). These include:

- Several HVDC Links (e.g. from Caithness to Moray Coast; an East Coast Subsea HVDC Link from Peterhead to England; in the Shetland Islands and an undersea cable connection from central Scotland to North Wales);
- 400 kV upgraded to address capacity requirements (e.g. East Coast AC 400kV; the Denny to Wishaw upgrade and the SPT East Coast; the Wylfa to Pembroke link and from Mid-Wales to Shrewsbury);
- 132kV subsea link between the west Orkney mainland and Caithness;
- Reconductor and transformers (beteween Trawsfynydd – Treuddyn);
- Substations upgrade (e.g. Mid-Wales Substation and mesh substation at Shrewsbury);

The Energy Networks Strategy group provides a quarterly major projects status update, with all projects in the pipeline with expected completion date ranging from 2018 to 2023. What is important to highlight that major electricity transmission projects have, since February 2012, allow delivering 8.35GW of network capacity

Source: Author's elaboration from ENSG (2012) and projects status update[210].

[208] Many new infrastructure projects provoke adverse reaction and public opposition, attributable at time at the Not in My Back Yard (NIMBYs) syndrome; see for instance Cotton and Devine-Wright (2013) and Cowell (2016).

[209] The Cabinet Secretary for Environment and Rural Affairs' Energy Statement, 26/09/2017 http://www.assembly.wales/en/bus-home/pages/rop.aspx?meetingid=4644&assembly=5&c=Record%20of%20Proceedings#C494225

[210] Available from https://www.gov.uk/government/groups/electricity-networks-strategy-group

One more issue needs to be highlighted. It could be argued that the problems in grid capacity across large areas of mid and west Wales could have provided an opportunity to incentivise innovation in the smart grid and storage sectors, particularly via the opportunities offered by the availability of European structural funds to financially support innovative projects. Yet, although attention has been given to these opportunities as they can reduce the need for expensive and controversial infrastructure upgrade, to date there has been little experimentation in the area.

8.4 The political legitimacy and the resources needed to participate in infrastructure renewal at regional levels

This section provides an account of the way in which the regions under consideration have been involved, have participated in, and supported decision-making processes for infrastructure renewal, highlighting conflicts and opportunities that might have arisen around different interests and objectives at different spatial levels. The Italian section only presents examples from the regions of Apulia and Sardinia, as it has been argued that these two regions have been most affected by RE increase and infrastructure challenges. This is not to say that Tuscany has not established any relationship with those who own the electricity network infrastructure, operate it and regulate it; on the contrary '*the region has always had a close relationship with our company*' (ENEL_INTERVIEW). As suggested in chapter 7, the region focuses on an industrial strategy for RE that promotes interaction ad network relations across all the different actors in the RE sector, encompassing infrastructure network operators.

8.4.1 Involvement and participation in infrastructure renewal: examples from Apulia and Sardinia

As mentioned previously, in Italy, under the present constitutional framework, energy issues are governed under 'concurrent legislative powers', which extend to include regional involvement in administrative matters. In other words, as discussed in previous chapters, the authorisation for any given project requires the agreement of the region concerned. As pointed out in MISE (2013), this also includes energy infrastructure renewal works deemed of national interest (and not just for those of regional and local interests). In particular, the development and construction (or upgrade) of network infrastructure (for example, transmission lines and substations) require permits mandated by state, regional and local legislations to ensure environmental protection and compatibility with existing infrastructure. The process of obtaining such approvals is regulated by a combination of state, regional, and local legislations, discussed and agreed with the Permanent Conference of the State, the Regions and local autonomies[211]. This process is, however, led by the regions (or sometimes the provinces), which co-ordinate all the agencies and authorities whose consent or opinion is required to in order to bring the 'consenting process' to a conclusion. While the process will depend on the nature and location of the facility to be developed and the permits required, it highlights, nevertheless, that infrastructure requirements have institutional concomitants that encompass regional steering. I have discussed the problems that the concurrent legislative and administrative powers have caused delaying the planning process in chapter 6. Accordingly, MISE (2013: 114) has suggested that more should be done to overcome problems of coordination with the regions and local government involvement, suggesting the restoration of 'legislative powers to central Government in energy matters where projects and infrastructure facilities of national importance are concerned'. This would not exclude the regions from the decision-making process, but would return the legislation to one single level and simplify the authorisation process.

While some of the network upgrades planned by both the distribution and transmission operators has been completed (or nearly completed), the bulk of improvement is still awaiting the authorisation required. Two issues are worth emphasising here. Firstly, some of the work already conducted (e.g. in Sardinia, in the Codrongianos area)[212] took place in an area that already hosted a Terna substation (Terna owned the site) and the inland connection to the SACOI, therefore this was an area whether further upgrade did not cause much controversy

[211] As discussed in chapter 6.

[212] The Codrongianos station hosts a sorting station where high-voltage lines converge, it is home to the SACOI DC power conversion and transport system. It also includes two recently installed compensators, which regulate the energy flows for the stability and safety of the Sardinian network, and host the "Storage Lab", the program developed by Terna in agreement with the Authority for Electricity and Gas, to test different existing storage technologies for the safety of the electricity grid. Codrongianos area is considered one of Europe's most technologically advanced hub for the support and protection of electrical grids.

(in terms of planning authorisation and public opposition)[213]. In Apulia, for instance, many of the planned upgrade works in the region are still awaiting authorisation (for some projects the authorisation process was initiated as early as 2010[214]). Perhaps the most urgent upgrade work that benefitted the region, in terms of management and transfer of RE flows, regarded the construction of an interconnector between Apulia and the neighbouring Campania region (including the creation of substations). This, although it received much media attention and opposition, was partly located outside the Apulian regional boundary in the Benevento area (in the Campania region)[215]. Nevertheless, it is worth noting that the regional government of Apulia sought to oppose the creation of a new gas pipeline[216], using regional planning laws. Although the decision was overruled at the national level, it highlights, though for the gas sector, that the regional level can play an important role in hampering further infrastructure renewal[217]. It also stresses the importance of the willingness of regional governments to give the authorisation necessary for the upgrading, as it can help when dealing with the public opposition to extensive network upgrade. This highlights another dimension of the difficulties of reconciling RE resource exploitation with existing land uses, which was discussed in chapter 6.

Secondly, it is often the relationship that regions can establish with network operators to better address and overcome issues related to particular infrastructure development that can facilitate and speed up the consenting processes (cf. MISE 2013). This is seen not only as an important factor that showcases the willingness of regional governments to facilitate the co-

[213] As part of a research project funded by the NRN-LCEE network (the Pan-Wales Ser-Cymru National Research Network for Low Carbon, Energy and Environment) I have interviewed a representative from TERNA on the 18th of January 2018, who raised this important point.

[214] See Terna's 'Grid Development Plan Summary' available at http://www.terna.it/en-gb/sistemaelettrico/pianodisviluppodellarete/sintesipianodisviluppo.aspx

[215] This was also raised during the interview with Terna conducted in January 2018.

[216] The Trans Adriatic Pipeline- the infrastructure aimed at bringing into Europe, via Lecce, gas extracted from the fields of Shah Deniz, Azerbaijan.

[217] Squires (2017) 'Olive groves in Italy become battleground over controversial gas pipeline, The Telegraph, 29/03/17, http://www.telegraph.co.uk/news/2017/03/29/olive-groves-italy-become-battleground-controversial-gas-pipeline

ordination of all the agencies and authorities in negotiating infrastructure upgrade. The regional government of Apulia has for instance:

i) instituted a ‘concertation table’ with the different organisations involved in the programming of the enhancement of the electricity transmission and distribution network infrastructure;

ii) signed a Memorandum of Understanding between the regional government and TERNA for the application of the Strategic Environmental Assessment procedure for the planning consent of the programme of interventions of the high-voltage power grid;

iii) promoted, working with Enel Distribution (e Distribuzione) and the national government, a programme of structural interventions for the development of the distribution network and smart grids, funded via European structural and convergence funds (the Operational Inter-regional Operational Program (POI) 2007-2013) to support RE integration in the distribution network[218].

As we have seen, both Apulia and Sardinia have experienced higher levels of congestion due to the physical constraints of their respective local transmission and distribution networks. Nevertheless, these limitations have also offered opportunities to become key regions for experimentation in the use of innovative technologies and electrical infrastructure. While within all the three regions, Tuscany, Sardinia and Apulia, much attention is given to engaging in research on smart grids and storage in order to strengthen the infrastructure network and facilitate RE integration, managing the grid is a scale and site-specific problem and the peculiarities and characteristics of Apulia and Sardinia have made the regions ideal locations for testing and piloting innovative solutions. Hence, a 39 MWh EU FP7-funded pilot plant for hydrogen-based storage for grid balancing was opened in Troy, in the province of Foggia, an area with many wind and photovoltaic plants where production peaks and power grid limitations mean energy cannot be locally used or transported. Sardinia has become a ‘high-tech hub’ for the experimentation of storage applications due to the investment of Terna in the area of Codrongianos. Moreover, energy storage and energy storage applications (those

[218] Together with Apulia (€ 35 million), the region of Campania (€27 million), Calabria (€ 32 million) and Sicily (€ 29 million) were also involved with a total investment of €123 million.

that support the electricity energy system and distributed storage) became an integral part of the Sardinian PEAR 2015 - seen as a key mechanism to deliver targets and RE aspirations.

8.4.2 Involvement and participation in infrastructure renewal: examples from Wales and Scotland

In the UK, steering the electricity network at the regional level is considered problematic (cf. Cowell et al. 2013; Cowell 2016). As suggested, 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 grid transmission charging. Such regulatory arrangements make it difficult to drive forward major system reinforcements in advance 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 it difficult to steer enhancements that go beyond the single project and that are important for the UK-wide RE agenda. It is an additional problem that new terrestrial network developments have also attracted significant public opposition[219] (Cowell et al. 2013).

The electricity infrastructure networks for Wales, reflecting post-War agendas of integration and centralisation, ignore the Welsh/ English border. Partially as a consequence of this, the Welsh Government – either as an arm of central government up until 1998 or through the devolved government after 1998 – has not been able to exercise control over grid regulation or the financial resources governed through it (Cowell et al., 2013). Nevertheless, as suggested in chapter 6, whilst the majority of planning functions in Wales are now completely separate from England, applications for major energy, transport and other large-scale infrastructure projects are decided by a joint body that is appointed by the UK Government, the Planning Inspectorate. This is responsible for deciding major infrastructure applications

[219] Cowell et al. (2013) argue 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. This point is also raised by Sataøen et al. (2015).

known as ‘nationally significant infrastructure projects’ and the primary basis for the decision taken are set out in the National Policy Statement for Electricity Networks Infrastructure (EN-5). Although this represents the primary decision-making guidance for planning infrastructure renewal, the Welsh Government, via the TAN 8, has also been able to shape the implementation of RE projects in areas that required little grid enhancement (a legacy of the higher network capacity created during earlier eras of fossil fuel-based industrialisation), as well as inserting projects within tracts of industrial forestry physically and socially detached from local populations. Nonetheless, as suggested above, strategic zones were also identified in mid-Wales due to their wind potential despite a lack of suitable grid connections. 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 a Westminster government more critical of onshore wind (which also stopped financial support to onshore wind energy, as discussed in previous chapters), the majority of the remaining mid-Wales wind farms were denied consent.

According to Cowell (2016), this also explains why the growing politicisation of RE in the National Assembly has tended to focus on issues of planning – ordering the relationship between RE infrastructure and other environmental values – rather than the difficulties of conceiving of how more localised control of grid networks, to facilitate the management of decentralised and intermittent RE sources, could be inserted into current arrangements. The absence of boundaries is an issue, and a contrast with Germany, for example, where grid networks were never centralised, allowing diverse ownership and control to emerge in order to facilitate decarbonisation.

To some extent, the lack of electricity network infrastructure development, at the regional level, can also render abstract policies for RE delivery. Hence, the Scottish Government has signalled consistently the importance of infrastructure renewal. This was identified in Scotland’s vision to ‘connect, transport and export Scotland’s full energy potential’ (SG 2013: 25) and in the support that the government has shown for the most significant piece of grid reinforcement, considering it essential to exploit the RE potential of northern Scotland. 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 towards RE generation during a consenting process contested by public pressure and landscape groups.

Furthermore, the Scottish Government has also played a key active role in the negotiations around grid issues at a strategic level, engaging with the UK Government, Scottish Power Transmission and Scottish Hydro Electric Transmission plans, the National Grid, and OFGEM on future network development and on the regulatory frameworks that deliver this. The Scottish Government has also played a key role in the UK-wide Electricity Networks Strategy Group to identify the scale of the need for network reinforcement across Scotland. These relationships not only allowed for the fast tracking of Scottish Power Transmission and Scottish Hydro Electric Transmission plans, including investment of £7 billion in Scotland's high voltage transmission network by 2021, as discussed earlier, but they also allowed the Scottish Government to push forward an agenda for reforms, at the 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 RE schemes more economically appealing.

Moreover, the Scottish government[220] has used Scotland's existing planning and consenting powers and functions to 'deliver a coherent and spatial approach to infrastructure development and planning, placing projects in the national interest at the forefront of our planning and consenting framework' (SG 2013: 25). The first National Planning Framework in 2004 already contained a section on energy infrastructure (Ritchie et al. 2013). Although electricity renewal was not considered a prominent item in this first planning document, subsequent versions showed evidence of a significant role for mapping national territorial development, providing political visibility and steering the renewal of electricity infrastructure (Ritchie et al. 2013). Hence, this created a presumption in favour of securing adequate network connection for areas that were identified by planning authorities as preferred areas for RE development.

[220] Section 37 of the Electricity Act requires that, with the exception of certain specific examples, all electricity lines exceeding 20kV will require consent to be granted by the Scottish Ministers. Section 57 of the Town & Country Planning (Scotland) Act 1997, amended by The Planning Etc (Scotland) Act 2006 suggest that planning permission can also be granted in the case of development with government authorisation.

8.5 Concluding remarks

I 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 (for transmission and distribution of electricity) and how this might influence deployment processes in RE. The discussion presented above has shown that as RE capacity has increased, the current infrastructure (e.g. grid connections, substations, electricity distribution and transmission lines), in the regions under investigation, has presented a number of constraints. I have shown that infrastructure renewal is a complex process. It involves several actors - the regulators, transmission and distribution operators, generating companies, and governments at different levels - and institutions. Given that the electricity network infrastructure is a natural monopoly, infrastructure renewal is affected by regulation of prices and capital and market mechanisms. The national level has played an important role in influencing infrastructure renewal in both countries and there is not much evidence that the regions under consideration have the political legitimacy to exercise control over grid regulation or the financial resources governed through it. However, as I have highlighted, connecting RE sources to the existing electricity transmission and distribution networks has required both the construction of new lines and the upgrading of current networks, questioning the relevance of the regions in steering infrastructure requirements, including planning approvals. As shown, infrastructure challenges have been felt differently across the case study regions and some of the regions studied have had the capacity to establish relationships with those who own the electricity network infrastructure, operate it, and regulate it helping to shape infrastructure network renewals and reduce the constraints on RE deployment.

Chapter 9

The value of understanding the material dimensions of RE and their influence in explaining regional spatial variation in RE deployment: Concluding remarks, reflections and issues for further research

Summary

This chapter concludes the thesis and summarises the journey undertaken during this research. The chapter reviews explicitly whether the aims and objectives of this research have been realised, highlighting the value of understanding the material dimensions of RE and its influence in the study of RE deployment. The chapter summarises the empirical evidence provided in chapters 6, 7 and 8 and argues that the framework has been useful to explain the spatially uneven processes of renewable energy deployment at the regional level in Italy and the UK. The chapter suggests how the analytical and conceptual approach used in this work could be adopted for further comparative empirical investigation. Such investigation might identify similarities and differences across a range of regions, and countries, that display distinct resource endowment and institutional settings. The chapter concludes by identifying the implications for policy and areas for future research, including some of the shortcomings and limitations of the research.

9. 1 Introduction

The research has sought to contribute knowledge towards understanding the spatially uneven processes of RE deployment at the regional level. It has done this by investigating the role played by natural resource endowment and through adding the materiality lens to the analysis. Two main interrelated research phases have been carried out which comprised of, firstly, the development of an analytical and conceptual framework and, secondly, its application and testing in the regions of Apulia, Tuscany and Sardinia, in Italy, and Wales and Scotland, in the UK.

This work has set two key research questions that sought to identify the factors that could explain spatial variations in RE deployment at the regional level. The research questions set in chapter 1 were the following:

> *Q1. What influence could the material dimensions of RE exert on its spatial distribution and deployment*?
>
> > *Q1.1 What are the material dimensions of RE? and*
> >
> > *Q1.2 How might they matter?*
>
> *Q2. Could these material dimensions of RE explain regional variations in RE deployment?*
>
> > *Q2.1 How might the material dimensions of RE influence regional institutions, governance and decision making? and*
> >
> > *Q2.2 How can we study the variations of RE deployment at the regional level?*

The research, therefore, needed to address a conceptual and analytical question that aimed to identify the factors that could potentially explain regional differentiation in RE deployment. This thesis proposed a novel way of researching RE deployment by investigating the relationship between energy and materiality. The research developed an analytical and conceptual framework that in contrast to much of the literature on innovation and systems innovation (as discussed in chapter 2) foregrounds the importance and role of natural resources, investigating their implicit physical and partially socially produced nature. The framework presented in chapter 5 described the key factors and concepts that might influence RE deployment and the presumed relationships among them. I discussed the material dimensions of RE, how they matter in analysing the deployment of natural RE resources and why it is important to give them consideration, and proceeded to unpack their role in RE deployment in specific terms. Conceptually, the work showed that stressing the material dimensions of RE offers an opportunity to explain how particular RE resources come to be fashioned in some areas and not in others. I argued that the framework could help explain how the social, material, and environmental dimensions of renewable natural resources (as viable sources of energy) come to be understood and contested, favouring or hampering particular RE deployment paths. In order to demonstrate the capacity of the conceptual framework to study the uneven processes of RE deployment, I also identified a number of analytical themes that showed how the material dimension of RE could be explored (see also table 5.3).

The research used a qualitative approach, to test, empirically, the framework developed to analyse differences in RE deployment across the case study regions. The framework, therefore, fulfilled the dual aim of providing:

i) a narrative account that described the key factors and concepts to be studied and the presumed relationships among them, and

ii) a series of analytical themes, identified within a consistent framework, to allow for differences across regions to be identified empirically, with an emphasis on contrasting and capturing the influence of the material dimensions of RE at the regional level.

The empirical research, presented in chapter 6, 7, and 8, focussed on different regional settings, across two different institutional contexts. This, I argued, offered the opportunity to:

a. investigate the material dimensions of RE in regions with distinct resource endowments, institutional settings and national contexts and to ascertain how well the framework works in allowing differences in RE deployment- and material dimensions of RE – to be captured;

b. to improve the basis for generalisation and comparative learning and increase the potential applicability of the framework to further comparative empirical investigations[221].

[221] Flyvbjerg (2013) refers to this as the 'force of example' and role of 'transferability' in case study research (2013: 179).

This chapter, while reviewing explicitly whether the aims and objectives of this research have been realised, highlights the value that the research has provided by foregrounding the material dimensions of RE and their influence in the study of RE deployment. The chapter is organised as follows and how each section relates to the research questions and objectives is graphically presented in table 9.1.

In section 9.2, I illustrate how the material dimensions of RE have been fruitful in highlighting the factors that can explain regional differentiation in RE deployment by summarising the results of the empirical investigation. This shows how, and why, RE deployment has realised its potential differently across the regions under investigation, both in terms of installed capacity and the type of RE deployment. Section 9.3 discusses how the empirical material has provided evidence of the importance of the regional level in understanding energy systems transitions (in particular the greater deployment of RE). Section 9.4 summarises the contribution of the research to knowledge and, in particular, how it has sought to contribute to the literature on the geography of transitions and regional innovation systems. The thesis has also contributed new empirical evidence by investigating an international case study (the selected Italian regions) that has been under-studied in RE research. The chapter concludes by providing some recommendations for policy and directions for future research.

9.2 The factors that can help explain regional differentiation in RE deployment: the material dimensions of RE

This section summarises the findings of the empirical application and testing of the analytical and conceptual framework, reflecting on how useful this has been in illustrating the differences in regional RE deployment in the case studies investigated.

As argued, both Italy and the UK have been subject to similar pressures from European and international regulatory frameworks to promote the generation of electricity from renewables. This occurred via burden sharing targets under the EU commitments to 2020 but also via the opportunities offered in playing a leading role in supporting climate adaptation and mitigation (especially with regards to the UK). Both countries, under EU targets, were challenged to achieve a significant increase in the deployment of RE and have put in place a number of support incentives (that has varied during the years) to promote RE deployment.

Hitherto, these reflected the particular characteristics of each country's energy system (e.g. privatisation in the UK and Italy's energy fuels import dependency) but also different resource endowments (with a focus on solar and onshore wind in Italy and onshore and offshore wind in the UK). In Italy, to some extent, due to the absence of a national energy strategy and/ or a clear roadmap for RE, RE deployment occurred mainly through being driven by market forces which were aimed at exploiting resources favoured by support mechanisms that ensured high remuneration for large scale investments. In the UK, however, the overall design of RE support schemes has reflected the UK government's commitment to reducing greenhouse gas emissions while minimising government intervention in markets and seeing competition as a key element to drive costs down.

The two countries share, to varying degrees, responsibility for energy policies with regional governments and have displayed great variations in the number of RE installations, their type and distributions, which are particularly evident by region. One of the aims of this work was to show that this regional variation could be explained using the analytical and conceptual framework developed in chapter 5. Table 9.2 summarises the main regional differences (and also similarities) across the 5 regions investigated that have emerged from the consideration of the material dimensions of RE, using the analytical themes that I have proposed to organise the presentation and the discussion of the empirical material.

Table 9.1 Addressing the research questions and objectives: chapter layout

Sections	Research questions	Research objectives
9.2 The factors that can explain regional differentiation in RE deployment: the material dimensions of RE	*Q1. What influence could the material dimensions of RE exert on its spatial distribution and deployment*? *Q1.1 What are the material dimensions of RE? and* *Q1.2 How might they matter?*	- to understand how and why RE deployment realises its potential (or why it fails to realise its potential) in some regions and not others; - to identify the factors that could explain regional differentiation in RE deployment;
9.3 The role of the regional level in understanding the deployment of RE	*Q2. Could these material dimensions of RE explain regional variations in RE deployment?* *Q2.1 How might the material dimensions of RE influence regional institutions, governance and decision-making? and*	- to provide empirical evidence that the region represents an important level from which to understand the transitions to energy systems (in particular the deployment of RE)
9.4 Contributions to knowledge and to policy	*Q2. Could these material dimensions of RE explain regional variations in RE deployment?* *Q2.2 How can we study the variations of RE deployment at the regional level?*	- to develop a conceptual and analytical framework to study renewable energy deployment at the regional level; - to inform research users (policy makers, academics and firms) of the value of foregrounding the role of the material dimensions of RE and their influence, in energy transitions, particularly renewable energy deployment.

Drawing from the processes under which natural resources are transformed into potential sources of energy, via the iteration between spatial resource assessment and alternative land uses, I have shown in chapter 6 that the devices used to frame such negotiations become highly important. Moreover, while resource potential is often articulated simply by mapping the availability of, for example, average wind speeds of the required strength, assessments of natural resource (and their abundance) are often articulated into coherent vision(s) for the exploitation of indigenous renewable resources. Section 6.3 illustrated how opportunities for RE development have been incorporated into spatial planning strategies considering the relationship between the energy resource and other material factors and section 7.2 discussed the discourses and narratives for RE sources abundance and how these have been translated into more concrete agendas, opportunities, and aspirations for the regions studied. Sections 8.2 and 8.3 also 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 (for transmission and distribution of electricity) and how this might influence deployment processes in RE.

In the Italian regions investigated, it was clear that the generous support mechanisms that ensured remuneration for investments in various RE projects played an important role and that a legislative and administrative framework of rules which were uncertain and often contradictory allowed for regional variations to emerge. As shown in section 7.1 Apulia responded to the introduction of the feed-in-tariffs more promptly than the rest of the country and, particularly, the rest of the south and the islands (Sardinia and Sicily), setting up ambitious deployment policies, and facilitating and simplifying the approval and licensing system. Generous, uncapped, feed in tariffs, a vision formulated for Apulia to assume a leadership role in the RE stakes and to alter patterns of economic growth and a desire to support RE development rather than the re-introduction of nuclear capacity in Italy-supported RE deployment, especially for large scale projects. Furthermore, a declining agricultural sector based on wheat cultivation has provided further opportunities for RE deployment. Nevertheless, the very rapid development of electricity production capacity from renewable sources created significant congestion problems, emphasising the limited capacity of regional governance to steer network upgrades and the difficulties of reconciling the exploitation of potential RE resources with infrastructure requirements.

Neither Tuscany nor Sardinia have been able to exploit their regional renewable resource endowments in the same way as Apulia. Sections 6.3.1, 7.2 and 7.3 showed that Tuscany, with higher RE capacities, such as geothermal and hydro resources, already deployed and characterised by landscape discourses that are an integral part of the regional ‘fabric’, managed to limit and constrain large scale deployment. RE development and deployment in the region is promoted following an industrial strategy that seeks to strengthen the interaction between local companies and research organisations, knowledge and technology transfer processes, and network relations in the RE sector. The example of Sardinia also illustrates several issues. These refer to the peculiarity of the energy system in the island (discussed in section 7.3.2), which is devoid of natural gas and has a limited electricity transmission and distribution infrastructure. These to some extent, together with the lack of a critical mass of actors, in particular firms in the RE innovation systems, have mobilised the attention of policy actors, shaping and constraining RE deployment opportunities.

Interestingly, targets in the Italian regions investigated (Section 6.2.1), were not seen as a specific instrument for evaluating, planning, and consenting of RE deployment initiatives. In other words, in the Italian cases, the co-evolution between resource assessments and efforts to promote and pave the way for development opportunities, in which figures for ‘resource potential’ play a key role, has been less evident. To some extent, the Apulia region represents an exception to this. While the framework argued that targets can be seen as important drivers of uptake, there are differences in the way regions utilise this tool. In Italy, it has been shown that RE targets lost their relevance, as they were achieved very early in the process. Besides, the need for Italian regions to contribute towards the national targets via a principle of burden sharing and the delay in the development of a methodology for its calculation left the regions to define their own targets or they were left waiting to comply with national regulations.

This is in contrast with the role that targets have played in the UK, in Scotland and Wales. As shown in section 6.2.2, in Wales and Scotland targets setting has been a key feature, and a policy output, of devolution, providing an important act of differentiation from Westminster. Together with targets, land use planning and energy consenting have been critical for both Scotland and Wales in shaping RE deployment as these areas have offered much scope for autonomous policy development. Nevertheless, differences in planning responsibilities and authority attributed to the two devolved administrations have partly influenced RE deployment outcomes. Furthermore, there have been differences in the way RE deployment has been mobilised at the regional level. In Scotland, as discussed in Section 7.2.2, the post-

1998 Scottish independence debates offered an example of the relevance of the imagery and visions associated with natural resources' exploitation. This created many opportunities for RE deployment paths. Accordingly, a vision(s) for RE deployment became part of a much stronger drive towards Scottish independence and the debate associated with it. These opportunities related, to some extent, to the gaining of further control over energy policy and the pursuit of RE priorities, building on the identified abundance of natural resources in Scotland.

In Wales, however, there has been a relative tentativeness to the RE 'vision(s)' – with targets expressed as 'aspirations' based on resource assessments and assumptions about projects in the pipeline. Here again, targets did not significantly drive policy action. The potential for steering RE deployment was critically dependent on the opportunities offered by the planning policy sphere and, considering the low rate of RE uptake, its subsequent modification, as discussed in Section 6.2.2. However, the strategy also floundered, in part, because of its failure to incorporate adequately grid capacity or – more accurately – to fully appreciate how it might act as a constraint in Wales (Section 8.3.1).

The empirical evidence shows how the materialities of RE sources have affected regional RE uptake, demonstrating the insights that arise from addressing the socio-material dimensions of RE sources. The thesis has shown how resource potential and capacity interact with the actors and the contextual conditions in which the resources are developed and deployed. These processes challenge current land-based resource use and interact with established infrastructure networks, creating opportunities and barriers at the regional level. I now turn to discuss the role that regions play as spaces that bring together the material with socio-cultural, economic, and political configurations and resources in powerful ways. Hence I discuss and illustrate what this research says about the importance of regions, and the regional level, in understanding RE deployment.

9.3 The role of the regional level in understanding the deployment of RE

This thesis has singled out the region as an important spatial scale at which materiality and scale coalesce in ways that significantly affect the selection and deployment of RE technologies and their consequences. In the investigated regions, a high proportion of RE resource potential is situated within the territory of Scotland and Wales, in the UK, and in the south and the islands, in Italy. Moreover, the case study regions (and their regional governments) have also had varied powers to mediate the exploitation of RE versus other resources. The research has illustrated how the regions have sought to organise the relationship between the energy resource and other material factors, reflecting the capacities and willingness of a number of regional actors to act to promote RE deployment and to render land available for RE development, at the same time constructing opportunities for, and sometimes raising barriers against, RE development.

This thesis has confirmed that there is an element of geographical contingency (at the regional level) in the location of the resources and their 'availability', in the regions investigated, which support the contention that the material dimensions of RE are highly context specific and coalesce at the regional level. However, the framework proposed also allows us to capture how the regions investigated sit within broader energy policy governance structures that encompass the regional level. The research has revealed the complexity of governance arrangements for RE but also the uncertainties and blurring in the allocation of competences, between the regional and national levels.

Firstly, the case study regions benefitted from a nation-wide pool of market support to promote RE deployment. Certainly, this support was utilised, at the regional level, to mobilise different narratives around the opportunities offered by RE deployment. These involved the promotion of clustering activities to foster economic development and innovation within their territory, where some regions have seen RE deployment as an opportunity to promote networking and knowledge transfer across the many actors involved, while others have mobilised RE deployment as an opportunity to foster regional identity and independence. Nevertheless, in Italy, for instance, the financial and economic support available for RE has been applied consistently across the country and this had an important role to play in RE deployment in all Italian regions, even the least insolated areas of northern Italy (cf. Antonelli and Desideri, 2014).

Table 9.2 Material dimensions for RE deployment in the regions under investigation: A summary of differences and similarities

Socio-material dimensions	RE sources as potentially deployable sources of energy, their appraisal and their interactions with current land-based resource use	Discourses, narratives and visions for renewable energy deployment	Physical characteristics and built infrastructure requirements for RE deployment
Analytical themes and regional differences	<u>Targets and resource assessment:</u> *Tuscany: targets to 2020 could be achieved with geothermal alone.* *Apulia: in 2006 there was little RE and Apulia is the only region without hydroelectric power.* *Sardinia: was late in preparing and publishing its PEAR which established regional policy objectives and targets, causing investment to start later than in the rest of Italy; potential opportunities are still untapped.* *Wales: Targets expressed in terms of aspiration based on resource assessments and assumptions about projects in the pipeline.* *Scotland: The importance of targets achievement as an 'upward spiral of credibility'.* <u>Planning for RE and potential and different values of environmental attributes when compared against RE targets</u> *Tuscany: has a low carbon economic agenda to harness local natural resources and emphasises the need to protect the importance of the region's significant historical, cultural and artistic characteristics.* *Apulia: Adopted a fast-track approval system and a simplified licensing system that helped streamline the*	<u>Imaginaries and vision for RE development</u> *Apulia: the abundance of natural resources offers a potential means to overcome the current patterns of uneven development.* *Tuscany: RE presented with a narrative that promotes the opportunities for the region to capitalise on its rich research expertise and to stimulate networking and technology transfer activities among the local research institutes (public and private) and the small and medium firm base.* *Sardinia: regional priorities expressed in terms of the need to strengthen energy transmission and distribution infrastructure and the lack of gas.* *Wales: tentativeness to the 'visions' for RE, conflicting messages about future priorities and lack of strategic vision.* *Scotland: Scottish independence as an opportunity to gain control over energy and to pursue RE priorities due to the abundance of natural resources.*	<u>Infrastructure requirements</u> *Apulia: has a more evident congestion problem than Tuscany, in the places where most of the plant installations are concentrated and where the network has a more limited transport and distribution capacity (reliance on 150KV lines) - 12 major infrastructural interventions are planned in Apulia alone.* *Tuscany: infrastructure requirements are less evident and governed under the principle of harmonization of territorial planning for the protection of the landscape.* *Sardinia: Peculiarity of energy transmission and distribution networks limits RE potential* *Wales: Areas in mid Wales were also identified in the SSAS due to their wind potential despite the lack of suitable grid connections. This generated a surge of applications that precipitated in plans for a major 400 Kv grid line.* *Scotland: excess generation capacity and its transfer to areas of high demand*

	authorisation process for the planning and approval of RE projects and their installation. *Sardinia: the 'moratorium' and increased uncertainty that delayed the realisation and authorisation of new plants.* *Wales: The role of the TAN 8 to increase the number of favourable locations for RE deployment (especially wind); characterised up until recently by limited powers to influence large projects;* *Scotland: Central decision- making for on shore generation over 50 MW and importance of Scottish Government in steering RE consent approval* Availability of land/ current land-based values *Apulia: the large agricultural sector as land reservoir and the region is less constrained in terms of the landscape'* *Tuscany: places significant value on the environmental (as well as the economic and recreational) potential of the alternative use of land.* *Sardinia: characterised by livestock farming and family ownership; the characteristic of ownership represents a barrier to entry to the agriculture sector potentially limiting RE.* *Wales: importance of Natural Resources Wales as the biggest landowner in Wales with its estate overlapping with the SSAs.* *Scotland: availability of large areas of land for development dominated by small number of private ownership.*	How RE are represented vis-à-vis alternative energy sources *Apulia: opposition to new nuclear and rejecting nuclear power siting in the region.* *Tuscany: the role of geothermal energy is currently dominant, and tend to limit further investment in wind and solar.* *Sardinia: Attention to methanisation of Sardinia and the 'Galsi' project to provide the main solution to the national energy security problem.* *Wales: to identify all energy developments (including fossil fuels and new nuclear) in terms of their investment opportunities and employment benefits.* *Scotland: own preference for RE over nuclear providing a compelling narrative for promoting RE expansion*	*adding to a network already operating at a maximum capacity.* Formal regulatory powers and political legitimacy to shape infrastructure networks *Apulia: congestion problems emphasise the problem of regional governance to steer network upgrade and to take up the opportunities offered by concerted action between the national and regional levels.* *Apulia and Sardinia: act as a test-bed for innovative solutions to network problems.* *Sardinia: priority to interconnect the island with Italy mainland (SAPEI) and Corsica (SARCO).* *Wales: the grid network in Wales reflects agenda of integration and centralisation. It ignores the Welsh border, treating Welsh territory as an integrated sphere of UK space.* *Scotland: Scottish Governments signalled constantly the importance of grid reinforcement and participation in key infrastructure actor-networks to facilitate infrastructure renewal*

In contrast, Scotland was able to control some market support mechanisms. Although these, as argued, have not been overly relevant in shaping the overall volumes of RE deployed in the territory, they signalled Scotland's influence over national energy policy. Nevertheless, at the point at which, the UK national government changed the market support mechanisms (with the implementation of the CfDs together with the withdrawal of support for onshore wind) Scotland saw its power to control the market support mechanisms for the resources it deploys reduced. This shows that the regional autonomy from national governments and capacity to exercise influence over energy issues is not only limited but can also change over time.

Secondly, while the regions investigated have sought to promote ambitious RE objectives, the research has shown that there are gaps between rhetoric and outcomes. The attention to the socio-material dimensions of RE has allowed the research to illustrate that these gaps are also determined by the lack, at the regional level, of competences and capacity to influence energy issues within the regional borders. In Italy, for instance, although the constitutional reform in the early 2000s provided a new framework for sharing regulatory competences between the State and the regions, a lack of clear and certain legislative and administrative frameworks affected the capacity and willingness of regional governments to influence RE deployment. Regulatory competences therefore have become less centralised, granting the regional level the capability to determine and influence changes in energy systems (via RE deployment). However, the urgency and need to intensify the mobilisation of RE sources, due to their perceived role as a 'public utility', has required the Italian national government to strengthen their levers, which has undermined the regional autonomy in approving RE deployment (e.g. as seen in terms of the provision of the Linee Guida and the reduction in time of the authorisation procedures).

In the UK, both Scotland and Wales have used land use planning arenas to steer RE deployment. Yet again, conflicts between the national and regional levels around planning responsibilities in Wales highlighted the trade-off between the need to enable greater territorial coherence in energy governance (e.g. with further devolution of consenting power to Wales) and the problems of achieving other national objectives (e.g. energy security and the achievement of overall national targets).

Thirdly, as demonstrated, the capacity of the regional level to influence the electricity transmission and distribution networks becomes especially important as RE uptake increases. The research has stressed that infrastructure renewal is a complex process. It involves several actors - the regulators, transmission and distribution operators, generating companies, and governments at different levels, as well as the public and institutions. In steering infrastructure renewal, the national level has played an important role and the regions investigated do not have the political legitimacy to exercise control over grid regulation or the financial resources governed through it. Nevertheless, three of the regions studied (Apulia, Sardinia and Scotland) have had the capacity to establish relationships with those who own the electricity network infrastructure, operate it, and regulate it, helping to shape infrastructure networks renewal and reduce the constraints on RE deployment in their territory. Importantly, the support for renewables at the 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 thesis, while focusing on the regional level, has shown that the scale at which RE deployment is investigated matters. Regions represent an important level at which to unpack the way in which natural renewable resources for energy are socially and materially produced in geographically uneven ways. As suggested, they can play an important role in influencing and shaping RE deployment. Nonetheless, the work has confirmed that careful attention needs to be paid to whether sufficient and appropriate levers are available for the regions to do so, and to stress the influence that policies formulated at other levels, or in other policy domains, exert on them.

This section has discussed the role that regions play as spaces that bring together the material with socio-cultural, economic, and political configurations and resources. The next section discusses the direct contributions that this research offers to the literatures of sustainability transitions and some insights on the role that more focussed attention to the material dimensions of RE can play in policy.

9.4 Contributions to knowledge and to policy

This research has sought to inform a debate on the value of foregrounding the material dimensions of RE and their influence on energy transitions, particularly RE deployment. In the next sub-sections, I discuss the contribution of the research to academic knowledge, and in particular to the GOST and RISs literature and also discuss the contribution of the research to policy development. This is done while reflecting on the way regions could best align their strategies and governance in order to maximise their RE potential, highlighting the key features of the case study regions that have allowed for distinguishing characteristics to emerge.

9.4.1 Contribution to academic knowledge: the GOST and RIS literatures

As argued in chapter 1, this work wished to address specific gaps in knowledge, contributing to the GOST that seeks to bring a spatial sensitivity to the study of transitions in energy systems. I have argued that despite meaningful contributions, the GOST literature has lacked sufficient appreciation of the regional context. The complementarity with the RISs approach has stressed the purposeful action of policy actors, at the regional level, in influencing institutional conditions via processes of regional policy-making and the way in which institutions adopt a place-distinctiveness that can influence the potential to develop regional economic activity. Nevertheless, in order to analyse the spatially uneven processes of RE deployment there is also a need to focus attention on the potential offered by natural resource endowments. I do this by proposing a novel analytical and conceptual framework that foreground the role of the material dimensions of RE, that emerge from looking at natural resources as an interaction between the physical qualities and social institutions. The empirical material has also offered an opportunity to reflect on how the framework can enrich our understanding of the spatial patterning, distribution, and dynamics of RE deployment processes.

Moreover, I argue that this work can directly contribute knowledge to these two literatures. Chapter 2 acknowledged that the ST and, more specifically, the GOST literature already identify the important role of the national and international institutional frameworks and their interaction with regional and local institutions. Yet these approaches too often consider localised institutions as a residual category, stating their importance but without revealing the nature of these institutions. Hence, this research has been valuable in identifying the type of localised institutions that influence RE deployment. As suggested, investigating the material dimensions of RE brings to the fore a constellation of institutional and regulative settings that have received less attention in studies of RE deployment. These refer to, in particular, spatial planning and land use regulation, regulatory infrastructure institutions, and culture and identity that can provide meaning to particular areas. The material dimensions of RE have shown that these, together with economic regulatory conditions, can also influence RE deployment and help explain its spatial variation.

In this respect, the framework can also contribute to recent research in the RISs approach. Some authors argue that there is a need to add analytical clarity between institutions and organisations (Zukauskaite et al. 2017) in RISs studies, as this can help specify the factors that can hamper regional development. In the empirical applications of the RISs approach, institutions, rather than being identified in terms of the institutional environment (the rules, laws and regulations, and norms and values), are often collated with organisations (such as research bodies, governments, and venture capital organisations) (Farole et al. 2011). Mapping institutions and organisations as separate entities, it is argued, would provide a more precise analysis of the factors underpinning regional development (e.g. inappropriate or contradicting institutions). The work conducted here, therefore, provides some evidence of how the identification of the institutions that are relevant for RE deployment have provided a more fine-grained analysis of the factors underpinning the regional influence in the spatially uneven processes of RE deployment.

9.4.2 Contribution to Policy development

In terms of policy, meeting the challenge of a secure, affordable, and environmentally sustainable energy mix while continuing to tackle climate change will require that countries remain committed to ambitious low-carbon energy targets. The research has shown that the achievement of higher-level targets will depend significantly upon the successful and rapid implementation of projects at sub-national levels, such as regions and their cities. These are the levels at which decisions about investments in, and the siting of, RE power schemes are crucial. This is also the level at which innovation can occur and objectives other than climate change, such as employment creation, may be achieved (Wolsink 2007; Balta-Ozkan et al. 2015).

This research has shown the influence on RE deployment processes that natural resources can exert, through their physical properties, their geographical recurrence and their symbolic and discursive values. This, as discussed in Chapter 1 (section 1.2) and Chapter 2 (section 2.4) has been insufficiently captured in the innovation and policy literature linked to RE. Understanding the material aspects of RE offers opportunities to unpack how specific RE resources become realised in some areas and regions and not in others. This can also provide useful insights into the spatial unevenness and variation of RE deployment at the regional/local levels and what can be done in policy terms to redress this unevenness.

Hitherto, the framework presented in this thesis has highlighted a number of factors – often in combination – that might influence RE deployment. Given the complex and dynamic nature of how these factors interact, for example how they evolve over time and the wider scalar/ political context (e.g. how different interests dominate at different levels, how issues are interpreted using different rationalities and the role of actors and agency at different spatial scales), there is a danger of over-simplifying the complexity of RE deployment in policy discussions. Nevertheless, the framework has highlighted a number of key features of the case study regions that allow for distinguishing characteristics to emerge and shows the way in which some regions (for example Apulia in Italy and Scotland in the UK) have managed to successfully align their strategies and governance in order to maximise their RE potential. These factors are displayed in Table 9.3 that shows the key features that have influenced RE deployment in the regions investigated. Within Apulia and Scotland, a number of driving factors have contributed to a successful implementation of RE at the regional level. These features include:

- the ways in which targets and resource availability have been seen as driver for RE deployment;
- the degree of political autonomy in planning and the capacity to facilitate consenting processes at sub-regional levels;

- the political will for RE expansion, elite consensus and the presence of relevant industry actors, together with a compelling narrative against nuclear energy;

- the participation and involvement in infrastructure renewal, despite the lack of formal regulatory powers and political legitimacy to shape energy infrastructure.

The research shows that, at the regional level, these features have influenced regional RE uptake but they can combine in different ways, depending on the peculiarities and specificities of the context in which RE projects emerge. It is important therefore that policy makers are aware of these drivers for RE deployment but also that, in their policy development, they accept the diversity and context-specificity of regions, rather than designing policy on the basis of 'one size fits all' tools.

Furthermore, the framework presented has been successful in highlighting the complex governance structure of RE deployment processes. As already stressed in Section 9.3 in this chapter, regions do not always have sufficient and appropriate levers to maximise their RE potential, suggesting that a number of issues have influenced regional agency. These include: i) regulatory power over infrastructure and market orientations that manifest themselves at the national level and ii) the role and influence of the local levels of governance in providing administrative functions (their role, for instance, in planning and consenting). Interestingly, as shown, regional political commitment has often been able to overcome such problems, via establishing relationships with network operators and local authorities/ province and municipalities that enhance coordination at different spatial levels and facilitate RE deployment. Similarly, the research has shown that as well as the lack of clarity or the 'tentativeness' of regional visions, regulatory and policy uncertainty can act as institutional and administrative barriers. These are certainly important policy issues that need considering for the effective deployment of RE.

A further strength of the analytical approach presented here is that it can be applied to inform RE policy thinking and decision making in ways that can help practitioners, developers and policy users to appraise resources and select, develop and more effectively deploy RE technologies (including wind, marine, hydro, geothermal, solar and bioenergy), highlighting the criticality of the electricity infrastructure networks at the regional level.

Table 9.3 Key features that influenced RE deployment in the regions investigated*

Derived from the AF	Apulia	Tuscany	Sardinia	Scotland	Wales
Targets and resource availability:					
Targets and resource availability as driver for RE	XXX	X	X	XXX	XX
Planning and land use:					
Distribution of power in planning	XX	XX	XX	XXX	X
Facilitation of consenting processes	XXX	X	X	X	X
Land ownership and availability (e.g. land reservoir')	XXX	X	X	XXX	X
Visions:					
Political will for RE expansion	XXX	X	X	XXX	XX
Elite consensus and presence of actors	XXX	XX	X	XXX	X
RE vis-à-vis alternative sources	XXX	XX	X	XXX	X
Infrastructure:					
Current infrastructure endowment	X	XX	X	XX	X
Power & legitimacy	X	X	X	X	X
Participation and involvement in infrastructure renewal	XXX	XX	X	XXX	X

*The number of Xs represents the extent to which each feature was present and influenced RE deployment in each region as derived from the case study research. For instance, one X denotes that although the feature is present, it has shown little impact on the deployment of RE, whereas three Xs (XXX) shows that this feature has played a leading role in influencing RE deployment in the region. Two Xs ((XX) indicates that while the feature is significant, it is not a key driver of RE deployment.

It could also complement several of the solutions that have already been deployed at the local authority level to scope out the potential for, evaluation of, and selection of RE resources. This can then lead to more effective appraisal, support, and delivery of RE projects and the required transformation of local energy infrastructure (such as for example the development of local area energy strategies using Energy Path Networks developed by the Energy Systems Catapult and ETI, implemented in the UK in Greater Manchester, Newcastle and Bridgend Local Authority). The framework developed in this thesis is useful as it could provide a way of moving beyond technical decision-support tools through integrating technical understanding (e.g. resource potential, infrastructure etc.) with social actors and their different interests in supporting RE deployment.

9.5 Limitations and Areas for further research

A key aim of this research was to demonstrate that giving careful attention to the material dimensions of RE can add to the analysis of the spatially uneven processes of RE deployment at the regional level. In doing so, I have provided new empirical evidence on how regions and regional governments are acting on RE deployment and with what effects (e.g. in terms of the outcomes and the governance structure). As shown, the regional level is an increasingly important scale to understand RE deployment processes. However, regions need to be investigated within broader governance structures in order to understand the different power relationships between various levels of governments that are influencing and shaping RE deployment.

Four issues might usefully be addressed by future research, which also highlights some limitations of this work. Firstly, the research has offered a conceptual and empirical frame under which the issues of materiality can be explored. These are identified in an attempt to capture how RE processes are shaped by a constellation of interacting actors, institutional and regulative settings, and the materiality of renewable natural resources. I suggest that this heuristic approach has not only been valuable in helping to explain spatial differences in Italy and the UK but could be adopted for further comparative empirical investigations. Such investigations might identify similarities and differences across a range of regions and countries that display distinct resource endowments and institutional settings. This will also help to further validate and refine the conceptual framework through additional testing, which will address a potential limitation around the relatively small number of case studies included here. This is enhanced by the fact that during this research the analytical and conceptual framework was published as part of a peer reviewed paper for a special issue on 'Energy Geographies' in the Journal of Energy and Social Science Research (De Laurentis and Pearson 2018) which will also potentially provoke further research in additional countries and regions. This should also demonstrate the wider applicability of the framework.

Secondly, to understand spatial variations, I have focused the analysis on the regional level. As discussed, although regions in Italy and in the UK have little influence on the level of economic incentives for RE (with the exception of Scotland), they share some responsibility that can affect energy policy within the national governments. They have also been able to influence RE deployment to accommodate regional material differences influencing the pace, scale, and outcome of RE deployment. The thesis has shown that 'regional governments' in the regions investigated have exercised the powers to mediate exploitation of RE versus other resources, adding geographical contingency to resource 'availability'. Moreover, infrastructures for transmission and distribution have mediated the extent to which regions are bounded spaces for organising the terms of exploitation. The scale at which RE deployment is investigated matters, therefore, and will depend on the nature of the source and associated technologies rather than on any single scale for all renewables (see also Smil (2017b, 2017a) and Stremke and Koh (2010)).

Nevertheless, the thesis shows that it is useful to further investigate the role of regions. Regions are seen as spaces that bring together the material with socio-cultural, economic, and political configurations and resources in powerful ways, especially as RE – perhaps more than fossil or nuclear fuel cycles – today often seems to dangle the prospect of greater autonomy and control over energy futures for regions. What the research has helped to illustrate with empirical evidence is that different configurations of institutions, renewable energy resources endowment and their material dimensions influence the governance choices made and the changes that can take place in the energy systems (cf. Kuzemko et al. 2016). Furthermore, recent research shows that by studying energy systems at the sub-national level, one can begin to understand how and why governance, policy-making and infrastructure arrangements vary and how, these can shape future energy pathways (Goldthau 2014; Cox et al. 2016; Kuzemko et al. 2016; Cowell et al. 2017).

Thirdly, this research aimed to investigate and highlight the various components of the institutional make-up that influence RE deployment. As suggested, the approach followed has remained rooted within the RISs studies and, in that literature, institutions are used as a point of entry from which to investigate certain aspects of processes of economic development (cf. Cumbers et al. 2003). The intention therefore was neither to draw explicitly on the institutional theory literature for understanding processes of RE nor to conduct institutional analysis. Yet, many scholars from the ST literature have successfully examined institutional theory literature to better understand the processes of niche-regime interaction and the structuration of socio-technical regimes (see for instance Fuenfschilling and Truffer (2014); Smink et al. (2015); Andrews-Speed (2016); Pearson and Arapostathis (2017)). These attempts are welcome and could provide a further area to explore the importance of local institutions on RE processes.

Last, but not least, this thesis has offered insights from work on materiality, spanning the literature of resource geographies and non-renewable resources that has investigated the similarities between the complex materialities of non-renewable resources and renewable natural resources. Although I have suggested several differences between the materialities of fossil and RE resources, and it has been suggested that fossil fuels have some stronger material aspects than solar and wind energy, further research would develop a greater understanding of the nature and implications of the differences between them.

This research offers an addition to previous research that aims to investigate the spatial unevenness of RE deployment processes. I hope that, following the useful suggestions by Bridge et al. (2013) and Calvert (2015), scholars and analysts of energy transitions, especially those engaged in understanding the role of geographical processes in energy systems, might find it useful to reflect further on the influences that materiality can exert on the uneven processes of RE diffusion and deployment.

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Appendix 1

Topic Guide for Participants

Part 1 Understand how the regional actors perceive specific pressures, policy targets and energy development in the region

The first set of issues will focus upon regional responses to pressures, targets and existing constraints on RE development and deployment

1. What do you think are the driving forces in RE development/ deployment in the region?
2. What are the main activities (projects, experiments and initiatives) that are taking place in the region?
3. What are the main motivations behind RE deployment in the region?

Part 2 Understand the role of natural resources in the region:

The focus here is upon regional natural resources and RE development

4. What, in your opinion, are the most important renewable resources in the region?
5. What do you think are the potential opportunities for renewable energy based on resource availability within the region?
6. What are your general opinions about the role that the abundance of particular natural resources plays in mobilising discourses and narratives around renewable energy?
7. What role do the national or regional governments play in identifying suitable locations for RE development? And what are the problems/ benefits of this?
8. Who, do you think, are the main actors involved (and excluded) in identifying suitable locations for RE developments? And Why?

Part 3 Understand how the policy is perceived and what scale is important for energy development in the region

These set of issues will focus upon multi-level governance of renewable energy development and innovation support

9. Who is driving RE development and deployment in the region?
10. What role do RE targets play?
11. At what level do these manifest themselves (e.g. European, national, regional targets)?

12. What are the key policy drivers at international, national, regional and local levels?
13. Which one of these, do you think, is the most influential for RE development in the region?
14. What do you think are the strengths and weaknesses of policy promoting RE in the region?

Part 4 Understand what are the problems that hamper RE development and deployment in the region

15. What are the main barriers faced by the different actors involved in RE development/ deployment in the region?
16. What role has the established infrastructure for energy transmission and distribution played in RE development/ deployment?
17. Has this limited the uptake of RE?
18. In your opinion, what else could be done to get over the barriers to RE development/ deployment in the region?
19. What do you expect to happen in your region in the short and medium to long-term future?