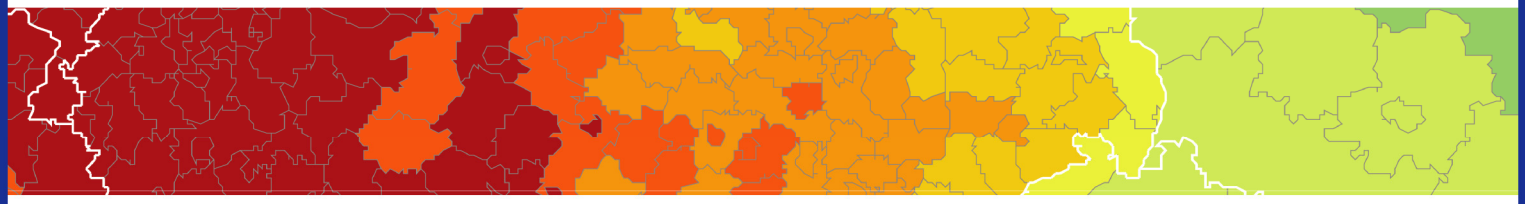
ESPON

EUROPEAN UNION

Co-financed by the European Regional Development Fund

Inspire policy making by territorial evidence



Territories and low-carbon economy (ESPON Locate)

Applied Research

Final Report

Version 14/03/2018

This applied research activity is conducted within the framework of the ESPON 2020 Cooperation Programme, partly financed by the European Regional Development Fund.

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

This delivery does not necessarily reflect the opinion of the members of the ESPON 2020 Monitoring Committee.

Authors
Christof Schremmer, Martyna Derszniak-Noirjean, Florian Keringer, Raffael Koscher, Michael Leiner, Ursula Mollay, Edith Stifter, Joanne Tordy ÖIR GmbH (Austria)
Lukas Kranzl, Mostafa Fallahnejad, Lukas Liebmann, Andreas Müller, Gustav Resch, TU Wien, Energy Economics Group (Austria)
Jan Steinbach, Rainer Elsland, André Kühn, Frederik Mayer, Martin Pudlik, Gerda Schubert, Fraunhofer ISI (Germany)
Simin Davoudi, Paul Cowie, Paola Gazzola, University of Newcastle, Global Urban Research Unit (United Kingdom)

Advisory Group
Project Support Team: Domenico Gaudioso, ISPRA – Institute for Environmental Protection and Research (Italy), Anneloes Van Noordt, Spatial Development Department Flanders (Belgium)
ESPON EGTC: Michaela Gensheimer (Senior Project Expert, Cluster Coordinator for Project Development and Coordination), Laurent Frideres (HoU E&O), Ilona Raugze (Director), Piera Petruzzi (Senior Project Expert, Communication and Capitalisation), Caroline Clause (Senior Office Administrator, Financial Officer)

Acknowledgements to case study authors
Cristina López Ubierna, Burgos Provincial Energy Agency, AGENBUR (Spain), case study Burgos
Angreine Kewo, Per Sieverts Nielsen, DTU (Denmark), case study Greater Copenhagen
Ruth Machen, Simin Davoudi, Paul Cowie, Paola Gazzola, Global Urban Research Unit, University of Newcastle (United Kingdom), case study Greater Manchester
Albena Nenova, Georgi Simeonov, Regional Energy Agency of Pazardjik (Bulgaria), case study Pazardzhik
Michael Leiner, Ursula Mollay, Joanne Tordy, ÖIR GmbH (Austria), case study Rheintal

Boštjan Krajnc, Niko Natek, Nejc Jurko, Lidija Stvarnik, Energy Agency of Savinjska, Šaleška and Koroška Region (Slovenia), report on the situation of energy data collection in Balkan countries

Information on ESPON and its projects can be found on www.espon.eu.

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This delivery exists only in an electronic version.

Contact: info@espon.eu

Territories and low-carbon economy (ESPON Locate)

Table of contents

List of Figures

List of Maps

List of Tables

Abbreviations

BEE	Biomass Energy Europe
CEP	Central Europe Programme
CF	Cohesion Fund
DG ENER	European Commission's Directorate-General for Energy
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
EEA	European Environment Agency
EMFF	European Maritime and Fisheries Fund
ENPI/ENI	European Neighbourhood and Partnership Instrument/European Neighbourhood Instrument
ERDF	European Regional Development Fund
ESI funds	European Structural and Investment Funds
EU	European Union
EU-28	European Union's 28 Member States
EUROSTAT	Statistical office of the European Union
FEDARENE	European Federation of Agencies and Regions for Energy and the Environment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMCA	Greater Manchester Combined Authority
GW	Gigawatt
IEE	Intelligent Energy Europe Program
Interreg	Community initiative aiming at stimulating interregional cooperation
IPA	Instrument for Pre-accession Assistance
IPCC	Intergovernmental Panel on Climate Change (UN Climate Panel)
ISI	(Fraunhofer) Institute for Systems and Innovation research
ktoe	kilotonne of oil equivalent
LCE	Low Carbon Economy
LULUCF	Land Use, Land Use Change and Forestry
MENA	Middle East & North Africa
MMR	Monitoring Mechanism Regulation
MS	Member State
MW	Megawatt
MW, MWh	Megawatt, Megawatt hour
NGO	Non-Governmental Organisation
NUTS	Nomenclature des Unites Territoriales, nomenclature of territorial units for statistics
PaM	Policies and Measures
PV	Photovoltaic
RAI	Regional Authority Index
RES	Renewable Energy Source
S3PEnergy	The Smart Specialisation Platform on Energy
SET-Plan	Strategic Energy Technology Plan
SETIS	Strategic Energy Technologies Information System
SSP	Smart Specialisation Process
TO	Thematic Objective
ToR	Terms of Reference
TU Wien	Technical University Vienna
TW, TWh	Terawatt, Terawatt hour
UK	United Kingdom
UN	United Nations

Executive summary

Making full use of European region's low-carbon potential needs considering regional prerequisites, combining forces and aligning governance-levels

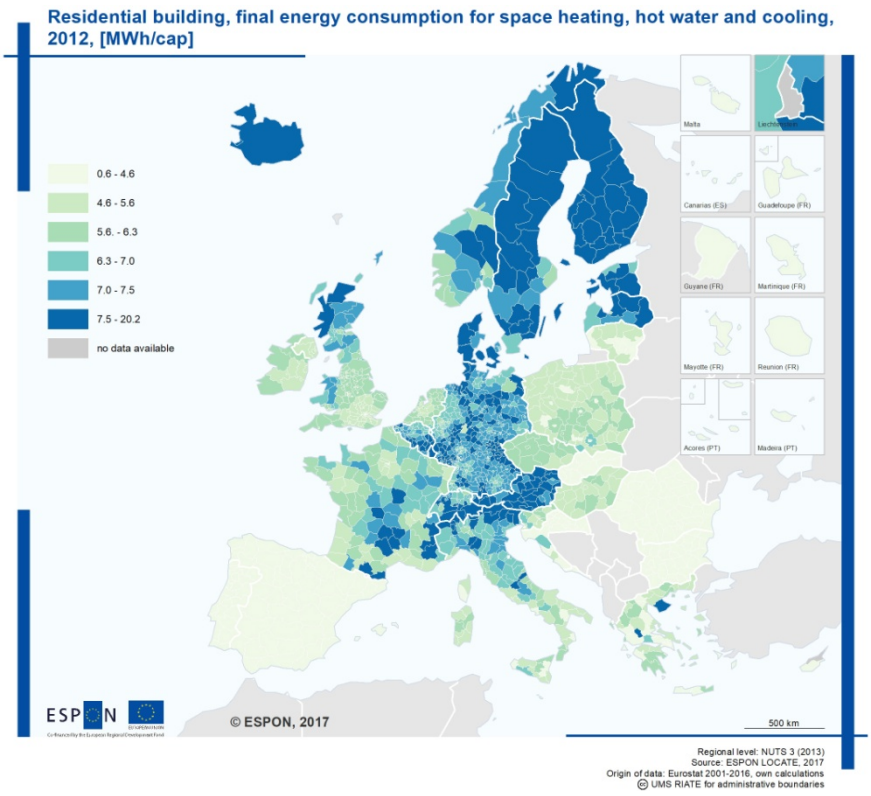
The project "Territories and low-carbon economy" demonstrates that unleashing regional low-carbon potential needs strategies making use of specific regional strengths and involving the regions´ stakeholder networks. In order to support such regional-level policy making, national framework conditions, EU directives and EU Cohesion Policy need to be designed in a way to better allow regions to use their potentials in the two main development strands, increasing energy efficiency and the production (plus distribution) of renewable energies.

Scope of the project

The project seeks to investigate the territorial dimension of the transition to a low-carbon economy. The project uses a more detailed methodology, specifically conducting the analysis at NUTS 3 level. Using a quantitative approach, the research focuses on energy consumption patterns and the potential to produce (and use) renewable energy sources. Energy-relevant regional policy competencies and regional level interaction with national and EU levels of legislation and policy making are analysed in a qualitative research approach. Combining these research's tiers, the study finally brings together the views and needs from different research fields and policy levels and formulates insights and recommendations for successful transition policies.

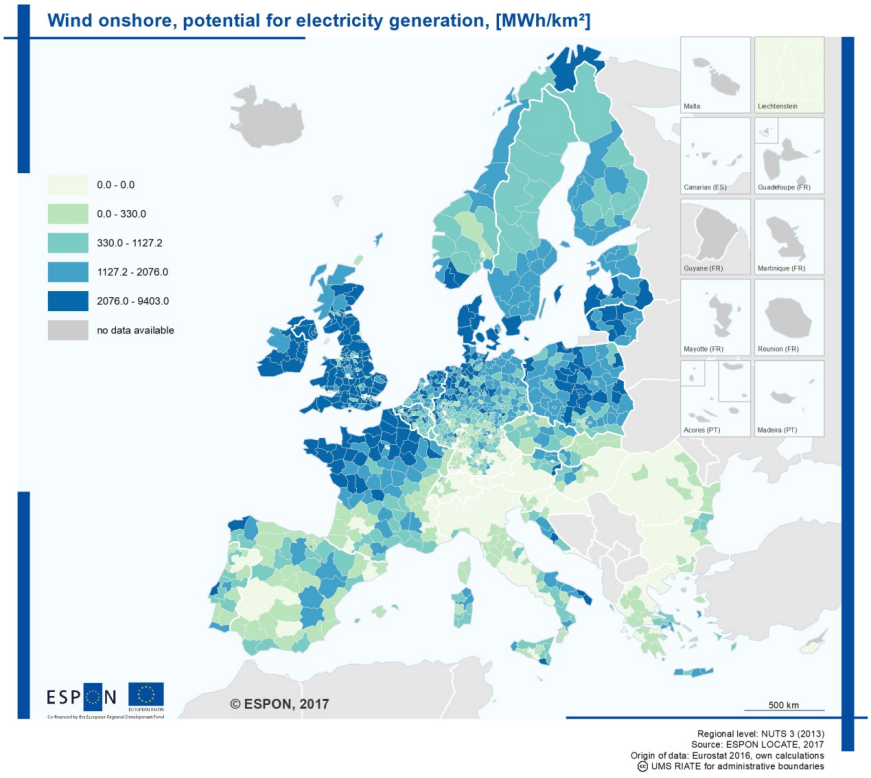
Regional patterns of energy consumption, renewable energy potential and exploitation

Energy consumption and renewable energy potentials are as diverse as the regional conditions encountered in the transition to a Low Carbon Economy (LCE): Climate conditions, topography, built environment and economic profiles as well as legal frameworks, governance structures and stakeholders show great variety.



For example, the regional pattern of *energy consumption for space heating, hot water and cooling* overall shows higher consumption in Central and northern European countries and mountainous regions with rather cold climate conditions. However, other factors are also important. For eastern European countries, which are located in similar climatic conditions, the economic wealth of the regions is decisive. Between 2002 and 2012 most western and northern European regions showed decreasing final energy consumption for this sector, mainly due to building retrofitting and increasing efficiency of heating systems. In contrast, many southern and eastern European regions experienced increasing final energy consumption in this end-use sector. Here, the main reason is an adjustment of comfort levels along with economic growth, especially in eastern European countries. The renewable energy shares of residential energy consumption for space heating, hot water and cooling are high for both types of regions, high consuming (mainly the Scandinavian countries) and low consuming (specifically in Bulgaria, Romania and Lithuania). Urban regions tend to have lower residential energy demand per capita, due to the higher density of functions and work places and a higher share of the service sector than in rural areas.

Regional patterns of renewable energy potential highlight considerable variances mainly due to geographic and climatic differences within Europe. For the example of *wind energy,* it can be clearly shown that regions in the areas of the North and Baltic Seas, in Northern France, Germany, Netherlands, Denmark, United Kingdom, Poland as well as in the Baltic countries and Southern Scandinavia have a privileged location with high wind energy potential compared to other regions.



Solar energy, on the other hand, shows highest potential in southern European regions, especially in Portugal, Spain, Southern France and Italy, Romania, Bulgaria, Greece, Cyprus, Malta and the countries of Western Balkan.

At the same time patterns of energy generation, exploitation rates and their change in the past 10 years differ widely between these two renewable energy sources: Considerable incre-

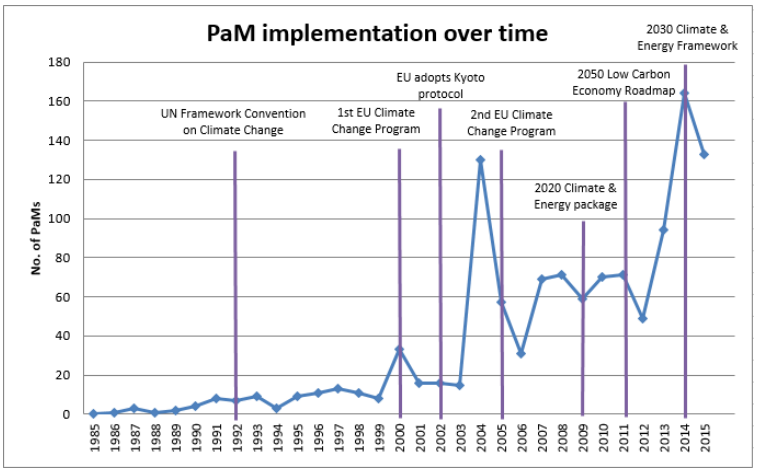
ase of wind energy generation largely took place in regions with high and very high potential. Contrastingly, PV generation shows considerable dynamic development in high potential (e.g. Italy) but also in less privileged solar regions, as especially in Germany, Belgium and partly Switzerland while hardly any change is observed in some areas with high solar potential. These findings highlight the importance of legal and aid frameworks and the contribution from regional stakeholders in their ambition to exploit renewable energy sources.

Regarding the preconditions for renewable energy generation in urban regions, mainly solar energy (roof top use), the use of organic waste and geothermal energy (if available) provide the highest potential for cities and densely built up urban areas.

It is not just the natural endowment of a region which is important, it is this combined with the socio-economic and governance conditions of that region that are critical in making an impact.

The analysis of patterns regarding energy consumption and renewable energy throughout Europe highlight the complexity and interdependencies between the legislative and the governance capacity of regions and their potential to exploit their renewable energy resources and improve energy efficiency: The ability for a region to exploit its renewable energy potential depends on its ability to mobilise socio-economic change in that region using both its governance powers and its ability to stimulate bottom-up informal initiatives through partnership and collaborative working.

The *studies on regional policies and measures* (PaMs) at the higher regional level (mainly NUTS 2) have sought to understand the relationship between international initiatives on climate change and the transition to a low carbon economy at the national and sub-national levels. It has been shown that there is a strong link between global initiatives, such as the Kyoto Protocol and the UNFCCC, and their translation into EU legislation, and in-turn their adoption by Member States and transposition into national policy (and regional implementation). As parties to the UNFCCC and its Kyoto Protocol, the EU and its Member States are required to report to the UN annually on their greenhouse emissions and regularly on their climate change policies and measures. As part of this process and under the Monitoring Mechanism Regulation (MMR), the EU has its own internal reporting rules based on which Member States are required to monitor their emissions and PaMs performance annually and submit them via completion of a questionnaire to the European Environment Agency (EEA).



Source: Author based data provided by EEA

The first set of data was published in 2015; the analysis included in this report are based on the latest data (unpublished at the time of writing) (2016), which was made available to the research team by the EEA. The analysis of the 2016 data emphasises the importance of the subsidiarity principle within the process, with Member States tailoring policies and measures to their national circumstances. It also shows an impressive growth of PaMs at the national level over the past decade, most likely in response to an increase in international and European climate change-related policy initiatives and to the enlargement of the EU in 2004, 2007 and 2013. By 2016 there was a reported total of 1323 individual PaMs across the 28 EU Member States.

Selected illustrative examples have highlighted that the *influence of international initiatives extends to the regional level.* In countries with strong multi-level governance structures, the principal of subsidiarity ensured regions are able to work with national governments to deliver the transition to a low carbon economy. In countries with weaker multi-level governance structures, there is evidence of the influence of international bottom-up peer to peer initiatives, for example, the Covenant of Mayors and the C40. It seems that regions are therefore seeking to look to their peers as well as their respective national government for inspiration for their initiatives on the low carbon economy.

With respect to the regional level of policy implementation, the findings are:

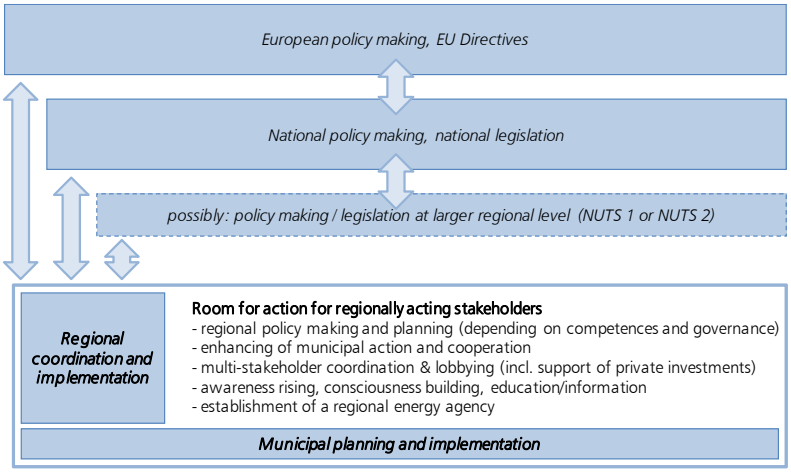
- In general, the *historic and evolving relationships* between the regional and local levels and the national level of governance have played an important role in determining regional contributions to the transition to a low carbon economy.
- The statistical analyses further indicates that there is a *strong statistical relationship between the level of regional autonomy (at NUTS 2 level) and progress towards a low carbon economy.* Whilst this does not indicate causality, it does show a strong correlation between the two factors.
- Concluding from a deeper look into a selection of *concrete illustrative examples,* within this sample there seems to be a *tension* between the process of implementing top-down policies and the ability of regional governments and institutions to have a meaningful say on the process.
- To have an impact on the elements of the low carbon economy that are important, i.e. renewable energy, low-carbon transport and energy efficiency, *regions need appropriate governance powers* in those areas to implement the necessary PaMs. Particularly so that a regions' unique physical, social and economic conditions can be accommodated.
- In *regions with lower levels of autonomy* (and perhaps less institutional capacity), it has been the *implementation of EU level policies driving the transition to a low carbon economy.*

Finally, there is also an interesting link between these transition processes and regional discourses around greater autonomy. The need to move away from a reliance on imported energy is seen as a strong driver for additional policies and measures whilst at the same time bolstering the calls for *greater autonomy*. The findings from the illustrative examples therefore show the power of building a narrative of political autonomy linked to the *idea of energy self-sufficiency*.

Effective LCE transition requires strong regional and local action

Experience from implementation derived from the case studies at a lower regional level (roughly NUTS3 regions) shows a great variety of relevant themes and of potential partners (municipal authorities, enterprises and businesses, public service providers, NGOs, households), who are facing different challenges from region to region. The case studies show that the regional level is an important factor in bringing the transition towards a low carbon economy on the ground. Active and well-resourced regions make a difference in terms of scope and speed of such a transition. Furthermore, the regional level can have a holistic, cross-sectional perspective and is able to work as transition promotor in an integrated way. Successful regions cooperate with the municipal level intensively, contribute added value by pooling of resources and finding synergies, and provide important linkage between national and European frameworks and the local level actors. Concluding, in order to stimulate bottom-up activities and motivate the local public and economic sector as well as private households in all European regions, strengthening and supporting the regional level as active transition promoter seems significant. Hence, a general formal responsibility of regional level institutions (including at least human, if not financial resources) would strengthen regional authorities/actors aiming at implementing transition strategies.

Low carbon implementation – room for action at regional level



The following *regional actions and policies* have been identified as most *successful:*

- To combine regional with local implementation and to make use of synergies of competences and resources.
- To develop tailored implementation strategies for different economic sectors, energy sources and spheres of everyday life.
- To consider regions' vastly different geographic and economic prerequisites and actor constellations by developing individual strategies.
- To exchange experiences and good practices between regions and to make use of the impetus of international low-carbon initiatives at regional level.
- To join resources at regional level in order to be able to apply for funding, financial investment aids and research funds.
- To make use of regional actors' presence in the region and regional knowledge.
- To collaborate with the economic sector as a key partner in successful regional low carbon transition strategies.
- To collect relevant information and inform regional stakeholders.

The role of European Cohesion Policy for supporting European regions towards low-carbon economy

Cohesion Policy is supposed to play a strong role in delivering the Energy Union on the ground, through projects that bring real benefits to citizens. Under the broad theme of "Low-Carbon Economy", the European Structural and Investment Funds (ESI funds, i.e. including EAFRD and EMFF) invest in a range of investment priorities and union priorities to support the shift towards a low-carbon economy in all sectors. In the current period a special focus is put on low-carbon relevant activities, as explicit contribution to EU 202020 targets: LCE-relevant CP-allocations for 2014-2020 have been raised substantially compared to the previous programming period – for energy efficiency from € 6 to 18 billion, for renewable energy projects from € 3.8 to 4.3 and for smart energy infrastructure from € 1.5 to about 3.6 billion.

The allocation strategies, however differ widely between Member States, but in some new MS the increase has been substantial, as in Poland, Bulgaria, Romania, Slovakia, Croatia, Latvia, Lithuania (where low-carbon-allocated funds more than doubled); also in Spain and Germany.

Cohesion Programme implementation experience from regional agencies, managing authorities and involved stakeholders show that

- the potential contribution of Cohesion Policy to foster more stringent and effective regional energy strategies is seen as very important; even if the resources deployed are minimal in highly developed regions it acts as a thematic guidance to regional policy makers,
- because it has a clear impact on agenda setting, gives priorities in a European context and leads to innovative search for other financing sources to realize energy/resource-related projects, as in R&D, innovation or capital investment support schemes.

Based on practitioners' experience, recommendations to increase the impact of Cohesion Policy focus mainly on the national/regional governance, where a number of *essential prerequisites* have to be provided. These include an all-stakeholder process in the region, research groundwork, establishing a regional Energy Agency as key institution and better coherence with national support schemes – only then, good quality projects and a wider economic impact can be delivered.

A further impulse for increasing the impact of Cohesion Policy would be the integration with relevant thematic policy fields, such as RTD and Energy. A methodological guideline to foster the regions' knowledge base and innovative capacity by using all support mechanisms (EU and national) is the Smart Specialisation approach. Following the S3PEnergy approach regions set priorities in order to build competitive advantage by developing and matching their own research and innovation (R&I) strengths with business needs. By addressing emerging opportunities and market developments in a coherent manner regions also avoid duplication and fragmentation of efforts and support regional economies in their transition to low carbon economy. It seems particularly apt for regions lagging behind in economic development, but showing potential in either renewable energy generation or in energy efficiency measures.

Introduction

Background and objectives of the research activity

The project on “Territories and low-carbon economy” aims at providing evidence on the territorial dimension of implementing the low-carbon economy approach in different parts of Europe and in different types of European regions and cities.

The research focus has been on information for regions and cities throughout EU-Europe at NUTS 3 level, relating to energy consumption patterns and the potential to produce (and use) renewable energy sources. Given the great variation of regional spatial and economic features in Europe, it is a valuable innovation to compile a database and make it accessible for analysis and policy formulation. In addition, this study provides an overview of policies and energy-relevant regional competencies to enable an understanding of how variation in regional autonomy impacts a regions’ progress towards a low carbon economy. Using insights from the case studies examining innovative policy approaches at the regional level, ideas and recommendations have been developed for policy formulation towards the transition to low-carbon economy. It has been of special interest to explore how policies and regulations from different levels (EU, national, regional) are interacting and how they can be combined effectively. Since regional competencies in policy making differ widely, informal cooperation arrangements, initiatives and joint actions have also been of interest. The final regional factor important to the successful transition to a low carbon economy is the ability of regions to involve all sectors of society in low carbon initiatives on a collaborative approach.

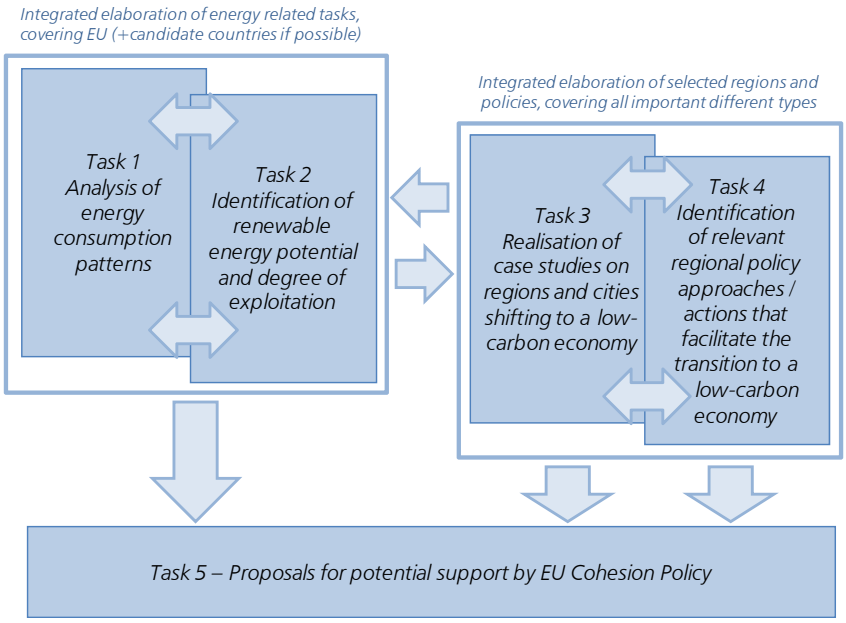
EU cohesion policy is focusing on economic development, research and innovation activities across Europe. In the current period a special focus is on low-carbon relevant activities, explicitly as contribution to EU 202020 targets – though implementation has only just begun. Experience with this approach and the findings from case studies and good practice examples have been used to formulate recommendations and ideas for successful transition policies. While the focus is on regions, EU and national framework regulations and aid schemes must be designed in a way to allow regions to use their full potential to act. The ambition of this project is to bring together the views and needs from different levels in order to make regional-level policy making more effective.

Having a good understanding of how different regional potentials can generate renewable energies is one key question; while understanding how to provide effective policies to implement energy efficiency and to make production, distribution and consumption economically feasible in different regions and cities, is the other. The attempt here is to contribute to both key questions.

Conceptual approach and general understanding

In this study, quantitative and qualitative research components contribute in an integrated work process to generate a greatly improved knowledge on past and current patterns of energy consumption and renewable energy production at regional level (NUTS 3).

Conceptual framework of the project – combining quantitative and qualitative tasks



While the quantitative potential has been estimated and documented in tasks 1 and 2, the necessary governance structures, policies and measures to actually make use of these potentials and help towards the transition to a low-carbon economy, have been analysed in tasks 3 to 5. The conclusions and recommendations have been drawn based on the findings relating to data availability and demand, necessary governance structures and policy designs and to further research needs.

Structure of the report

The report firstly presents results from the quantitative research at the level of NUTS3 regions on energy consumption during the past 10 years (chapter 1) as well as the potential for renewable energy and its exploitation (chapter 2). The findings from the studies on regional policies and measures provide an overview on the relationship between international initiatives and the national and sub-national efforts to implement these initiatives (chapter 3). These issues have been further analysed in selected regions in cross-cutting case study work, informed by the analysis of existing case study outcomes from previous research projects (chapter 4). Finally, the lessons learned have been combined with recent experiences from the implementation of European Cohesion Policy in order to formulate recommendations for future European policy making (chapter 5). In the final chapter we concisely highlight future demand for research in the subject area (chapter 6).

1 Energy consumption – change of regional patterns throughout Europe

The objective of this chapter is to provide detailed data, analyses and maps on energy consumption patterns in European regions broken down into households, public buildings, economic activities (services, agriculture and forestry) and transport. The analysis is conducted in a spatial resolution on a NUTS3 level. The results for the year 2012 are contrasted with the consumption patterns in the year 2002, thus revealing the change of these consumption patterns in the period of 10 years from 2002-2012.

Up to now no such data showing consumption patterns over different end use sectors, was available on NUTS3 level in this form. Since no primary data collection was possible within this project, the results build on modelling methods, combining different data sources for the regional distribution of energy consumption data. Thus, for some of the maps, data uncertainties exist, which should be taken into account. By properly explaining our method, approach and assumptions we want to make these uncertainties transparent (for detailed information, please see the Annex/Scientific report).

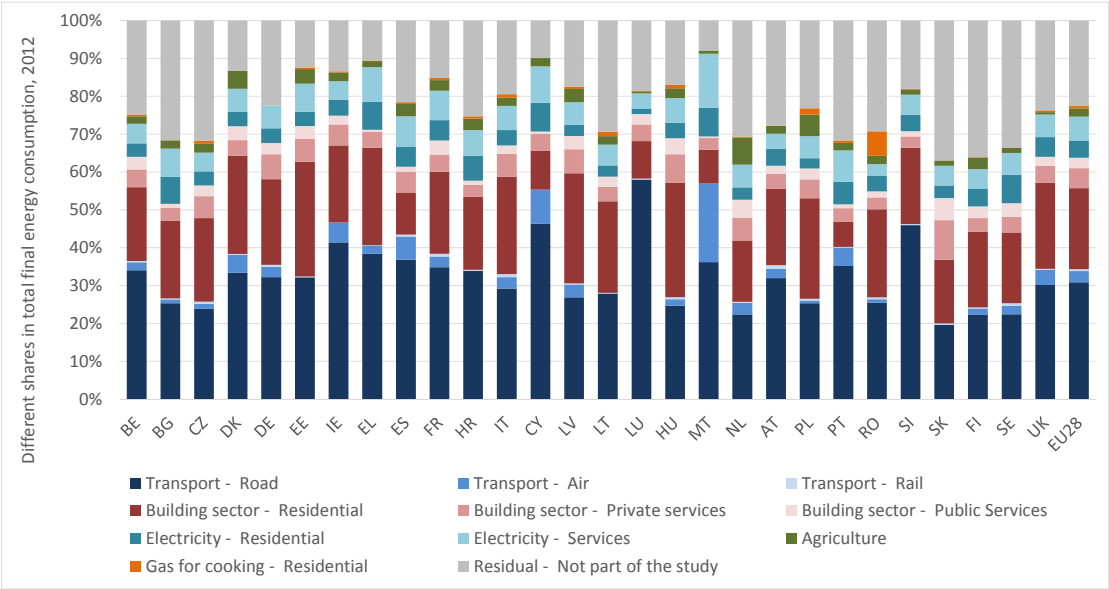
The results are checked for consistency with results from the regional renewable potential and degree of exploitation analysis (see chapter 2) in this report. The data as such improves the ability of regions to develop regional energy plans and adapt regional policies on corresponding consumption patterns. Since the elaborated datasets strongly build on existing ESPON, Eurostat and other relevant data sources, it was important to achieve consistency between our results and this existing data.

In order to properly distinguish end-uses and different sectors, we cluster the results in the energy consumption for space heating, hot water and air conditioning in residential and non-residential buildings (section 1.1.1), energy consumption for appliances, lighting and cooking in the residential and service sector (section 1.1.2), energy consumption in agriculture and forestry (results are shown in the annex) and transport energy consumption (section 1.1.3). Finally, we show the renewable shares in these end-use sectors (section 1.2). To put the different end-uses and sector in perspective, the following figure shows their shares in the total final energy consumption of each country. On average, the included sectors cover about 70% to 90% of the total final energy consumption of each country in the year 2012. The residual mainly covers industrial energy consumption, which was not part of this study.

1.1 Regional energy consumption patterns on NUTS3 level (2002-2012)

This chapter presents the key results regarding energy consumption patterns and related share of renewable energy on NUTS3 level for all EU-28 Member States plus Switzerland, Norway, Iceland and Liechtenstein for the years 2002 and 2012.

Figure 1.1: Shares of different sectors in the total final energy consumption for selected contries in 2012. (own calculations)



Please note: The category "Building sector" comprises space heating, hot water preparation and space cooling. "Electricity" includes electric appliances and other electricity end-uses in the residential and service sector excluding electricity consumption for space heating, hot water and space cooling.

Methodological approach

While for each sector, different approaches are applied in order to account for the peculiarities of all prescribed sectors of energy consumption, the common method has been to apply regional disaggregation matrices to break down the energy consumption data on NUTS0 level to NUTS3 regions. These matrices build on a combination of various indicators like population, structure of building stock, economic activities etc. Moreover the disaggregated data from the simulation models INVERT/EE-Lab[1] – for heating and cooling energy demand – and FORCAST-Regional[2] – for appliances, lighting and processes – have been applied within this analysis. The detailed methodological approach is described in separate subchapters in the Annex/Scientific report.

Please note: The following maps on energy consumption show clusters of variables which are set according to an equal percentile distribution of data on all European regions. Thus, each cluster includes the same number of NUTS3 regions. It turns out that for some countries all NUTS3 regions fall in the same cluster. Although there are deviations between different regions within these countries, they cannot be displayed in this map due to the high differences between European countries.

1.1.1 Energy Consumption for space heating, hot water and cooling

In this section, the indicators of the energy consumption for space heating, domestic hot water and cooling of the residential and non-residential building stock on the level of NUTS3

[1] http://www.invert.at

[2] http://www.forecast-model.eu

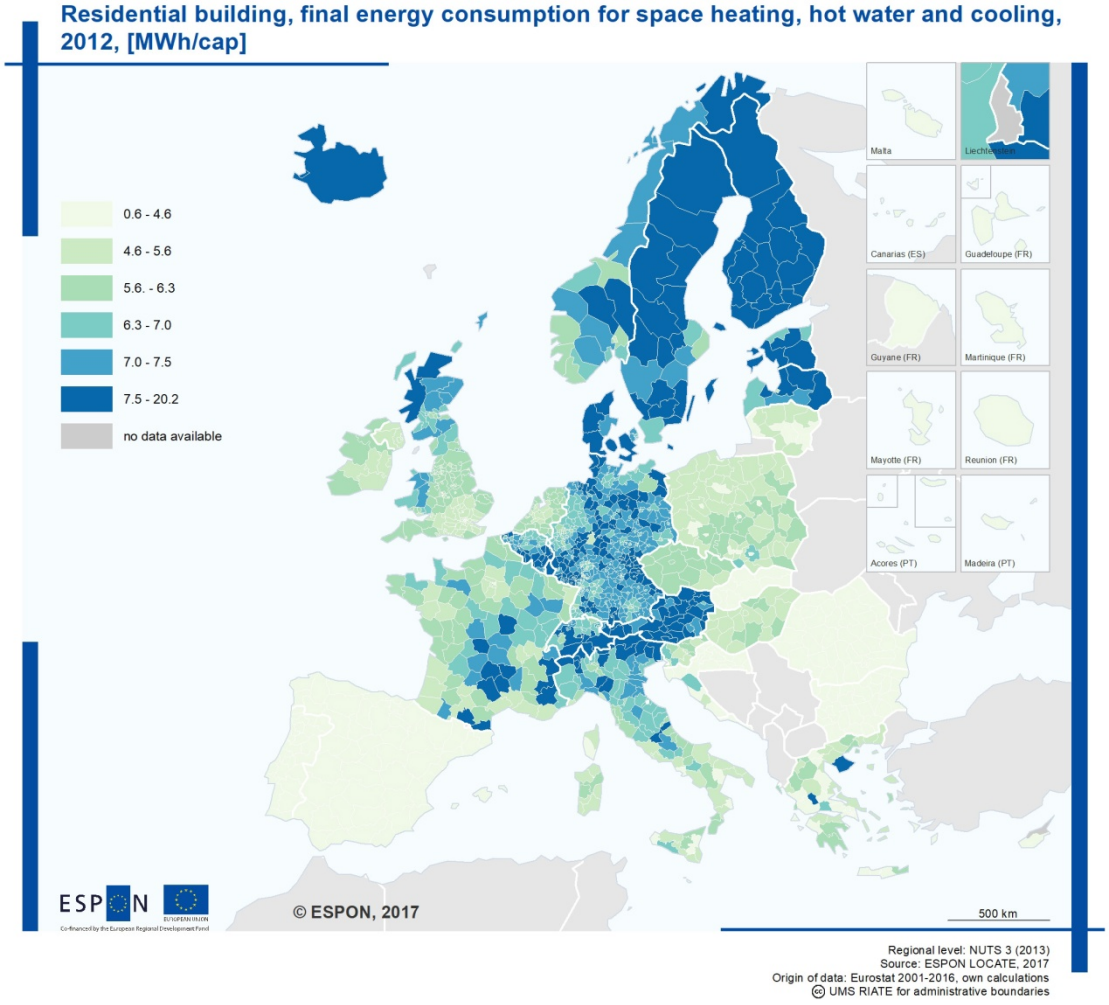
regions is shown (see Map 1.1). We focus on the presentation on energy consumption patterns on NUTS3 level. The renewable share is shown in section 1.2.

It should be taken into consideration that the maps show *final* energy consumption. This means that conversion efficiencies from final energy (e.g. natural gas, electricity) to the end use is included. Thus, regions with a higher share of district heating and electricity in the supply of heating and cooling show lower *final* energy consumption than regions with a higher share of fossil or biomass fuels. This means that the results presented do not only indicate the energy efficiency of buildings, behaviour and resulting consumption levels but also end-use efficiency of heating systems; thus, the mix of existing heating systems without any judgement on the primary energy consumption.

Since the specific climate conditions of the respective year do have a major influence on the space heating and cooling demand, climate correction factors based on heating and cooling degree days are applied in this analysis. We want to emphasize that the development of energy consumption maps from 2002 to 2012 is not distorted by the change of heating degree days and cooling degree days in this period. For both years we applied the same climate data. Therefore, the results present energy consumption assuming the same temperature distribution for 2012 and 2002. We believe that this is essential since the objective of this study is not to show the impact of historical climate change (or randomly deviating weather conditions in these selected years), but rather to give policy makers evidence on energy efficiency and consumption patterns.

For all maps, we applied six variable clusters which are set according to an equal percentile distribution of data. Thus, each cluster includes the same number of NUTS3 regions. Since final energy consumption for space heating, hot water and space cooling strongly varies across Europe, it turns out that in Spain or Romania, for example, all NUTS3 regions fall in the lowest cluster below 4.7 MWh/cap. Although there are deviations between different regions within these countries, they cannot be displayed in this map. The main reason for these low values is a combination of warm climate, leading to low space heating demand, combined with relatively low indoor comfort and lower floor area per capita in these countries, compared to central, western and northern European countries.

Map 1.1: Final energy consumption for space heating, domestic hot water production and cooling of residential buildings in 2012, MWh per capita



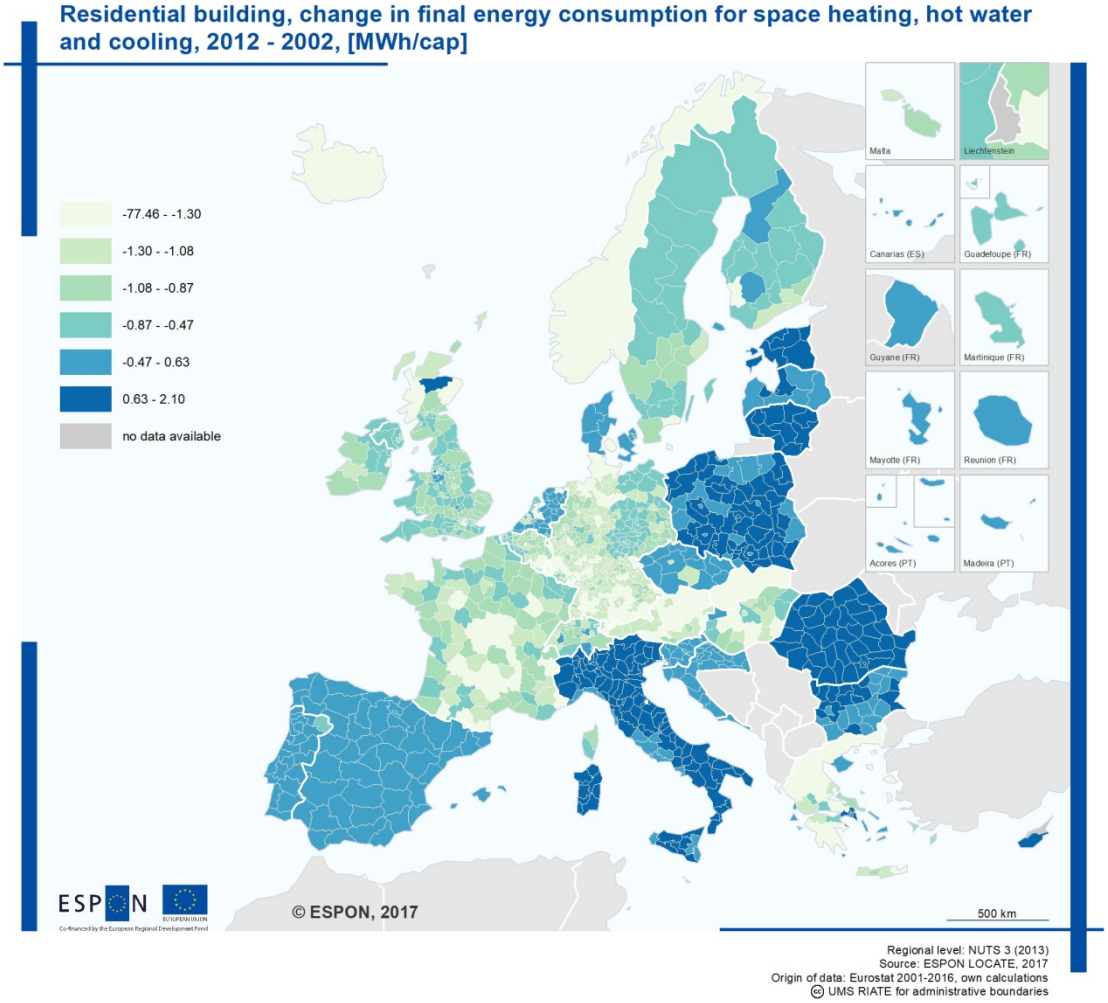
The following Map 1.2 shows the change of this indicator between 2002 and 2012. The development from 2002 to 2012 (presented in absolute figures above) is mainly driven by following factors:

- Change in the energy performance of the building stock by thermal building renovation and installation of other (more efficient) heating systems.
- Change in the overall supply of energy services, e.g. the related floor area of the building stock of a certain region. The comfort level also plays a key role.

Therefore, different trends in different regions can be explained through these drivers. In many regions, such as in Germany, the improvement of the energy performance of buildings outweighs the growth in supplied energy service. However, in other regions the opposite happened[3].

[3] Due to the method of using quintiles for the presentation of regional differences within Europe, one category summarizes both decrease and increase of energy use for space heating, hot water and cooling. Considering the methodological uncertainties referring to the actual regional energy demand and development, we state it reasonable to present such a category which is depicting regions with a (more or less) stable situation.

Map 1.2: Change in final energy consumption for space heating, domestic hot water production and cooling of residential buildings 2012-2002, difference in MWh per capita

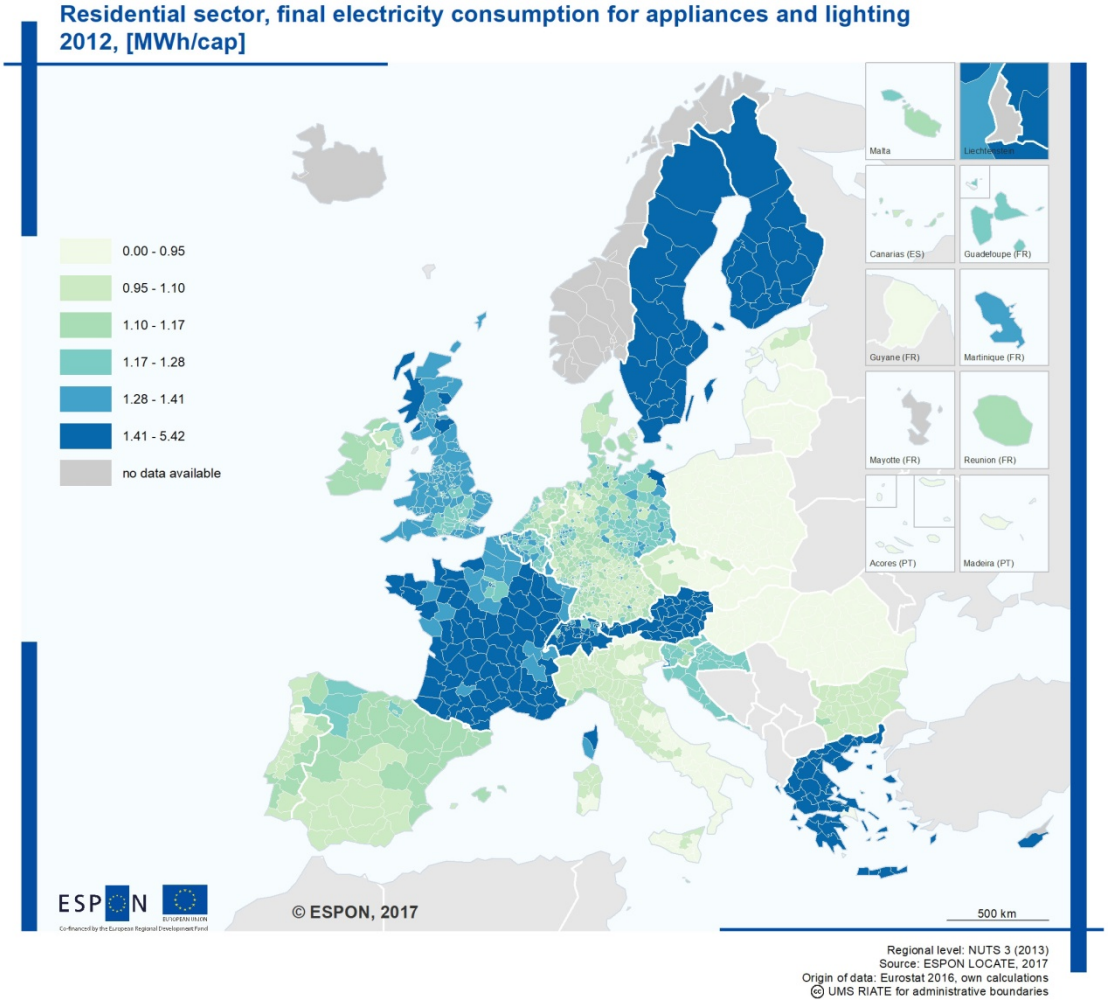


Most western and northern European regions show a decreasing final energy demand for space heating, hot water and cooling from 2002-2012. This is mainly due to thermal building renovation and increasing efficiency of heating systems. On the other hand, many southern and eastern European regions show an increase of final energy demand in this sector. The main reason is an increase of comfort levels (e.g. increasing effective indoor temperature, increasing share of central heating systems and a decreasing number of single stoves with lower service factors). In some regions in eastern Europe the decreasing relevance of district heating also plays a role.

1.1.2 Final energy consumption of appliances, lighting and processes

Electricity consumption of the residential sector is essentially attributed to household appliances such as washing machines or lighting. The following map shows significant differences in the energy consumption for these end-uses among countries but also among some regions within countries.

Map 1.3: Electricity consumption per capita for appliances and lighting in the residential sector in 2012 in MWh/capita



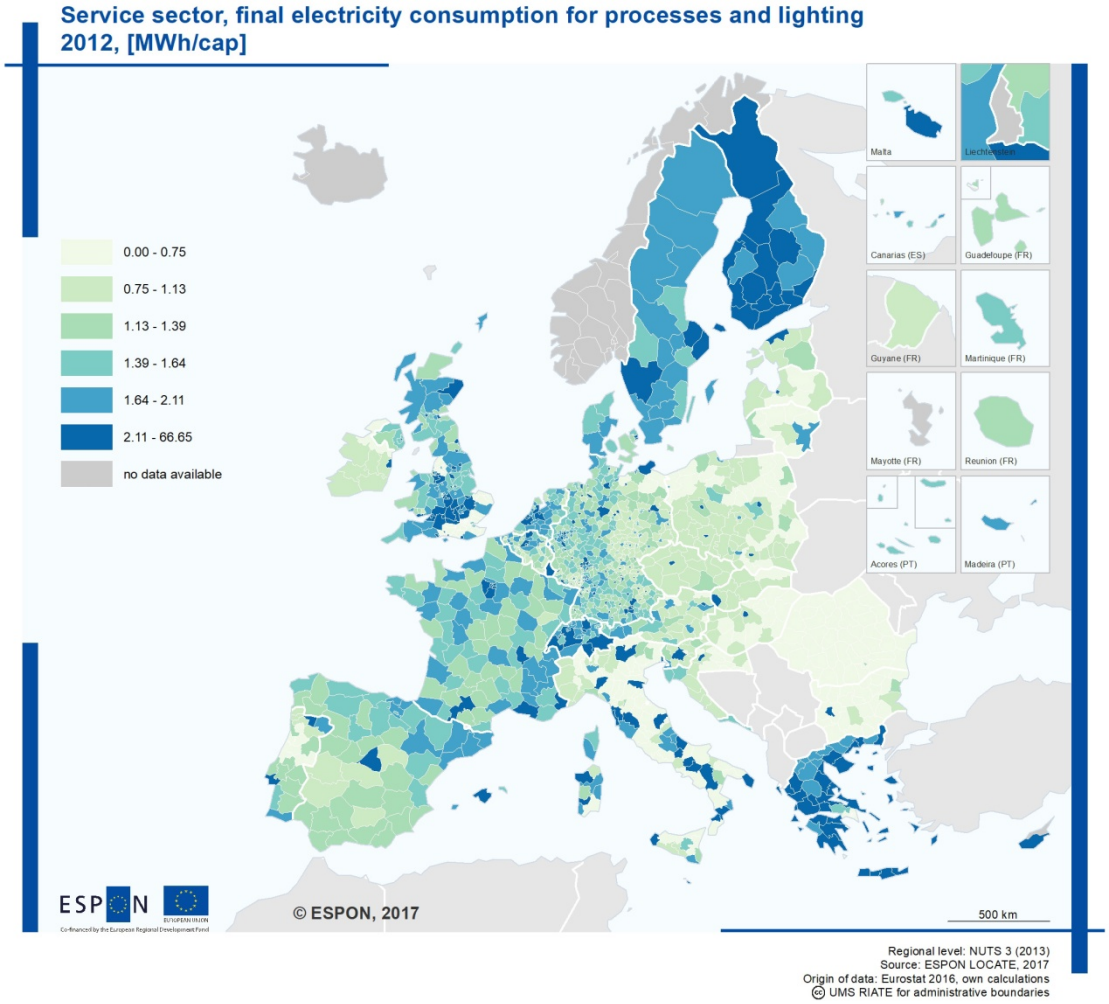
Especially in Sweden, the annual electricity consumption is above 3,000 kWh per capita in many regions. On the other hand, many eastern European countries and parts of Spain exhibit very low specific electricity demand for appliances and lighting that is even below 1,000 kWh per capita. One of the reasons for these significant differences is the share of cooking that may be provided either by electricity or by gas. In addition, the ownership of electric appliances differs strongly between regions. The comparison between 2002 and 2012 shows an increase of electricity demand per capita in almost all countries. The strongest increase can be observed in many regions of Greece, Romania and Lithuania.

The annual *gas consumption* for cooking per capita in the *residential sector* is by far the highest in Romania and in many regions in Poland with over 400 kWh per capita. In comparison, more than half of the analysed regions have gas consumption per capita below 100 kWh. The lowest consumption per capita can be observed in Norway, Sweden, Finland and Iceland.

Map 1.4 presents the final energy consumption per capita attributed to appliances, lighting and processes in the *service sector.* As illustrated 2/3 of NUTS3 regions are in the range of 0,75 MWh per capita to 2,11 MWh per capita. The NUTS3 regions with the highest consump-

tion per capita are mostly located in Italy. This can be explained due to a low number of inhabitants in these NUTS3 regions compared to a very high level of economic activity, particularly of the tourism sector.

Map 1.4: Electricity consumption per capita for processes and lighting in the tertiary sector in 2012 in MWh/capita



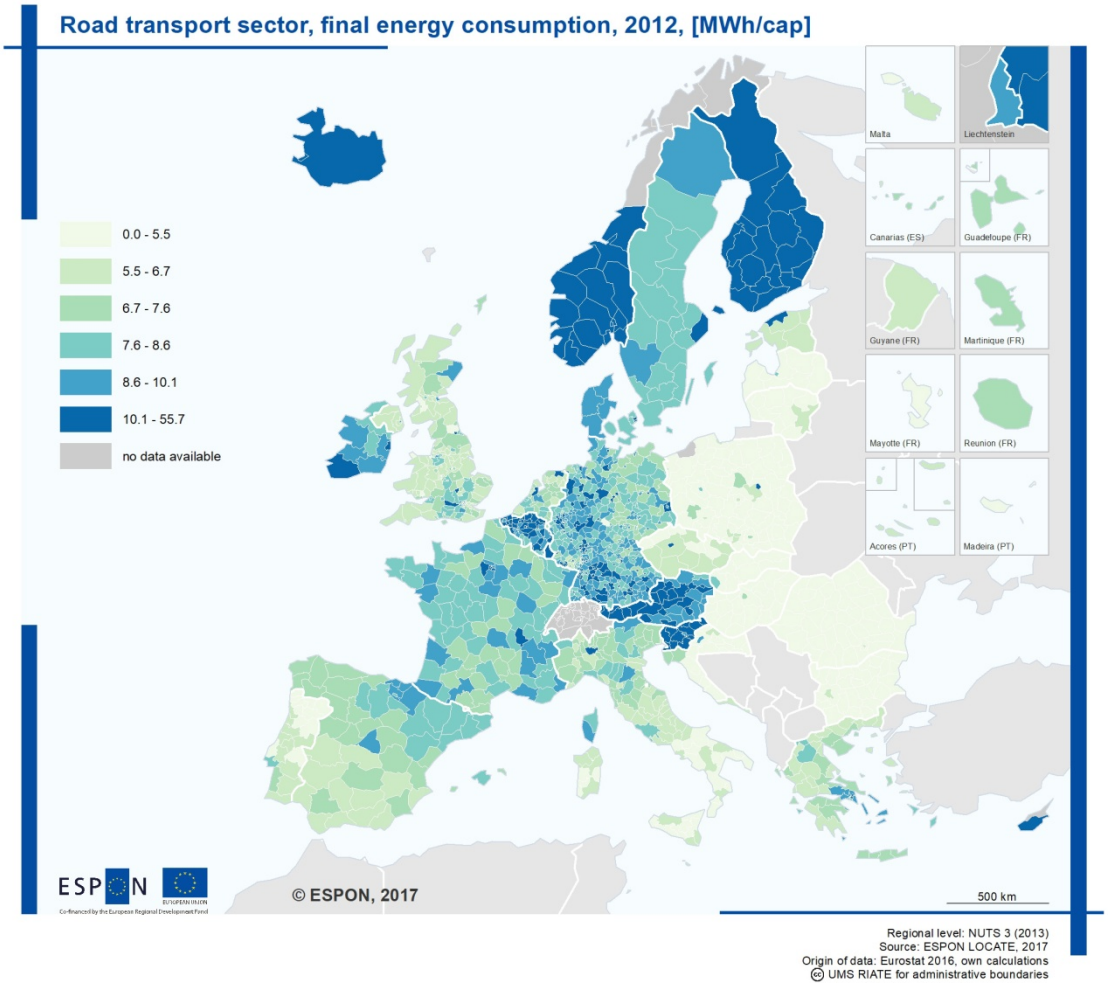
From 2002 to 2012, electricity consumption per capita increased in the service sector in most areas as well. An analysis of the largest consuming regions per capita in 2012 reveals that the ranking of regions have largely not changed since 2002. The strongest increase since 2012 can be observed in Romania and Belgium. For Iceland and Norway no data are available for this indicator.

1.1.3 Final energy consumption for transport

Road transport energy consumption has the highest share of the total transport energy consumption. It includes diesel and gasoline driven passenger cars as well as diesel driven trucks, busses and off-road vehicles. Map 1.5 shows the results for road transport energy consumption in 2012. Remarkable is the relatively high consumption per capita in Central and

Northern Europe. Due to efficiency technologies the energy consumption per capita has declined in the period 2002 to 2012. The structural differences between Eastern and Central Europe have not changed.

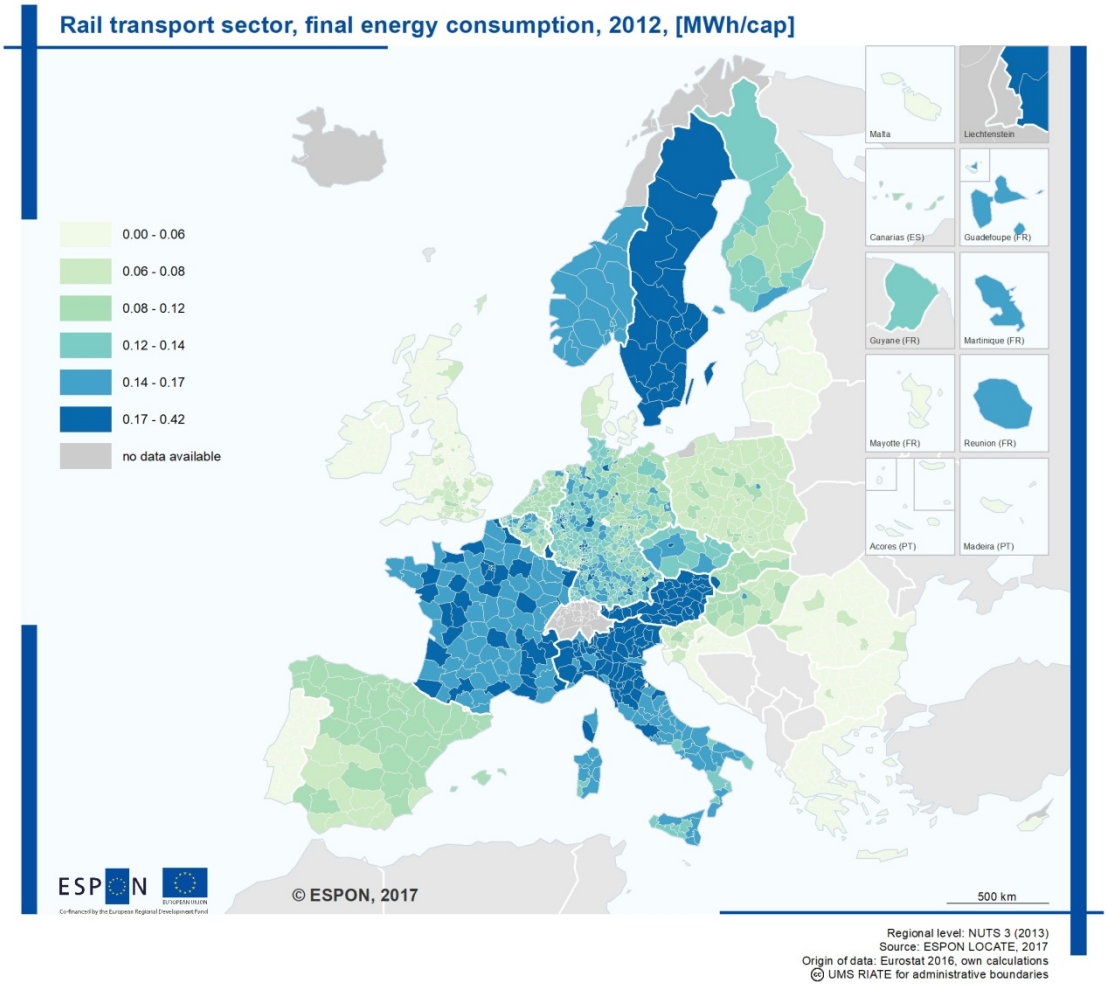
Map 1.5: The energy consumption for road transport in 2012, MWh per capita



As for most countries, the modal share of rail is tremendously lower than the share of road transport; the *energy consumption of rail transport* per capita (Map 1.6) is only about one tenth of the road transport energy consumption.

A comparison of the results for the years 2002 and 2012 shows that rail energy consumption has also declined during the past decade. The main reason is the growing efficiency of passenger and freight trains. Compared to road transport energy consumption, there is no clear difference between Central and Eastern Europe; Czech Republic and parts of Slovakia exhibit a similar energy consumption per capita as Central Europe.

Map 1.6: The energy consumption for rail transport in 2012, MWh per capita



The results for *air transport energy consumption* are different compared to the other modes. Kerosene consumption is related to the aircraft movements at the airports. This leads to a selected number of NUTS 3 regions with high energy consumption per capita whereas no energy consumption is accounted for in other regions. In general, the energy consumption of air transport has not declined to the same extent as the consumption of other transport modes.

1.2 Share of renewable energy

The following map shows the share of renewable heating/cooling for 2012 in residential buildings (as an exemplar). The annex includes the full set of results for all sectors and end-uses. The renewable share in the heating and cooling sector is defined according to Eurostat as

$$RES_{H/C} = \frac{Final\ energy\ consumption\ RES\ \left(excluding\ electricity\right)}{Total\ final\ energy\ consumption\ \left(excluding\ electricity\right)}$$

This implies that regions with a high share of electricity in the heating supply may lead to a higher share of renewable energy than those with a low share. In contrast to the energy consumption patterns, there is a general trend towards a higher share of RES-H/C in most re-

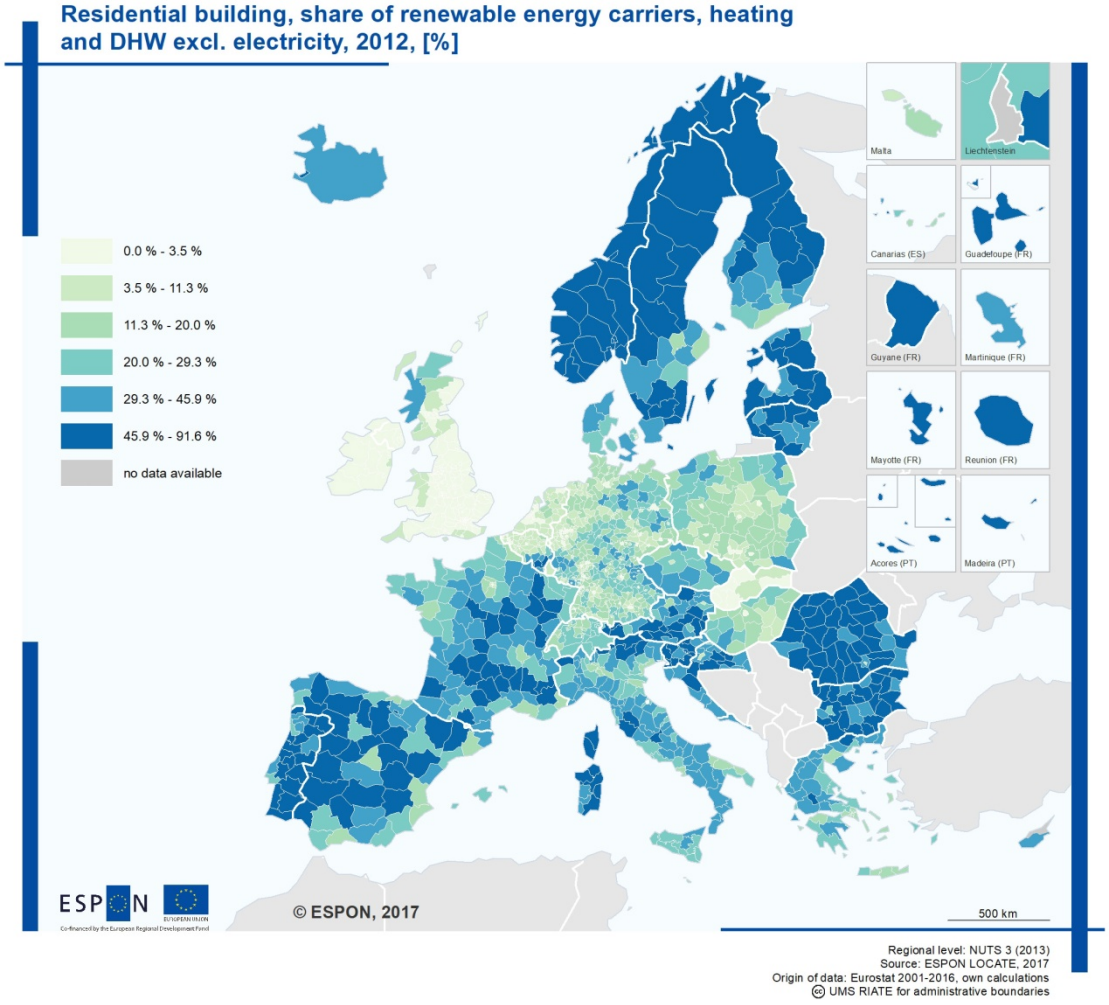
gions from 2002-2012. At the same time, the non-residential building stock lags behind the residential buildings in terms of renewable heating and cooling.

For the interpretation of Map 1.7 it is important to bear in mind that actual statistical data on the regional share of energy carriers for space heating and domestic hot water production are not available for the very most (European) countries. Therefore, we derived the regional share of renewable energy carriers from the national data by considering the estimated availability and applicability of different energy carriers in the different regions. This implies presumptions such as the assumption that district heating systems are prevailingly applied in urban areas, where as biomass is predominantly used in rural areas, or the assumption that the availability of natural gas as an energy carrier depends on the closest distance to the European natural gas network (European natural gas transmission pipeline network – ENTSOG). Also, regional data on the applied primary energy carriers in district heating networks are not available. Therefore, we consider for each region that the share of renewable energy carriers utilized in district heating networks equal that on the national level.

Currently, the predominantly applied renewable energy carrier for heating purposes in Europe is biomass, either decentralised used in building central heating systems or in district heating networks. The high share of renewable energy carriers in Sweden, the Baltic states, Rumanian, Bulgaria and Austria primarily stems from long and deeply rooted tradition of using biomass for heating and domestic hot water production. For Iceland, the high share of renewable energy carriers results from the intensive usage of geothermal energy in district heating areas. In the case of Norway, it is important to keep in mind that about two thirds of the heat is provided by electricity. However since this energy carrier is exclude in the formula we applied to derive the share of renewable energy carriers, the calculated share refers only to a minor share of the actual delivered energy for heating and cooling. In other countries with are commonly known for having an high share electric heating system such as France, Spain or Portugal, this effect is already not significantly influencing the calculated renewable share, as electricity contributes in these countries only to about 20-30% of the total energy for space heating and domestic hot water production.

On the lower end of the share of renewable energy carriers, countries are found, which have a very low domestic woody biomass potential or/and a long tradition of a widely distributed natural gas network. Great Britain and The Netherlands countries are most outstanding countries from the second category of countries, Ireland and Belgium are the two outstanding countries from the first category.

Map 1.7: Share of renewable energy carriers for space heating and domestic hot water production of residential buildings in 2012, in %

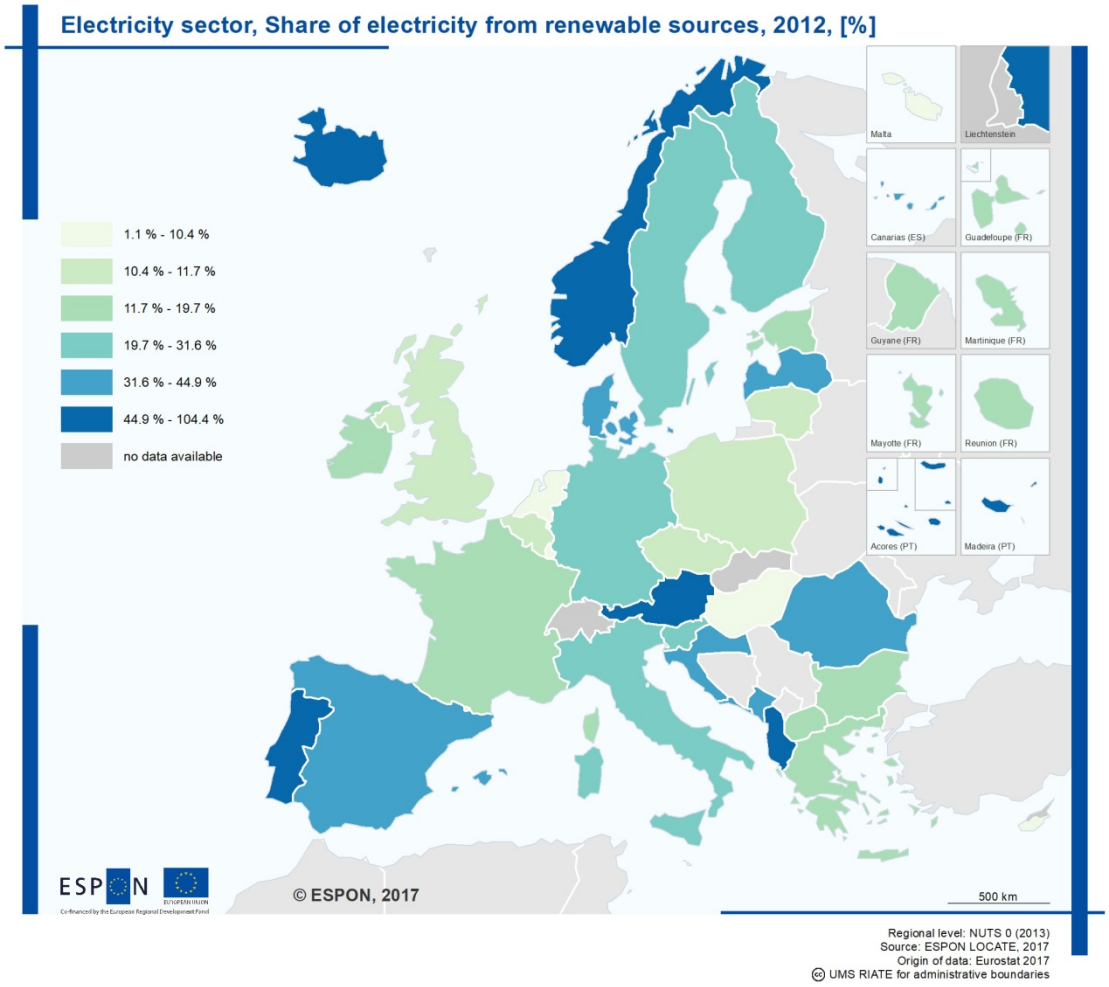


RES-share within gross final electricity consumption

Due to a lack of official statistics and methodological problems to allocate the region of electricity generation to the region of electricity consumption, the RES-share within gross final electricity consumption (RES-E share) can only be displayed on a NUTS 0 level. The RES-E share is calculated by Eurostat (SHARES 2015 results, Eurostat, 2017).

In 2012 Norway shows a RES-E share of 104.4%, because the country produces more electricity from renewable sources than it consumes and exports the excess electricity to its neighbours. Norway is followed by Iceland (95.4%), Sweden (95.9%), Albania (72.4%), and Austria (66.5%). The lower RES-E share can be found in Malta (1.1%), Luxembourg (4.6%), Cyprus (4,9%) and Hungary (6.1%). All other countries range between a RES-E share of 10% to 50%.

Map 1.8: Share of energy from renewable sources for electricity (RES-E) in 2012, %



The highest positive change in percentage points between 2004 and 2012 was realized in Portugal (20.1 pp), Estonia, Denmark, Spain and Germany (all show an increase of 14.2 to 15.2 pp). Latvia is the only country with a decreasing RES-E share (-1.1 pp).

1.3 Conclusion

The two sectors with the highest per capita end-use in European regions are road transport and the building sector (including space heating, hot water preparation and space cooling). Besides the climate impact of the latter one, in both end-use sectors we can identify a close link to economic activities. In eastern (and partly southern) European regions the consumption per capita is significantly lower than in Western and Northern Europe. However, the road transport and building sectors experienced different developments and patterns in the period from 2002-2012: Energy consumption in the building sector declined in most regions considerably and was only partly offset by increasing indoor comfort and per capita floor area in eastern and southern European countries. The renewable share for space heating and hot water varies strongly between regions and increased in most of them from 2002-2012. On the other hand, energy consumption for road transport increased in all NUTS3 regions. In general

the regions with the highest consumption in 2012 also show the highest increase from 2002-2012. Although the absolute relevance of energy consumption for appliances is much lower than the sectors described above, appliances show a very strong growth in most regions in the observed period. This means, that the growing efficiency of appliances was at least partly offset by increasing ownership rates.

Overall, the results show that economic activity is a strong driver of energy consumption in all end-use sectors, in particular in the service and road transport sector but also in the residential building sector – e.g. due to higher floor area per capita.

2 Potential for renewable energy and its exploitation at a regional level

The objective of this chapter is to provide an overview of the regional potential for generating and distributing renewable energy at the level of NUTS3 regions across Europe. We cover the whole range of renewable energy sources, i.e. wind power, solar energy, biomass, geothermal, hydropower, tidal and wave. Results for geothermal as well as tidal and wave are only included in the Annex/Scientific Report. Also a more detailed explanation of assumptions, definitions and system boundaries for each of these renewable sources is presented there. The Annex/Scientific Report also includes maps for exploitation rate in 2012 and changes from 2002-2012 for the different renewable energy sources.

In most maps, the ranges of classes have been defined in order to have an equal number of NUTS3 regions represented in each class.

Please note: The data are based on available information according to installations data. On NUTS 3 level results on changes mainly depend on the regional potentials. Due to policy measures, certain countries and regions show a relatively higher change than others. This insight on regional differences is highlighting the importance of specific actions regions and municipalities may take to support renewable energy generation if willingness and acceptance is high. Nevertheless, the project team is not able to explain all regional differences and changes within the scope of the project.

2.1 Wind power

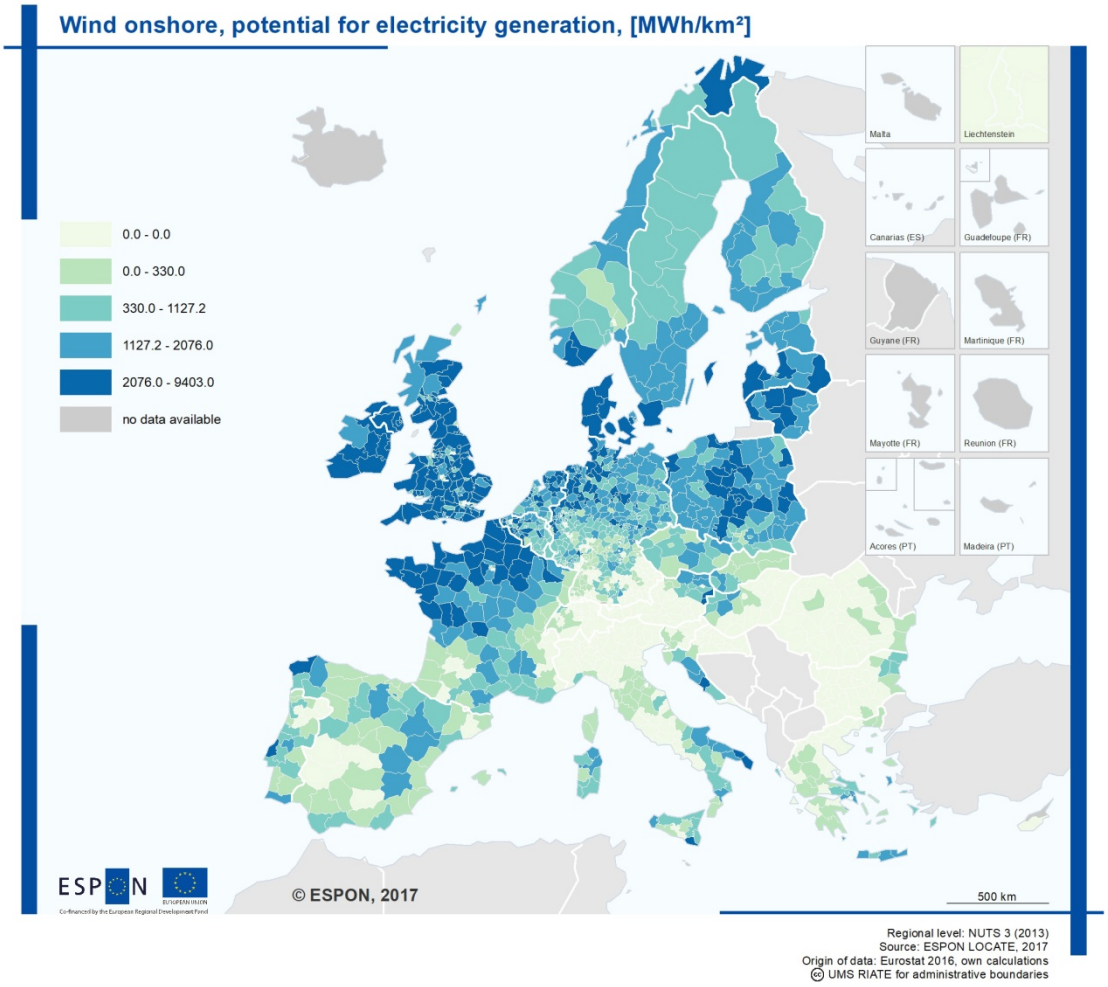
The overview on supply potentials for renewable energy sources was informed by a GIS-based analysis, combined with the application of the Enertile[4] electricity system model, as well as desk research and processing of relevant data sources.

To achieve a detailed and reliable picture of renewable energy potentials two complementary work steps are performed. The first step is the calculation of the land available for the deployment of renewable energy production. The second is the calculation of the renewable potential at the sites available determined by the prior work step. As a result, the technical and economic potential is derived.

Map 2.1 shows the resulting wind power potential in Europe. The potential for wind energy depends strongly on average wind speeds and land availability for wind power installations. To account for economic restrictions, areas with low wind energy harvest (less than 1,800 full load hours) are excluded from the potential.

[4] http://www.enertile.eu/

Map 2.1: Wind onshore energy potential in MWh/km²

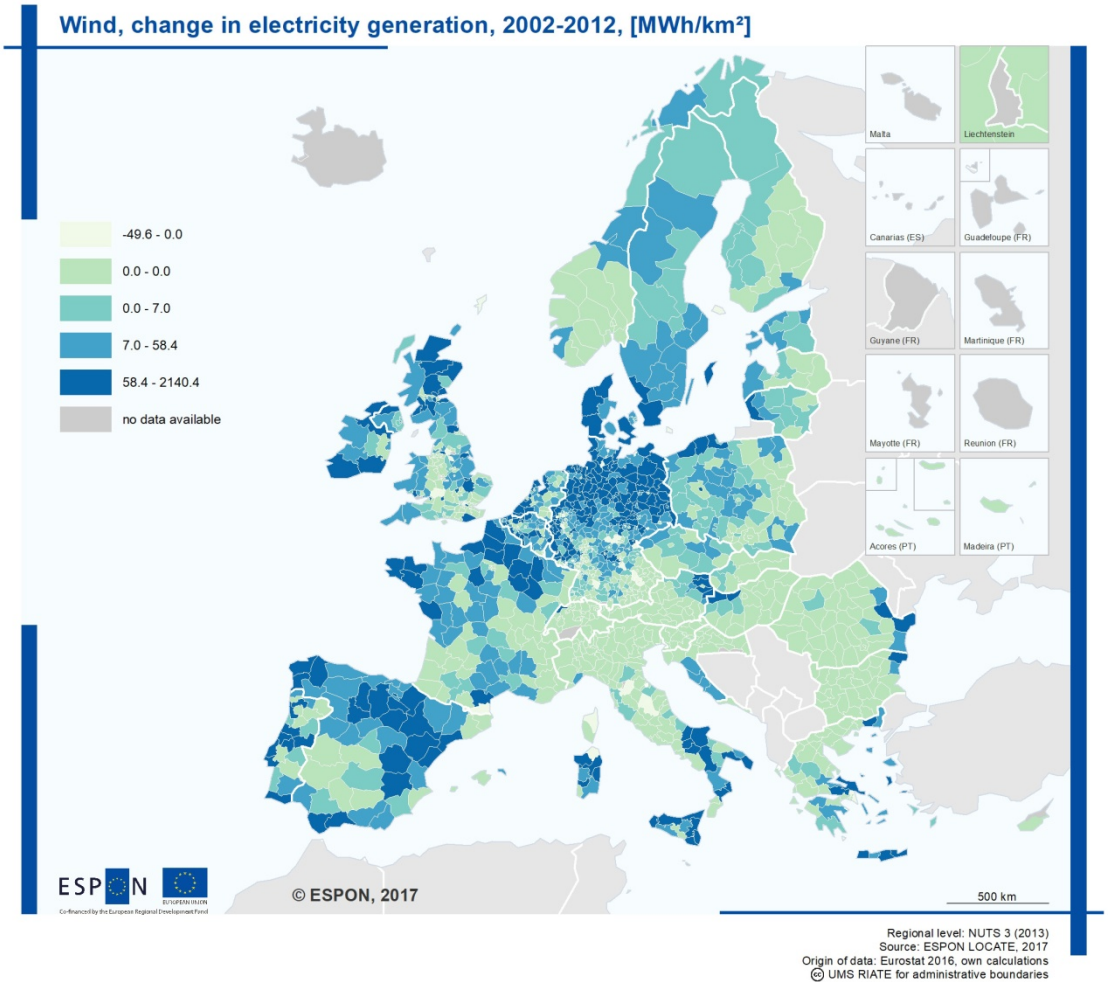


The following Map 2.2 presents the change of onshore wind power capacities between 2002 and 2012. It clearly highlights the differences in national focuses in terms of wind power deployment. Whereas on shore wind power has been promoted especially in Denmark, Germany, Spain, Portugal, the Netherlands and Belgium, and, where feasible, also in Italy, Greece and Romania; in other countries existing potential is not exploited to a higher extent, yet. This particularly refers to France, UK, Ireland, Poland as well as to the Baltic and Scandinavian countries.

Nevertheless, the installed wind power capacity increased strongly between 2002 and 2012 in many countries. The data on installed capacity is based on country specific data from Eurostat. The calculation of data for NUTS3 regions is based on a commercially available database for wind power installations[5].

[5] The Wind Power Database. World wind farms database. (2017)

Map 2.2 Wind onshore, change in electricity generation, 2012-2002 in GWh

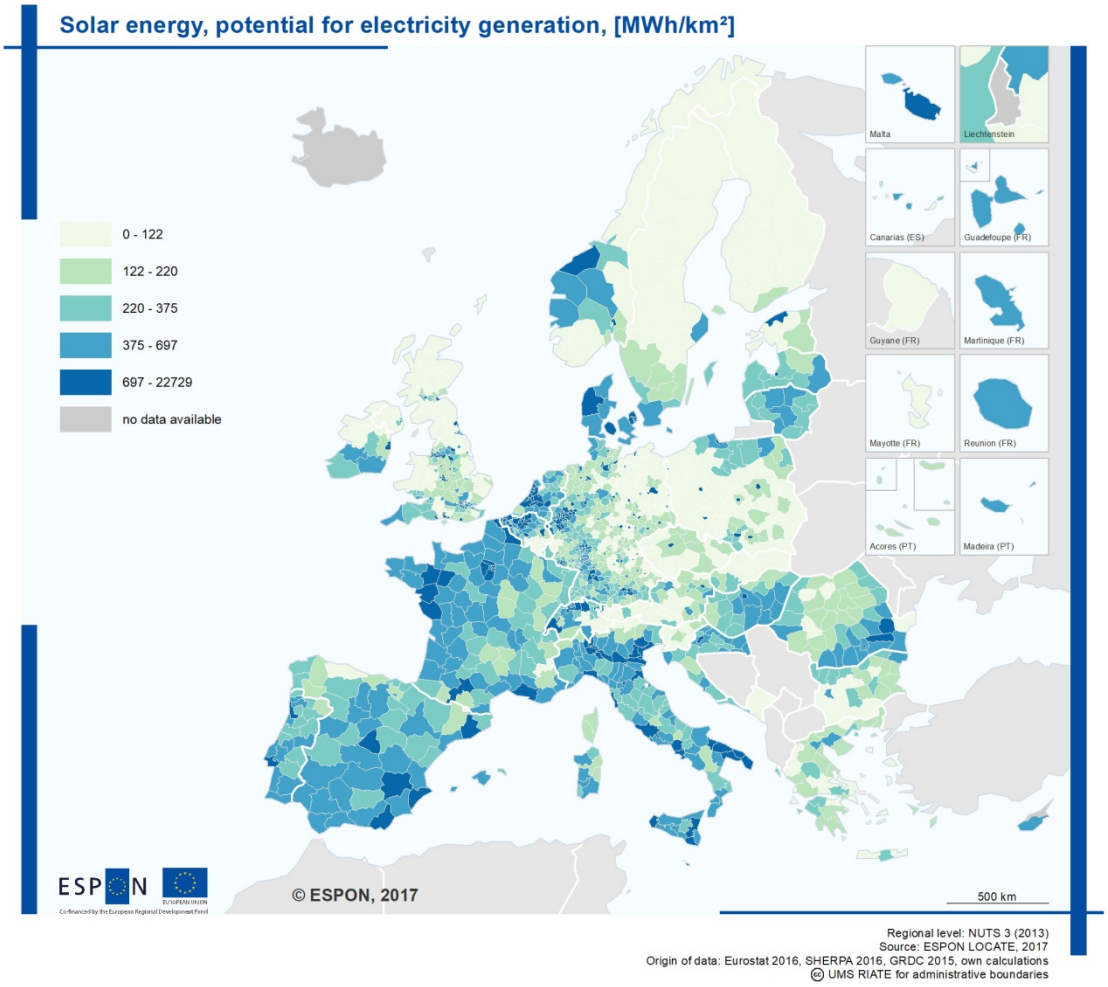


2.2 Solar energy

Solar energy developed even faster than wind energy between the 2000s and 2010s. While in the beginning of the 2000s it was a mature technology, a strong decrease in investments followed the market take up in Europe, especially in Germany.

Map 2.3 shows the solar power potential in Europe on a regional level. To account for economic restrictions, areas with low solar energy harvest (less than 900 full load hours) are excluded from the potential. Nevertheless, the potential is displayed in potential electricity harvest per area, and does not show the investment necessary to exploit the potential.

Map 2.3: Solar PV energy potential in MWh/km²



2.3 Hydropower

In this study hydro power has been assessed using existing data and study results on NUTS 0 level in combination with our own methodology to distribute the potential on NUTS 3 levels. For the distribution of the potential, long-term mean monthly discharges of flow rate station have been used. Depending on the basins they are representing, the overall potential is distributed on the different streams. The streams have been distinguished in large and small rivers/streams to distribute the small and large hydro potential accordingly. Using this approach, it is also possible to distinguish between small and large hydro.

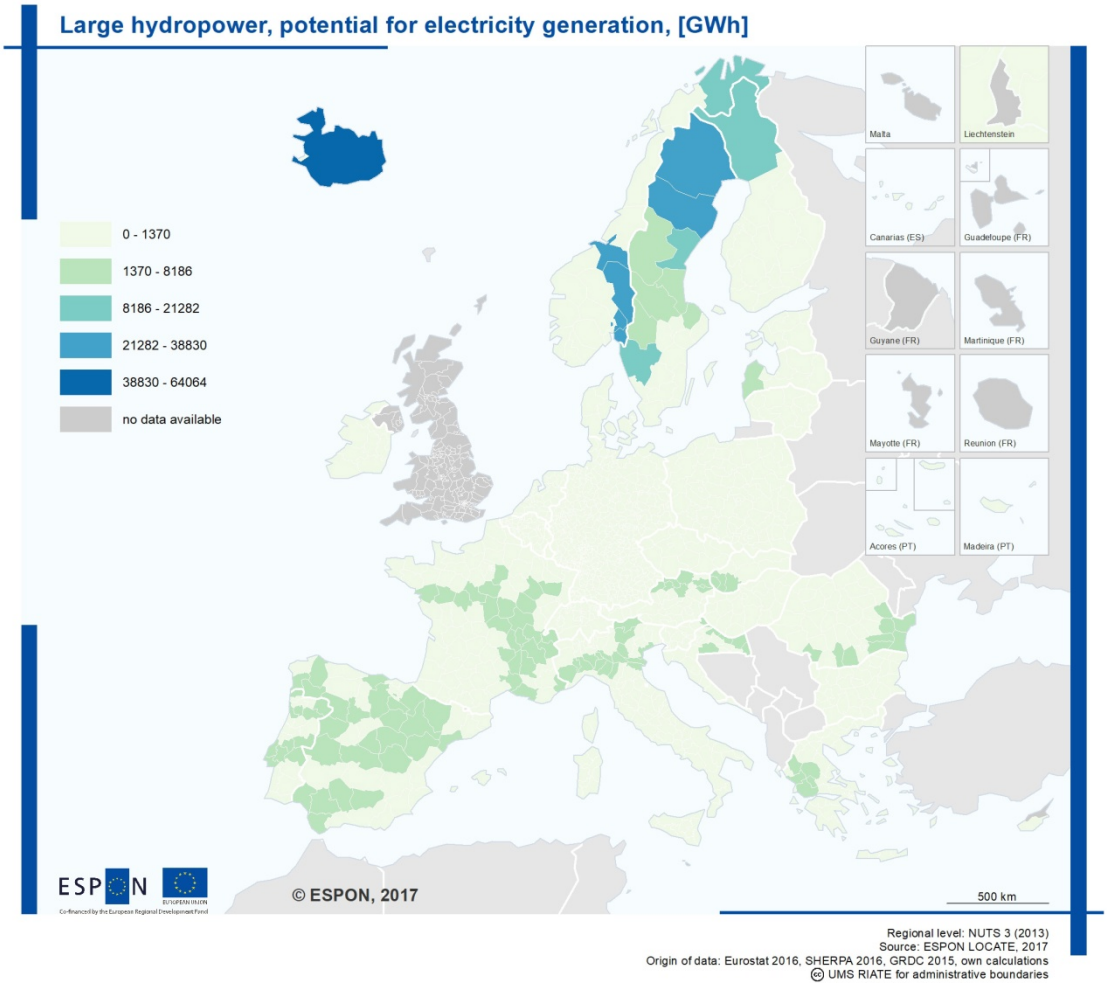
While large hydropower (>10 MW) is used in Europe to a high extent, the potential of small hydropower (<10 MW) remains untapped in various European regions. The following chapter will firstly give an overview on the large hydro power potential and then present the perspectives on small hydro power.

Large Hydro Power Potential

Hydro power potential estimations often differ from each other. The estimated potential in some cases is twice as big as in other studies. In the following analysis EUROLECTRIC[6] data has been used and referenced with Eurostat data. It showed relative similar values compared to some reference countries.

The following map shows the technical large hydro potential in Europe. The highest potential for electricity generation by large hydro power can be found in Norway 52 TWh, Iceland 52 TWh, Sweden 50 TWh and Spain 33 TWh.

Map 2.4: Technical potential for large hydropower (GWh)



The exploitation of the hydro potential is already very high in several countries. In Germany it reached over 90% in 2002. Exploitation rates of between 53% and 70% are reached in France, Italy, Austria, Norway, Czech Republic and Slovakia. However, in some studies small hydro potential is still considered widely untapped. The exploitation has not significantly

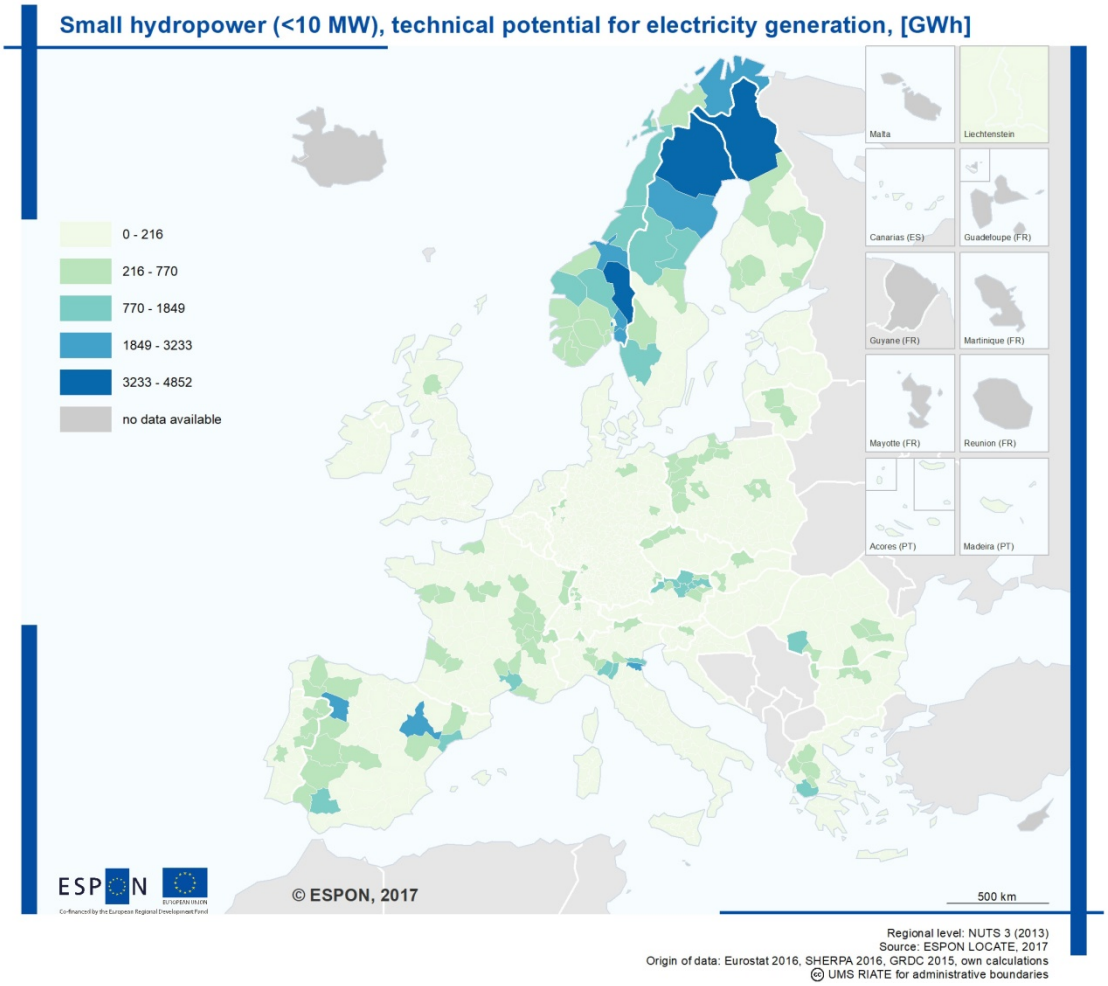
[6] Eurolectric (2010): Hydro in Europe. (http://www.eurelectric.org/media/26690/hydro_report_final-2011-160-0011-01-e.pdf)

changed by 2012. The capacity in the countries presented above has increased from 113 GW in 2002 to 119 GW in 2012.

Small Hydro Power Potential

The following map shows the resulting technical potential on a NUTS3 scale, estimated to reach around 117 TWh/year in total for the investigated area.

Map 2.5: Small hydro technical potential (< 10 MW), GWh



Referring to the potential per km^2 per country, the small hydro potential varies between 1 and up to 61 MWh/year and km^2. The latter value is a peak value[7] in Austria. The average value[8] in all NUTS 3 areas is 19 MWh/year/km^2. The economic small hydro potential is based on the technical potential. The overall economic potential of small hydro sums up to 79 TWh/year and an average value of 10 MWh/year/km^2 per NUTS 3 area.

The mean *exploitation rate* of small hydro potential reached around 32% in 2002. With an overall generation of 48 TWh, considering the technical potential of 86 TWh, the small hydro

[7] The data step is at 483 MWh MWh/year/km^2 in Norway (NO01)

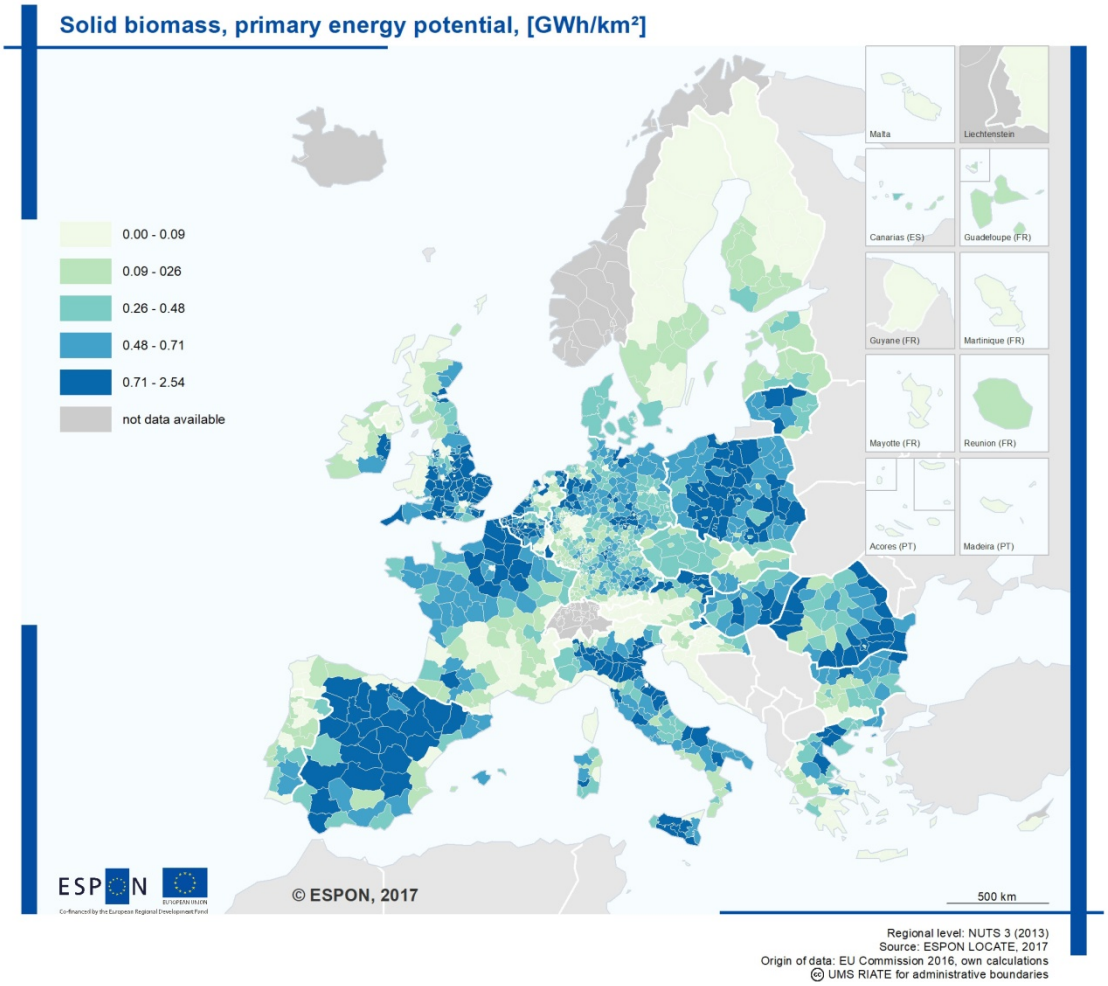
[8] Standard Deviation: 49,14 MWh/year/km^2

potential remained untapped in 2002, reaching a value of nearly 55%. The highest exploitation rates can be observed in France and the basins related to the Alps. Relatively low exploitation rates can be found in middle and eastern Europe as well as in Spain. Up to 2012 the exploitation increased especially in Germany and also other regions with an initially lower potential exploitation, reaching an average rate of 36%. The total generation is summing up to 62 TWh, representing around 72% of the technical potential.

2.4 Biomass

This study makes use of the existing classification of biomass feedstock in the Green-X model of TU Wien. It distinguishes three main types of biomass feedstock categories, consistent with the Biomass Energy Europe (BEE) project: Forest products and forests residues (following map), energy crops as well as organic wastes (for the latter two, please see map in the Annex/Scientific Report). A European study (EC, 2017), done on behalf of the EC, DG ENER aimed at ensuring the sustainable production and use of bio energy in the EU beyond 2020, forms the basis for the potential of the different biomass potentials. Within that project an intensive review of biomass supply potentials and demand pattern has been conducted for each EU Member State, offering a sound basis for our follow-up analysis at regional level. Within this report, a review of recent literature was conducted; the aim was to identify updated 2030 biomass supply capacities from forestry, agriculture and waste that could be available for the EU, through sustainable domestic production or imported from international markets. Further, based on the overall bio energy supply potential on NUTS0 level divided by the different types of feedstock listed above, the current and expected use of biomass for material use, food and feedstock use was subtracted. As such the total primary energy potential is shown in Map 2.6.

Map 2.6: Primary potential of solid biomass in GWh/km²



2.5 Measures for mobilising identified future potentials

This section discusses measures for mobilising the identified potentials. Therefore, the current policy framework for supporting RES is analysed and best practice policy schemes are derived.

In the National Renewable Energy Action Plan, each EU Member State explains how it intends to reach its binding target by 2020. That includes a description of current and planned policy measures. The main support policies for Renewable Energy sources sector are:

Independent financial state budgets and market based support schemes

- Feed-in tariffs (FIT)
  - Administrative set feed-in tariffs
  - Auction based feed-in tariffs
- Feed-in premiums (FIP)
  - Administrative set feed-in premiums
  - Auction based feed-in premiums
- Quota obligations
  - Administrative set quota system
  - Auction based quota system

State budget financed support schemes

- Tax exemptions
- Investment grants
- Subsidies[9]

Regulations and taxation

- Building codes requirements
- Use obligation for RES-H/C
- Ban of fossil fuel technologies
- Taxation of fossil fuels or CO_2

Feed-in tariffs guarantee a fixed price per amount of energy fed into the grid by renewables.[10] Therefore, new renewable technologies are independent from price risks. This excludes producers from actively participating in the market and thus overcompensation is very possible.[11] *Feed-in premiums* are an advanced version of feed-in tariffs. Depending on the price achieved at the electricity market, the plant operator gets an additional payment. Thus, it is assured that the plant operator is participating at the energy market and market signals reach the renewables.[12] Feed-in tariffs and feed-in premiums are called supply-push instruments.

On the other side, there are demand-pull instruments such as *quota systems.* Thereby, the amount of electricity produced by renewables is fixed (for example by Tradeable Green Certificates). It is therefore possible for renewable energy plant operators to sell certificates, which helps to enable a market between renewable producers and suppliers of energy and other market players.[13] Quota based systems such are *energy saving obligations* and white certificates systems are also effective market based instruments for supporting energy efficiency in European Members States. Thereby, energy suppliers are obliged to conduct and certificate certain amounts of energy savings. Depending on the design, also RES-H/C systems such as solar thermal collectors, heat pumps and biomass boilers are eligible in the system. In preparation for the proposal for the recast of the Renewable Energy Directive, the EC suggested a RES-H/C quota system which would be limited to RES-H/C systems only.

Tenders are a process where the level of support is allocated by a competitive bidding procedure. This procedure can prevent the overcompensation of renewable energy producers and can lead to a reduction of support costs. This is possible because a tender has several criteria, such as the amount of energy generation, the capacity deployed and also the maximum setting of a price. All these criteria make support costs more predictable. The disadvantage of such a scheme is the rise of higher transaction costs, due to the fact that there are more bure-

[9] Delivering the internal market in electricity and making the most of public intervention (https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention_swd04_en.pdf)

[10] towards 2030 D4.2: Ex-ante assessment of potential gap-avoiding and gap-filling instruments regarding the 2030 RE target

[11] Delivering the internal market in electricity and making the most of public intervention (https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention_swd04_en.pdf)

[12] Ibid.

[13] Ibid.

aucratic procedures and planning requirements. This could lead to the problem that only large-scale investors can afford to participate in tendering schemes. Depending on the design of a tendering scheme, the technological diversity of installed plants might be limited. However, this could be solved by setting up technology specific tendering procedures, for instance for wind energy and photovoltaics (PV). Tendering schemes are suitable for developed RES markets in which competition is likely to lower costs. The European Commission wanted to strengthen cost competitiveness of renewable technologies and therefore, requested all EU Member States to introduce competitive tenders from 2017 onward.[14]

Investment support exists in various forms as *grants, soft loans, tax exemptions* or reduction. They can be an advantage if incentives are not necessary or desired or if the market itself gives an adequate production signal. Furthermore, it can initiate the expansion of mature technologies with high up-front costs and is additionally a one-off measure, which means no readjustments at a later state.[15] Investment grants are currently the main support mechanism for renewable heating and cooling (RES-H/C) technologies in the EU Member States.[16]Tax exemptions are available indirectly for all taxpayers but not for energy consumers. The Directive 2003/96/EC allows tax exemptions or reductions for bio fuels and also for electricity produced by solar, wind, tidal, geothermal and hydraulic devices. These instruments should be used with caution as the Commission service declares there is a need to uphold the budgetary consolidation efforts of Member States.

Regulations are especially important for supporting RES-H/C technologies. Thereby, requirements defined by the national building codes support not only the uptake of energy efficiency measures but also efficient and renewable heating systems. The Energy Performance of Buildings Directive (EPBD) requires Member States to implement the so called “Nearly-zero-Energy building” standard for all new buildings by 2020 in national legislations. The Directive defines it as a building with very low energy demand which is mostly covered by renewable sources.

A few countries such as Germany have implemented direct *use obligation for RES-H/C,* requiring owners of new buildings or existing buildings, in case of major renovation or heating system change, to source a certain share of their heating demand by RES. Actually, all Member States are required to implement such a regulation according to the current Renewable Directive. A complete ban of fossil fuels for new heating installation is another effective regulation which has been implemented by Denmark.

An economic *price based approach* increases the price of fossil fuels in order to support RES. Since the European Emissions Trading Systems addresses only large power plants and in-

[14] Ex-ante assessment of potential gap-avoiding and gap-filling instruments regarding the 2030 RE target

[15]Delivering the internal market in electricity and making the most of public intervention

[16] Status and perspectives of renewable energy policy and deployment in the European Union—What is needed to reach the 2020 targets? by Corinna Klessmann, Anne Held, Max Rathmann, Mario Ragwitz

dustrial consumers, there is effective price signal for households or services to change their heating systems to RES. Even though taxation of energy is required by the Energy Taxation Directive, most Member States have only very low tax rates for fossil fuels. Countries such as Sweden and Denmark have proven that high CO_2 taxation is an essential policy for guaranteeing stable market conditions for RES.

3 Regional policy approaches and actions that facilitate the transition to a low-carbon economy

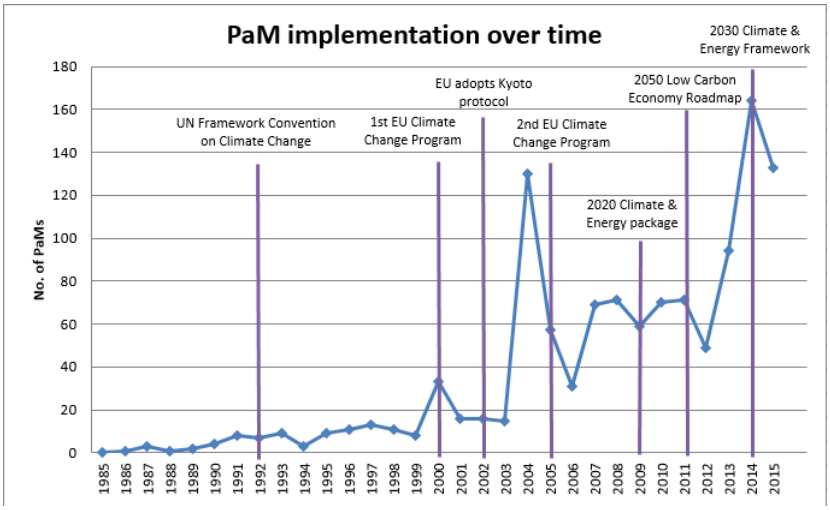
3.1 Introduction

This task aims to trace how Policies and Measures (PaMs) instigated at the EU level are promulgated down to the national and sub-national levels of governance. It highlights how far national governments are able to adapt PaMs to fit to their particular circumstances. It also aims to investigate whether the level of regional autonomy within a country has any impact on that country's ability to make the transition to a low carbon economy. This will be examined through the analyses of Regional Authority Index (RAI) and the data provided by the quantitative research work on regional energy consumption and renewable energy production. Based on these analyses, illustrative examples have been selected for more in-depth understanding of the multi-level governance approaches to the transition to low carbon economy. Based on an analysis of the illustrative examples a number of policy recommendations will be proposed to assist regions and their national governments to transition to a low carbon economy.

3.2 Overview of Policies and Measures (PaMs)

Following the EU ratification of the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, the EU Member States have provided information on the types of PaMs that they have planned, adopted, and implemented to move towards a low carbon economy. The collection of national data was formalised under the EU Monitoring Mechanism Regulation (MMR) in 2014 and the first set of data collected under MMR was published in 2015. The analyses in this report are based on the latest data (2016) which although not published at the time of writing, has been made available to the research team by the EEA.

Figure 3.1: PaM implementation over time



Source: Author based data provided by EEA

Figure 3.1 shows how the number of implemented PaMs has fluctuated over time with two peaks in 2004 and 2014. Whilst it is difficult to speak of a direct cause and effect relation, the fluctuation could be due to international climate change-related policy initiatives. The graph shows the relationship between international initiatives, such as the UNFCCC and the Kyoto Protocol, and EU level PaMs. This is evidence of how international treaties are translated into EU level PaMs and then to national legislation.

By 2016 there was a reported total of 1,323 individual PaMs across the 28 EU Member States, ranging from the lowest number of PaMs in Luxembourg with only five PaMs to the highest in Belgium with 123 single PaMs[17], followed by France and Romania. While the size of a country seems to be a factor, there are exceptions. For example, two large countries, Greece and Poland, have introduced only 36 PaMs and are the 3rd and 4th lowest numbers. In terms of the entity responsible for implementing PaMs, it is the national government that dominates. 72% of PaMs are implemented by national government alone. This contrasts with regional government which is only responsible for implementing only 6.5% of PaMs.

Types of instruments used for implementation of PaMs

The IPCC Report on Climate Mitigation has since 2007 provided a classification of policy instruments and measures that are used to enable transition to low carbon economy. These include: economic instruments, regulatory approaches, information programmes, government provision of public goods, and voluntary agreements. While in principle these policy instruments are capable of dealing with the entire low carbon economy, in practice they are often targeted to particular sectors or industries. Drawing on this classification, the PaMs report uses eight types of policy instruments (EEA: 2015: 25).

Overall, economic and regulatory instruments are the most often used accounting for 61% of all PaMs. Research and "other category" are the least frequently used. Economic and regulatory instruments are also dominant across most Member States (21 Member States use them in over 50% of cases).

A small minority of countries seem to favour a particular type of instrument. The most extreme case is Luxembourg, which is more skewed towards informal PaMs. On the other hand, Bulgaria has very few informal PaMs and favours financial and regulatory PaMs. In Spain, planning is the dominant policy instrument (EEA, 2015).

Sectors targeted by PaMs

There are seven economic sectors that are targeted by PaMs: energy consumption; transport; energy supply; agriculture; waste; land use, land use change and forestry (LULUCF); and industrial processes. It is possible that a PaM may target more than one sector, meaning that

[17] Though this is partly due to the federal governance structure in Belgium with the three regions replicating the same PaM.

each PaM can be associated to more than one sector. It is also possible for a Member State to report a PaM that targets more than one sector as being "cross-cutting".

The overall distribution of sectors targeted by PaMs varies significantly between the EU Member States. For example, Estonia has a significant proportion of PaMs targeting the LU-LUCF sector. These differences might reflect the physical or economic characteristics of a country, suggesting that it might make more sense for individual countries to target the sector(s) that most significantly contribute to GHG emissions in their respective context.

3.3 Development of regional typologies

In developing clusters of regions two factors were used: the extent to which a region has progressed to a low-carbon economy and the degree of regional authority. Table 3.1 shows how the regions are placed in 1 of 9 clusters.

Table 3.1: Methodology for the selection of regional clusters

Reg Performance (from Task 1) / **Regional Governance (RAI)**	**Good progress**	**Medium progress**	**Low progress**
High authority	Cluster 1 regions	Cluster 2 regions	Cluster 3 regions
Medium authority	Cluster 4 regions	Cluster 5 regions	Cluster 6 regions
Low authority	Cluster 7 regions	Cluster 8 regions	Cluster 9 regions

Source: Consortium 2016

Regional authority is explored in terms of self-rule and shared rule, which when measured create the Regional Authority Index (RAI) (Hooghe et al., 2016). Self-rule is evaluated through five dimensions: institutional depth, policy scope, fiscal autonomy, borrowing autonomy, and representation. The five dimensions evaluated for shared rule are: law making, executive control, fiscal control, borrowing control, and constitutional reform.

'To measure a region's transition to a low carbon economy a synthetic indicator was created using data from the project's quantitative research work on regional energy consumption and renewable energy production.

To produce an overall score which measured a *region's progress* towards a low carbon economy a composite index was created. Unfortunately, only data for Solar PV, wind energy and energy consumption in buildings were sufficiently complete across all regions to be used in the analysis. Therefore, the three variables used to create a low carbon score were: change in the Solar PV exploitation rate 2002-2012; change in the amount of wind energy capacity for a region in MW/km^2 2002-2012; and change in the energy consumption by all buildings (domestic and commercial) in GW/per capita 2002-2012.

Solar PV and wind are by far the biggest contributors to renewable energy and have the biggest physical impact in terms of their deployment. In terms of consumption, buildings account

for 40% of energy used in the EU and 36% of CO_2 emitted, so they serve as a useful proxy a region's effort in reducing greenhouse gas emissions through energy efficiency.

From the synthetic variable a regional score was generated. The regions were then ranked according into their overall score and divided into poor, medium and good scoring regions. The scores seek to express progress made rather than the absolute level of attainment[18]

Table 3.2: Distribution of regions by cluster

			RAI score			Total
			Low	Medium	High	
Progress to Low Carbon Economy	Poor	Count	**52**	20	12	84
		Expected Count	**33.5**	25.1	25.4	84.0
	Medium	Count	37	**41**	24	102
		Expected Count	40.7	**30.5**	30.8	102.0
	Good	Count	22	22	**48**	92
		Expected Count	36.7	27.5	**27.8**	92.0
Total		Count	111	83	84	278
		Expected Count	111.0	83.0	84.0	278.0

By combing the RAI score and the Low Carbon score the matrix of clusters shown in Table 3.1 was completed. Table 3.2 shows the distribution of regions across the nine clusters and the Chi-squared cross-tabulation of the matrix. The results show a significance level of <0.00 indicating that the results are highly significant.

The highest number of regions fall in the Low Regional Autonomy/poor progress sector of the matrix and this is significantly more than would be expected if the regions were uniformly distributed. There are also significantly more regions in the High Autonomy-Strong progress sector of the matrix. Conversely there are fewer regions than expected in the High Autonomy/Low progress and Low Autonomy/Good progress clusters of the matrix. This does suggest that there is a positive correlation between the degree of regional autonomy and progress towards a low carbon economy. The greater the degree of regional autonomy the greater progress towards a low carbon economy a region seems to be making. However, what is not clear from this data is the direction of the causal link between the two. The inference from our research shows that higher regional autonomy is resulting in a stronger progression to a low carbon economy but these results do not allow us to establish this for certain. More data across a wider range of indicators is needed before the link between regional autonomy and progression towards a low carbon economy can be established with a greater degree of certainty.

[18] We acknowledge that this approach does have the potential to skew the data, as countries that have already achieved a high level of renewable energy deployment before 2002 have less scope to make progress.

3.4 Selection of "illustrative examples and examples" in-depth study

Selection process

Three cluster were chosen for the illustrative examples: high autonomy/good progress; high autonomy/poor progress; and low autonomy/good progress cluster. These offered the most interesting insights into the relationship between governance and the transition to low carbon economy.

The final selection of the 8[19] illustrative examples was done on the basis of PaM analysis to ensure representation of the various key instruments employed at the national level (see Table 3.3). Further fine tuning of examples were carried out in consultation with ESPON EGTC to ensure that the selected examples represent a territorial balance both geographically and with regards to other relevant territorial specificities. In a cluster where there was more than one candidate region (e.g. cluster 1 – Financial PaMs contained a number of German Länder), the original data was examined to select the best-case example. Regions that were subject to a case study of the project were excluded from the selection of illustrative examples to avoid repetition. In comparison to the case studies, the illustrative examples were based on a smaller number of interviews in order to highlight certain aspects of the relationship between low carbon transition and governance and to gain information about particular aspects of the issue. Though the aim was to interview two or three key stakeholders per illustrative example, this has not always been possible due to time constraints and difficulties in securing interviews.

By exploring illustrative regions within each cluster, this stage of the project aimed to gain a richer understanding of the drivers and barriers to implementation of PaMs at the regional and sub-regional levels. Particular emphasis was put on finding innovative initiatives, notably in involving and partnering with the private and voluntary sectors and communities, lessons learned and the potentials for transferability of good practices.

Table 3.3: Methodology for the selection of illustrative examples

PaM Instruments	**Financial**		**Regulatory**		**Informal**			
Regional clusters	**eco-nomic**	**fiscal**	**regula-tory**	**Planning**	**volun-tary**	**infor-mation**	**research**	**educa-tion**
Cluster 1 regions High progress & high authority	Region in a country with highest no. of financial PaMs		Region in a country with highest no. of regulatory PaMs		Region in a country with highest no. of informal PaMs			
Cluster 3 regions Low progress &high authority	Region in a country with highest no. of financial PaMs		Region in a country with highest no.r of regulatory PaMs		Region in a country with highest no. of informal PaMs			
Cluster 7 regions High progress & low authority	Region in a country with highest no. of financial PaMs		Region in a country with highest number of regulatory PaMs		Region in a country with highest number of informal PaMs			

Source: Consortium 2016

[19] Cluster 3 – Informal PaMs sector had no regions within that category

In-depth study of illustrative examples

Table 3.4 shows the final selection of example regions for each cluster. It also gives an overview of the key messages from each example. It is clear that there is a mix of top down and bottom up initiatives. Also the history of the region, both in terms of governance and socio-economic heritage, has a significant impact on the regions ability to engage in the transition to a low carbon economy.

Table 3.4: Final selection of regions and overview of examples

	Predominantly use Financial PaMs	**Predominantly use Regulatory PaMs**	**Predominantly use Informal PaMs**
Cluster 1	**Germany**	**UK**	**Belgium**
High Regional Authority and strong Transition to low carbon economy	Rheinland-Pfalz Strong federal structure allows states to take control of their own policy and tailor it to their own needs and circumstances. Evidence of cascade of policy down to the region	Scotland Strong independence discourse linked to transition to low carbon economy. Focus on domestic energy capacity and a circular economy	Antwerp A tension between EU and national PaMs and regional implementation. Belgium's strong regional governance can cause delays in taking a top down approach
Cluster 3	**Switzerland**	**Finland**	***No regions***
High Regional Authority and poor Transition to low carbon economy	Nordwestschweiz Sitting outside the EU some flexibility to create own PaMs. Strong initiatives but needs better implementation.	Åland Difficulties of taking action in a small peripheral region dominated by one industry. Only now starting to plan strategically for a low carbon economy.	
Cluster 7	**Czech Republic**	**Greece**	**Republic of Ireland**
Low Regional Authority and strong Transition to low carbon economy	Moravian-Silesian Dominance of EU policies and measures in the shift to a low carbon economy. Very much a top down approach to developing capacity.	South Aegean Influence of financial crisis developed a green narrative to progress a low carbon economy. Significant physical barriers, i.e. infrastructure.	Southern Region Lack of devolved competency countered by a bottom-up approach using international initiatives such as C40 and Covenant of Mayors.

The studies on regional policies and measures have sought to understand the relationship between international initiatives on climate change and the transition to a low carbon economy and the national and sub-national efforts made by ESPON countries to implement these initiatives. In section 3.2 we showed the strong link between global initiatives, such as the Kyoto Protocol and the UNFCCC, and their translation into EU legislation, and in-turn their adoption by Member States and transposition into national policy. The analysis of the EEA's annual returns also emphasises the importance of the subsidiarity principle within the process, with Member States tailoring PaMs to their national circumstances.

Using this data on national implementation of PaMs, we have selected a number of illustrative examples to investigate in more detail whether the degree of autonomy of a region has an impact on a region's ability to progress to a low carbon economy. The statistical analyses indicate that there is a strong statistical relationship between the level of regional autonomy and progress towards a low carbon economy. Table 3.2, above, for example, shows the over-

representation of regions in the low regional autonomy/poor progress and high regional autonomy/good progress clusters of the matrix.

Whilst this does not indicate causality, it does show a strong correlation between the two factors.

Within the illustrative examples there seems to be a tension between the process of implementing top-down PaMs and the ability of regional governments and institutions to have a meaningful say on the process. This was particularly evident in the Belgium example with a political impasse between national and regional level government delaying the implementation of key low carbon targets. In areas with lower levels of regional autonomy and perhaps less institutional capacity, it has been the implementation of EU level PaMs that has driven the transition to a low carbon economy, as is the case in the Czech Republic.

The illustrative examples have also highlighted that the influence of international initiatives extends to the regional level. In the case of both Åland and the Southern Region in the Republic of Ireland, the strategies developed at the regional level are heavily influenced by the international initiatives rather than national policy measures. In addition, there is also evidence of the influence of international bottom-up initiatives, for example, the Covenant of Mayors in the case of the Republic of Ireland. It seems that regions are therefore seeking to look above their respective national government for inspiration for their initiatives on the low carbon economy. Indeed in the case of Scotland it is an attempt to be ahead of the national government both in policy terms and in actual progress to a low carbon economy. They are engaging in both top down initiatives, such as the Paris Agreement and EU PaMs, as well as more bottom-up peer to peer initiatives, such as the C40 and the Covenant of Mayors. In both cases, the historic and evolving relationships between the regional and local levels and the national level of governance have played an important role in determining regional responses to the transition to a low carbon economy.

There is also an interesting link between the transition to a low carbon economy and regional discourses around greater autonomy. In both the Scottish and Åland examples, the need to move away from a reliance on imported energy was seen as a strong driver for additional policies and measures whilst at the same time bolstering the calls for greater autonomy, in the case of Scotland, or maintaining their autonomy in the case of Åland. These examples show the power of building a narrative of political autonomy linked to the idea of energy self-sufficiency.

The Swiss and German examples show how a strong multi-level governance approach can be used to make the transition to a low carbon economy. Collaboration between national and regional government can design and implement PaMs that are effective and geared to the regions circumstances. This is difficult to develop in the short term however and needs a balance of power between the governance levels and a continuing dialogue. The last illustrative example to mention is Greece and the difficulty in making progress with both limited regional authority and significant physical barriers to implementing PaMs to foster a low carbon economy. Progress is being made through a combination of regional collaboration between institutions, a triple-helix approach, and through levering external resources through networks and EU structural programmes.

3.5 Conclusions on regional policies and measures

A number of themes have emerged from the illustrative examples which highlight the issues facing regions as they seek to transition to a low carbon economy. The strongest theme that has emerged is the significance of framing. In the more peripheral regions, Åland and Scotland for example, the narrative around the low carbon economy has been framed in a way that ties it to narratives of independence and sustainability of the region. In the South Aegean example the framing came from a national narrative around moving on from the severe financial crisis that hit the country in 2008. In other regions, the transition to a low carbon economy was framed as a moral decision and as a way of standing with other regions in taking action in response to climate change. In most, if not all of the examples, the process of developing a common framing for the transition to a low carbon economy was done through an open and collaborative process. This often took the form of a quadruple-helix of stakeholders: public sector, private business, academia and civil society. Only once this common framing had been agreed upon could the region start to develop a roadmap for the transition to a low carbon economy. This is the model already advocated by organisations such as the Covenant of Mayors and C40 cities.

Policy recommendation 1 – A quadruple-helix approach to implementing Policies and Measures is key to their success

The transition to a low carbon economy is difficult, complex and not guaranteed to succeed first time. However, adopting a quadruple-helix approach to developing and implementing policies and measures, could assist this process. A quadruple-helix approach is one in which the regional authority collaborates with the academic, private sectors and the community of the region in the transition to a low carbon economy. This could also lead to a greater degree of experimentation and creativity in finding solutions to make the transition happen. Our illustrative examples contain a number of examples where this is already happening, Åland and Tipperary have progressed furthest down this path. In both cases, one of the first stages in developing a strategy and vision to transition to a low carbon economy was to bring together the various institutions from the region and engage the citizens in the debate. This approach does not ensure success but it does make it more likely.

Policy recommendation 2: Provide the resources to allow institutional capacity to be built at the regional level. Time (and continuity) is also needed to develop the necessary institutional capacity.

The illustrative examples have shown that as well as having powers delegated to regions in relation to the low carbon economy, regions also need the capacity to lead on these issues. As we have seen capacity can be built from both the bottom-up and through well constituted multi-level governance processes. Examples such as Tipperary and the South Aegean regions show how broad networks such as Covenant of Mayors and C40 as well as networks for specific types of regions i.e. DAFNI in Greece, can share knowledge and learning between the regions. This takes a number of forms including sharing strategies and standard frame-

works for tackling the challenges as well as more active programmes of research and experimentation through EU funded programmes such as INTERREG.

In the case of Rheinland-Pfalz a strong federal system of governance has fostered a system of multi-level governance which has allowed regions to develop individual programmes to transition to a low carbon economy within the national framework – Energiewende.

This process of capacity building takes time and does not always deliver immediate tangible results. This means many regions have created new institutions (Aland's bärkraft.ax network) or formed stable partnerships between a coalition of regional institutions to tackle the transition to a low carbon economy (Scotland's Edinburgh Centre for Carbon Innovation).

Policy Recommendation 3 – Regions must develop a common, shared faming of the issue as a first step in the transition.

Having secured the collaboration of all relevant actors (policy recommendation 1) and institutional capacity (policy recommendation 2), the final policy recommendation consist of the need to provide resources to regions to allow them to develop a framing of the problem in a way which is relevant and resonant to their region. This takes time, particularly to ensure all elements of the region within the quadruple-helix are meaningfully engaged in the process. There are excellent resources out there already to guide regions through this process, though more could be done to promote these and to assist in the peer to peer learning that is necessary to ensure their success.

Greater devolution of planning and regulatory powers to regions can assist in the development of low carbon policies and measures. In some examples there was a good multi-level governance relationship between national and regional level but this was not uniform. However, in the Belgium example, the strong federal structure actually hampered top down multi-level governance as autonomous regions could not agree the division of carbon targets derived from EU policy. The matrix analysis showed a clear positive relationship between higher levels of devolved authority and progress to a low carbon economy. This perhaps reflects the ability of regions with control over taxation and regulation to tailor policies and measures to their regions specific situation. This relates not only to the physical infrastructure of the region and potential for renewable energy it possesses but also to the socio-economic conditions of the region. However there was also a cluster of regions which have made strong progress towards a low carbon economy but have little devolved governance. In these examples it was the capacity for collaborative working, both within and beyond the region that has been a catalyst for action. In the Irish example, Tipperary Council used the framework provided by the Covenant of Mayors to bring together a coalition of stakeholders to develop an action plan. Similarly in the Southern Aegean example networks such as the DAFNI network are able to convene the necessary stakeholders to tackle the issues. This capacity building requires a commitment of resources from both national and regional governments, and time for developing trust and understanding.

4 Regional action towards a European low-carbon economy – experiences from case study regions

4.1 Introduction

Regions[20] and cities can be important drivers of low-carbon development. At the same time, regions' prerequisites differ considerably and the appropriate transition path comprises measures in all sectors with a wide range of possible approaches and solutions and the involvement of various stakeholders. For regions seeking to make progress towards a low carbon economy, the region needs to motivate stakeholders whilst at the same time, have regard for the existing economic, physical and cultural capital. One of the major challenges is to combine governmental activities at national, regional and local levels in a coherent way. Another challenge is to follow a holistic and coordinated approach in order to ensure horizontal implementation of sector policies and top down legislative requirements as well as balancing local prerequisites, options and needs within (and for) a specific region. In addition, regions successfully stimulating private sector activities to complement their own efforts, are able to raise investment levels without necessarily enlarging public spending.

> *"Many regions have a very complex policy context for renewable energy, usually encompassing a number of sectoral policies – such as energy and environmental policies – and more holistic ones, such as regional and rural development policy. In general, the incentive schemes for renewable energy come largely from the national energy sector and the emphasis is on increasing the level of deployment. This policy has to percolate through different levels and policy frameworks, with every tier adding complexity to the general policy target. Multiple objectives driven by different policies can generate confusion." (OECD, Linking Renewable Energy to Rural Development, Executive Summary Brief for Policy Makers)*

Hence, the major question was to identify regional stakeholders' and regional decision makers' room for action and their most important fields of intervention as well as lessons learned from ongoing processes and success stories. In order to provide a large spectrum of information on regional low-carbon development in practice, the case study work is based on two tiers of analysis: new case study work on five selected regions and a comprehensive additional meta-analysis of thematically focused European initiatives and research projects, depicting more than 40 published case study results with regional experiences[21]. For gaining an

[20] Please note: According to the majority of available case study reports, this chapter focuses on a definition of "region" which is comprising one or several NUTS

3 regions (also indicated by the term "(sub-)regional"). In most cases, these regions are areas of common characteristics, functional relations and/or identity but do not dispose of (sub-national) legislative power. Often they even do not have formal regional planning competences.

[21] Regional case study reports from following sources: ESPON GREECO – Territorial Potentials for a Greener Economy (2014), CEP-REC – Regional Energy Concepts (2014), EU2020 going LOCAL (2012), MANERGY (2012) and Regions4GreenGrowth (2012/2013).

even broader geographical coverage of findings, we analysed European research on regional low carbon development from similar projects which did not provide comprehensive regional case studies in written reports but referred to specific regional situations in their main report.[22].

These experiences, conclusions and recommendations on the implementation of low-carbon development practices at the regional level have been taken into consideration together with findings from ESPON Locate's comprehensive regional case study work. With the two main tiers of information (case studies and meta analysis) we achieved nearly full coverage of European countries' experiences which have been evaluated in an integrated way, in order to make best use of the available information. For further information on the findings from our case study regions (Burgos/ES, Greater Copenhagen/DK, Greater Manchester/UK, Pazardzhik/BG and Rheintal/AT), please refer to the annex.

4.2 The role of regional implementation – regions' room for action

Implementation at regional level, particularly below NUTS 2 level, needs the close cooperation of municipalities, particularly for projects such as a large district heating system in densely built up urban areas or for are building up regional platforms for an energy and resource efficient economy, and obviously, for transforming mobility within a region.

> *"The aspect of scale determines how concrete measures and actions can be defined. A strategy on a regional scale means uncertainties on a local level will stay unresolved and more detailed strategy for parts of the region is needed. A strategy on local scale means some measures will be appraised as unfeasible or cannot be implemented because they need regional consensus. This may be the case for biomass and large wind or solar parks. Biomass and waste heat are measures that require connection on a logistic or infrastructural level. Thus the borders of an energy strategy may have to be flexible according to the energy measures." (North-Sea-SEP, Final Compendium, 2013)*

Additionally, regions may act as intermediary body, translating and implementing EU and national policies to the regional context and level, by making use of synergies between municipalities' actions, by supporting resource pooling and stimulating less ambitious municipalities within a region.

> *"In that complex arena of different stakeholders the role of the Region is important. The leadership of the Region is most effective in an equivalent and facilitating mode: ready to involve partners, to listen to the stakeholders and willing within to adapt schemes, instruments and even operational goals as long as the joint agreement leads to the long*

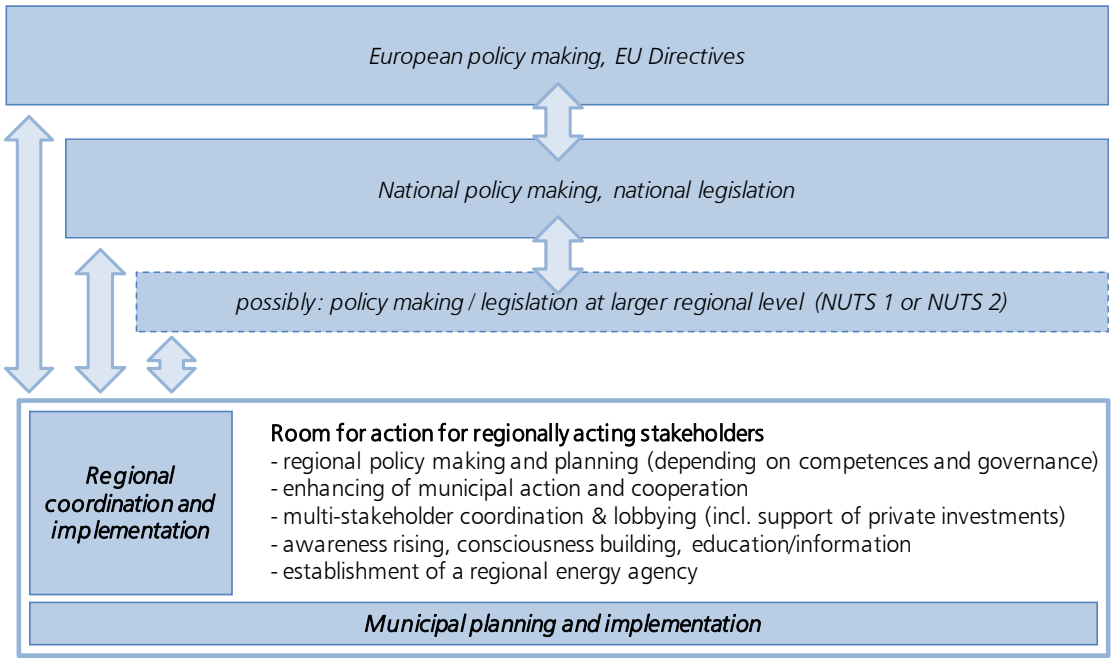
[22] Further research projects on regional low carbon development including regional cases: LoCaRe – Low Carbon Economy Regions (2013), ENERGY REGION (2014), ANSWER – A North Sea Way to Energy-Efficient Regions (2012), VISNOVA – Clean energy from rural regions (2014), GreenPartnerships – Local Partnerships for Greener Cities and Regions (2015), North SeaSEP – North Sea Sustainable Energy Planning (2013), recharge.green – Reconciling Renewable Energy Production and Nature in the Alps (2015), Coopenergy (2016).

term goal of a low carbon economy." (Vollaard, 2013, New Reality, Final Report Lo-CaRe-Project 2010-2013)

The conclusions from a recent workshop "Smart Specialisation in Energy, driving societal challenges" (21/06/2017) in the framework of the Smart Specialisation Initiative, strongly supports the importance of the regional level in fostering technological innovation.

"Finally, the role of regional authorities in implementation of energy priorities is fundamental as they have the capacity to facilitate integration of several initiatives and funding as well as to mobilise territorial actors." (S3Plattform, JRC[23])

Figure 4.1: Low carbon implementation – interrelation between governmental levels and room for action at regional level



Source: ÖIR

Figure 4.1 illustrates the overall system of interrelated governmental levels and highlights the room for action for regional authorities and stakeholders. As presented, close cooperation between the regional and the municipal level by adopting an integrated approach to municipal planning and implementation which takes account of respective regional perspectives, are key for the successful implementation of low carbon development practice at the regional level.

The most important *benefits of regional action* defined as implementation between national/larger regional legislation and municipal planning are:

- coordination and implementation of regional measures;

[23] http://s3platform.jrc.ec.europa.eu/-/smart-specialisation-in-energy-driving-societal-challenges?inheritRedirect=true&redirect=%2Fs3p-energy

- resource pooling (capacities, personal resources, know-how) and creating a critical mass of actors and options;
- direct exchange of experiences between neighbours and positive competition within the region.

These benefits may be supported by focused interventions at the level of the region, which are briefly described below (please refer to the annex for a more detailed presentation of issues to be considered, lessons learned and regional experiences). In order for regional actions to be successful, human resource work capacities and professional knowledge are needed, be it as civil servants or experts working in an intermediary body, an NGO or other regional organisations.

> *"It is to be expected that some contractors will require constant advice during the implementation of their projects. Furthermore, the corresponding specialist knowledge must be conveyed to contractors and other actors in the region. [..] These considerations lead to the conclusion that a coordinating body is necessary for implementation of the energy and climate protection concept." (MANERGY, case study Muldenland)*

4.2.1 Regional policy making and planning – Policy making competences and target setting at (sub-)regional level

Certainly, the respective situation of regional governance including the distribution of competences is decisive for the way regions are able to steer their common development – also in terms of energy. From the study of regional experiences it becomes obvious that only few regions at the level of one or several NUTS 3 have formal competences and common structures at (sub-)regional level. Together with national laws (and the way EU directives are implemented nationally) this governance background has a major impact on the way in which regional energy strategies are formulated. This includes the development of regional strategies' content, the definition of priorities and time perspective (short-term action plans to long-term strategies), and the decision about whether to define (binding/non-binding) quantitative targets and associated monitoring activities or not.

Examples of formal regional competences at a lower regional level may be seen in Bulgaria where the elaboration of regional energy strategies is mandatory (e.g. Pazhardzhik) or in Italy with its regional burden sharing approach: Here the state has passed national targets on to the regions (renewable heat and electricity targets) which are now obligated to contribute via a binding regional renewable target (e.g. the region of Friuli-Venezia Giulia, according to CEP-REC).

Burden sharing and contribution at regional and local levels is also relevant for achieving energy efficiency targets. Correspondingly, one of the main recommendations from the Feedback Loop Report focussing on the implementation of energy efficiency measures in all EU

countries (Energy Efficiency Watch Project[24]) was to strengthen the role of regions by including quantitative targets at local or regional level in the requirements of the Energy Efficiency Directive (EED).

> *"According to viewpoints from the local and regional level, the national energy efficiency target should be broken down by sector. This could result in specific national plans, which in turn should be devolved to the regional and/or local level. While this is already the case in some countries, including it as a requirement would make this practice more widespread. By specifying this in the EED, regional and local bodies would gain a greater authority to set their own targets and plans and be able to monitor these effectively – for example by obtaining data from the industry, including energy network operators." (Efficiency Watch 3 Project, 2016, page 91)*

The above cited quote highlights both, the lack of competency for a certain share of regions as well as the challenge of obtaining appropriate, actual data on energy consumption and production at the (local and) regional level.

> *Additionally, in some countries also incentives and planning support (reducing non-economic barriers) have been introduced successfully by regional authorities in order to contribute to low carbon development: "The incentive system allows for long term planning, so the investor can have a clear picture regarding the return rate of their investment and accordingly make a strong business plan which banks are also willing to support financially.*
> *As an added benefit, the Abruzzo Region issued guidelines where they clearly indicated the places where is permitted to install the wind turbines which save the investors a lot of planning time". (R4GG, case study Abruzzo, peer review)*

Finally, the alignment of EU, national, regional and local policy making is most important, as it allows to align climate and energy policies at different levels, as well as climate and non-climate regulations (Fujiwara, et.al., 2017).

4.2.2 Enhancing municipal action and cooperation

In addition to elaborating regional strategies and plans, regional actors may support local actors in decision making. Although municipalities form the lowest level of governmental actors, they have powerful competences for local planning (mainly spatial planning), implementation (municipal buildings, service facilities, vehicle fleet) and function as a role model for communities in terms of behaviour and implementation of projects.

> *"Real action is usually done at the local level, and it is therefore important that also the regional energy and climate strategy leads to strategies and action plans on county and municipality level. These local strategies and plans should of course connect to the re-*

[24] FEEDBACK LOOP REPORT, Progress in energy efficiency policies in the EU Member States, Findings from the Energy Efficiency Watch 3 Project (2016), Stefan Thomas et.al. (Wuppertal Institut)/Ecofys/OÖ Energiesparverband/Eufores/Energy Cities/Fedarene/eceee (pg.91)

> *gional strategies and plans, but also incorporate the local conditions." (R4GG, case study Lazio, peer review)*

In addition, large differences have to be stated in terms of *local energy concepts.* Some countries have defined the top-down obligation for local energy concepts (e.g. Slovenia, Bulgaria), though major differences exist in terms of ambition and requirements. In other countries, the national (or larger regional) level provides incentives for municipalities to elaborate local energy concepts (e.g. Austria). In this case the focus is put on ambitious local actors. Even if there is a legal obligation for elaborating local energy concepts for municipalities, support at regional level is essential, as human capacity is often missing in small municipalities.

Regional signatories to the Covenant of Mayors ("CoM-signatories") provide support for municipalities. Their contributions are mainly based on supporting the implementation at local level (promote accession to CoM, provide assistance and financial support to CoM-municipalities, reporting, support experience and knowledge sharing between – existing and potential – Covenant signatories, cooperate with other supporters and participate in CoM activities).

4.2.3 Multi-stakeholder cooperation and lobbying – regional partnerships

The transition to low carbon development and economy will not be possible without considering governmental levels of implementation, cooperating with various stakeholders, as well as interacting with an active civil society. Whereas multi-level cooperation (in terms of governmental levels) is legally binding and implemented widely, cooperation with stakeholders from various fields, including the wider population, is much less regulated and depends on the ambition, knowledge and capacities within regions.

> *"The social and economic benefits to the community of maintaining investment in these activities needs constantly to be brought to the fore. The links with ensuring growth of the quality of the regions must be underlined, so citizens and investors have a common interest in success. The Regions have an important role in the transition to a Low Carbon Economy." (Vollaard, 2013, New Reality, Final Report LoCaRe-Project 2010-2013)*

Economic stakeholders, businesses, enterprises and research

In reference to the regional economy, partnerships between the region and its municipalities with SMEs and large enterprises, educational and research institutions and NGOs can act as important drivers of a regional low carbon economy. Very good examples of initiatives aiming at a fruitful combination of low carbon development and economic prosperity can be found in our urban case study regions:

- Greater Copenhagen's green growth project applies a quadruple-helix approach that involves government, industry and research institutions, as well as local communities and NGOs. The strategic green growth area laid down in the Regional Growth and Develop-

ment Strategy includes conversion of the energy and transport system and green job creation.

- In Greater Manchester, the transition towards a low carbon economy are led and coordinated by the GMCA Low Carbon Hub (with the Greater Manchester Combined Authority acting as city-region with common planning competences). In addition to the five themes of transport, energy, buildings, natural capital as well as consumption and production, two economically driven cross-cutting work programmes deal with low carbon and environmental services sector growth and skills development.

Strategies such as low carbon related regional clusters, Technology Districts (D.I.T.N.E., Italy[25]) and Smart Specialization Strategies, represent other relevant forms of regional partnerships with the economic sector for the implementation of a low carbon economy. The European initiative for Smart Specialization Strategies is related to technological innovation and intends to support the implementation of the European Energy Union through (regional) bottom up activities. This initiative enables regions to engage and exchange knowledge and relevant approaches. In the framework of the Smart Specialisation Platform on Energy, the so called "S3 Energy Partnerships" offers support for interregional cooperation in five priority fields relating to energy: Bio energy, Marine Renewable Energy, Smart Grids, Solar Energy, Sustainable Buildings. Currently more than 60 EU regions are participating in these partnerships.

> *"These strategies set priorities at national and regional levels to build competitive advantage by developing and matching research and innovation (R&I) own strengths with business needs, to address emerging opportunities and market developments in a coherent manner, while avoiding duplication and fragmentation of efforts."*
> *(http://s3platform.jrc.ec.europa.eu/s3p-energy)*

Cooperations with the economic sector mostly happen voluntarily; businesses and enterprises contribute either because of intrinsic factors or because by supporting regional cooperations, they will gain competitive advantages. As such, voluntary agreements on CO_2 reduction (including e.g. companies' staff in training activities, energy audits or dissemination of best practice solutions) are highly important for including these actors in the overall low carbon development ambitions in any region (LoCaRe, 2013).

[25] D.I.T.N.E was set up in Brindisi in order to strengthen cooperation between research and industrial institutions, competitiveness of the region, international wide visibility and quantitative growth of business and skills in the field of renewable energy and production of electricity. (ESPON Greeco, case study report Apulia)

Support of private involvement

In addition to the involvement of actors representing the economic sector, it is important to include wider society, including private households, in the shift to a low carbon economy at a regional level. In this context, regional level stakeholders may play a key role as trusted motivators and information sources of investment decisions, projects and suitable technologies (especially for the population in small municipalities without capacities to offer such services):

- In the recent past, the cooperation with *Energy Service Companies* – ESCOs – has proven successful in many cases. ESCOs combine energy solutions with a financing model which ensures fixed costs during an agreed pay-back period for the owners while benefitting from energy savings from the beginning. As such, ESCOs guarantee energy savings and/or provision of the same level of energy service at lower cost. Risk minimizing is ensured by the ESCO's guarantee to take over commercial, technical implementation and operation risks over the whole project term (typically 10-15 years) (further information can be found at the ESCO library[26]).
- *Citizens' energy cooperatives* have been documented as another successful approach for involving private households and communities in various regions. Often organized or managed by a regional NGO or by local/regional energy utilities these initiatives provide the option for private persons to support the installation of renewable energy production facilities – usually with a fixed financial contribution and return rate within a given period.
- Finally, several regions have also highlighted the added value of *revolving funds* as an appropriate funding mechanism for financing regional energy projects. In such cases, regional authorities or responsible stakeholders administer and manage funds to be requested for defined projects, typically offering lower interest rates and/or more flexible terms than available commercial capital markets.

4.2.4 Awareness raising, consciousness building, education/information

Overall, the potential of private households for reducing energy demand and increasing the share of renewable energy is substantial, with a variety of options for cost effective measures to reduce carbon emissions. Hence, convincing the regional population will be essential for a successful transition to a low carbon economy.

Communication strategies tailored to the region can help make contacts with the population, capture regional issues, present good practices and specific regional challenges.

> *Education and awareness-raising for citizens and public employees play a key role in understanding why it is necessary to act locally and what can be done by individuals in their homes. Municipalities or regional authorities can take a leading role here. (Green-Partnerships, The final publication, 2014)*

[26] JRC database of Energy Service Companies: https://e3p.jrc.ec.europa.eu/communities/energy-service-companies

4.2.5 Establishment of a regional energy agency

The transition to a low carbon economy requires attention not only to technological change but also to the legal and policy frameworks within which such change happens. Regional authorities are often seeking to balance a strategic, holistic view with the detailed implementation of low carbon projects. This can be difficult and lead to potential conflicts of interest. Therefore, regional energy agencies acting as intermediary bodies are a valuable partner for regional authorities and actors providing specific information and innovation for low carbon transformation.

> *Local and Regional Energy agencies, mainly supported by public authorities, advise local authorities for the implementation of their sustainable energy policies, and often provide as well technical assistance in the design of energy projects and the dissemination of information. These agencies support local development by acting as an intermediary between the local/regional authority and local/regional stakeholders of the energy market. Over the years, the role of Local and Regional Energy Agencies (LAREAs) has been crucial to ensure the delivery of good quality Action Plans and their implementation. (http://www.covenantofmayors.eu/about/local-and-regional-energy-agencies_en.html)*

In general, regional energy agencies play an important role within low-carbon governance systems in many regions. They are supporting implementation and elaboration of strategies, providing human resources, contributing comprehensive knowledge and know-how and promoting the use of national or European funds. Hence, regional energy agencies can be responsible for a large portfolio of tasks, depending on the cooperation agreement with local and regional authorities and the respective competences that they have at those levels.

4.3 Conclusions – regional action matters

Experience from regional implementation shows a wide field of relevant themes and a considerable variety of potential partners (be it municipal authorities, enterprises and businesses from the economic sector, providers of public services, NGOs or private households) and different challenges from region to region.

> *"Experience cannot be directly transferred from one country/region to another, so it is important to understand local needs and conditions." (Lessons learned, SEAP+ project)*

Undoubtedly, regional level actors and institutions can play an important role among the different forces engaging and working for a European transition towards low carbon economy. The following *regional actions and policies* have been identified as important and most *successful* (ESPON Locate reports, other/previous projects):

- *To combine regional with local implementation and to make use of synergies of competences and resources.*
  The local players, especially municipalities, have considerable competences and powers for implementation. For example, strategic planning and land use planning by the local authority (municipality) are key mechanisms to deliver a low carbon economy. Local im-

plementation can be supported by the regional authority to inform local planning decision making (information, consulting, analysis, best practice examples, etc.). Additionally, the coordination between actors and building on synergies at the regional level, can in turn add considerable value to local level activities. Furthermore, some issues have to be jointly solved between municipalities at the regional level, as this level allows for a more strategic, adjusted and balanced view on decisions (e.g. land use decisions for large power plants, dealing with the interrelationship between settlement structures, mobility and commuting as well as energy infrastructure planning, etc.). Particularly for regions with small municipalities and less resources, regional level actors may be instrumental in offering urgently needed capacities by pooling of resources and support for implementation. More in detail, they are able to make use of common options and to cooperate, by offering "benefits of scale", e.g. in applications for European investment projects and research. In order to establish effective sub-national forces, local and regional level actors have to work in a joint and collaborative way.

- *To develop tailored implementation strategies for different economic sectors, energy sources and spheres of everyday life.*
  Each source of renewable energy and each policy sector striving for energy efficiency follows different logics, needs specific knowledge and support, and is influenced by different groups of actors. Often, regional decisions are depending on externally defined framework conditions (from legislation, aid instruments such as feed-in tariffs, quota-based systems, environmental taxes, or from economic actors/investors in case of industrially driven technologies). Since these also may change quickly, regional level transition promoters need a staff of experts with a broad range of specialised know-how to provide for successful project development.
- *To foster collaboration at a regional level to allow regions to develop a low carbon strategy that deals with the specific regional conditions.*
  When seeking to develop strategies for a low carbon economy, regions need to take into account their own specific challenges and opportunities. Any policies or programmes have to be tailored to the physical, regulatory and social conditions of the region. However, that is not to say that regions cannot learn from each other. Best practice can and should be shared between regions. This inter-regional collaboration can also help regions have stronger voice when dealing with national and supra-national initiatives ensuring they take account of the specific needs of regions.
- *To join resources at regional level in order to be able to apply for funding, financial investment aids and research funds.*
  Available funds are as fragmented as the issues of low carbon economy are multifaceted. Such aiding initiatives, including EU policies, are seen as decisive for practical project implementation, but need specific organizational knowledge and resources as the respective landscape is quite complex and the application often demanding. Therefore, continuous evaluation of relevant available funds, coordinated information about concrete aiding options and a specialized task force for application and support of project management is of highest importance.
- *To make use of regional actors' presence in the region and regional knowledge.*
  Local and regional level governance is closer to the regions' actors, businesses and population and as such, they can be more effective for mobilizing the transition than national level institutions. People's trust in unbiased, hands-on information and professional knowledge is an important basis for convincing potential partners and for forming lasting implementation partnerships. Acting for the region with a credible regional perspective is essential for unlocking low-carbon investment from the private sector.

- *To collaborate with the economic sector as a key partner in successful regional low carbon transition strategies.*
  For successful long-term strategies, combining low carbon development with economic development and innovation, is a key issue. Successful regions have proven that addressing climate change and economic growth ambitions can be met in parallel. Furthermore, from the viewpoint of European climate change policy, this is the only option for achieving Europe's objectives until 2020, 2030 and 2050. Thus, regions need to build a platform for bringing together actors from public and private institutions, focusing on real needs and realistic development options, and need to support sustainable cooperation between relevant regional players.
- *To collect relevant information and inform regional stakeholders.*
  Regional low carbon development needs appropriate information at the regional level. A substantial lack of available data has been noted in many regions. This refers to data on recent energy consumption and renewable energy and time series data. Though essential for a profound analysis of regions, the lack of available data poses major challenges for regions, particularly in relation to the elaboration of sound strategies and feasible measures, and to the monitoring and comparison of regions' successes.

From an overall perspective, we found that in contrast to higher spatial levels (responsible for larger sub-national areas, with legislative competences), the smaller (sub-)*regional level can adopt a holistic, cross-sectional perspective and is able to work in an integrated way.* The sub-regional level cooperates with the local level intensively, adding value by pooling resources and finding synergies, and by acting as an important linkage between national and European frameworks and the local level. In many regions, regional energy agencies act as partners of regional authorities providing essential support for low-carbon development.

However, this (sub-)regional level – even if personal resources are provided – often lacks formal responsibility to perform these services and activities and does not possess sufficient political authority to implement certain interventions. Regions need to combine top-down initiatives with more bottom-up activity in a way that adapts to their particular circumstances. Regions cannot do this without the necessary competencies, regulatory and financial authority. In some countries, this has been already implemented (at least partly) by devolving obligations from national to the regional level. It goes without saying that a formal responsibility needs to go hand in hand with at least human, if not financial resources at the respective regional level, in order to fulfil the tasks appropriately. Nevertheless, this would have positive effects for a sustainable regional development and pay off, by making use of synergies, by developing regionally-tailored business models for implementing projects, and by leading regions towards green growth and a low carbon economy.

5 The role of cohesion policy for the regions' transition to low-carbon economy

5.1 Identifying experience from programme evaluation, case study results and expert knowledge

A framework strategy for a resilient Energy Union with a forward-looking climate change policy was adopted by the European Commission on February 25th, 2015. The strategy aimed to reduce energy dependency, promote the free flow of energy across borders, boost energy efficiency and support the transition to a low-carbon economy.

Cohesion Policy is supposed to play a strong role in delivering the Energy Union on the ground, through projects that bring real benefits to citizens. Under the broad theme of "Low-Carbon Economy", the European Structural and Investment Funds (ESI funds, i.e. including EAFRD and EMFF) encompass a range of investment and union priorities to support the shift towards a low-carbon economy in all sectors.

The emphasis of this study is on Cohesion Policy (CP) which actively supports the transition to low-carbon economy in the current funding period 2014-2020. More in detail, it aims to develop recommendations on how to bring (further) added value to the regional implementation, based on a detailed review of ongoing practices and of evaluations of the application of CP instruments at the level of regions.

5.2 Experience from the 2007-2013 period of Cohesion Policy

The scale of Cohesion policy relating to GDP and government spending

In order to gain experience from the period 2007-2013, it is essential to look at the financial and spatial dimensions of EU Cohesion Policy (CP), by focussing on ERDF and Cohesion Fund spending across Europe's regions. Since the overall ambition of CP is to reduce the economic development differences between Member States and regions, CP has been designed in a way to provide assistance money for development projects, predominantly in less developed regions. In order to be eligible for ERDF or Cohesion Fund money, a number of indicators with particular emphasis on GDP per capita, form the basis for the classification of EU regions. Since the Cohesion Fund has focused on less developed regions, providing assistance for infrastructure, for business development, administrative capacity building and research, the EU's assistance contribution per capita is substantially higher when compared to the more developed regions and Member States. As a result, most Cohesion Policy money during the 2007-2013 period was spent in new Member States, and in the southern regions in Greece, Spain, Portugal and Italy.

In conclusion, during the period 2007-2013, the contribution of Cohesion Policy in new member States (EU-12) and in southern European regions (Convergence Regions) reached sig-

nificant levels. In some Member States and regions nearly half or even more than half of public money financing capital formation in infrastructures and businesses came from EU Cohesion Policy. Only a small part of that money, however, was addressed energy and low carbon-relevant projects and measures.

Ex-post evaluation of programme implementation 2007-2013 – conclusions

The evidence set out in the ex-post evaluation synthesis report[27] demonstrates that Cohesion Policy, though operating in a very difficult environment during the period considered, worked effectively and produced tangible results. It made major contributions to jobs and growth, to the pursuit of both the Lisbon priorities and the Europe 2020 strategy, as well as to the reduction of regional disparities. This is reflected in the findings of evaluative studies on the ground, and is complemented by the results of the macroeconomic models indicating the added-value of the Cohesion Policy in terms of additional GDP generated in all Member States.

Ex-post evaluation of programme implementation 2007-2013 – focus on the priority theme energy efficiency, co-generation and energy management

Only a small part of Cohesion Fund money went to energy-related projects and measures – the share of the priority theme energy was 4.5% in the EU-27, with more developed regions in the Competitiveness programmes achieving the higher share of 6.6%.

In the regions falling under the “Convergence” objective, the European Regional Development Fund and the Cohesion Fund support trans-European energy networks with the objective of improving the security of supply, completing the internal market, integrating environmental considerations, improving energy efficiency and developing renewable energies.

For the Convergence and the Regional Competitiveness and Employment objectives, an important ERDF priority was to stimulate energy efficiency and renewable energy production, and the development of efficient energy management systems.

In the framework programmes for 2007-2013, EU allocations of € 4.8 billion have been made for projects in renewable energies (including wind, solar, biomass, hydroelectric and geothermal), € 4.2 billion for energy efficiency, co-generation and energy management and € 1.7 billion for investment in traditional energy sources, of which € 674 million is allocated for investment in Trans European energy networks in electricity and gas.

Within this framework, there was a great variation in national (and regional) strategies towards a low-carbon energy future. This variation was reflected in both, the priority given to the energy theme in the individual programmes (overall intensity of funding) and in terms of the focus given to RES and energy efficiency.

[27] Ex Post Evaluation of Cohesion Policy Programmes 2007-2013 – WP1: Synthesis report focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund (CF); Applica and Ismeri Europa, August 2016.

Focus evaluation on energy efficiency in public and private buildings

While the ex-post evaluation provided a good overview of the general picture relating to the main objectives of Cohesion Policy in that period, the rather complex theme of energy transformation was covered in only one special segment, i.e. energy efficiency in public and residential buildings. As has been seen from the variation between Member States in allocating funds to the priority theme energy, the variation between Member States for the energy efficiency segment was also high – between 0.5% and 6.5% of the total funds were allocated to energy efficiency.

The recommendations from this specialized evaluation study illustrate the challenges. The question is, how do EU programmes fit into the overall regime of support schemes and institutions, regulatory schemes and energy transformation strategies? Do EU funds help to get things done on the ground, and in an effective way ?

The authors of the ex-post evaluation on energy efficiency in public and private buildings recommend[28] the following:

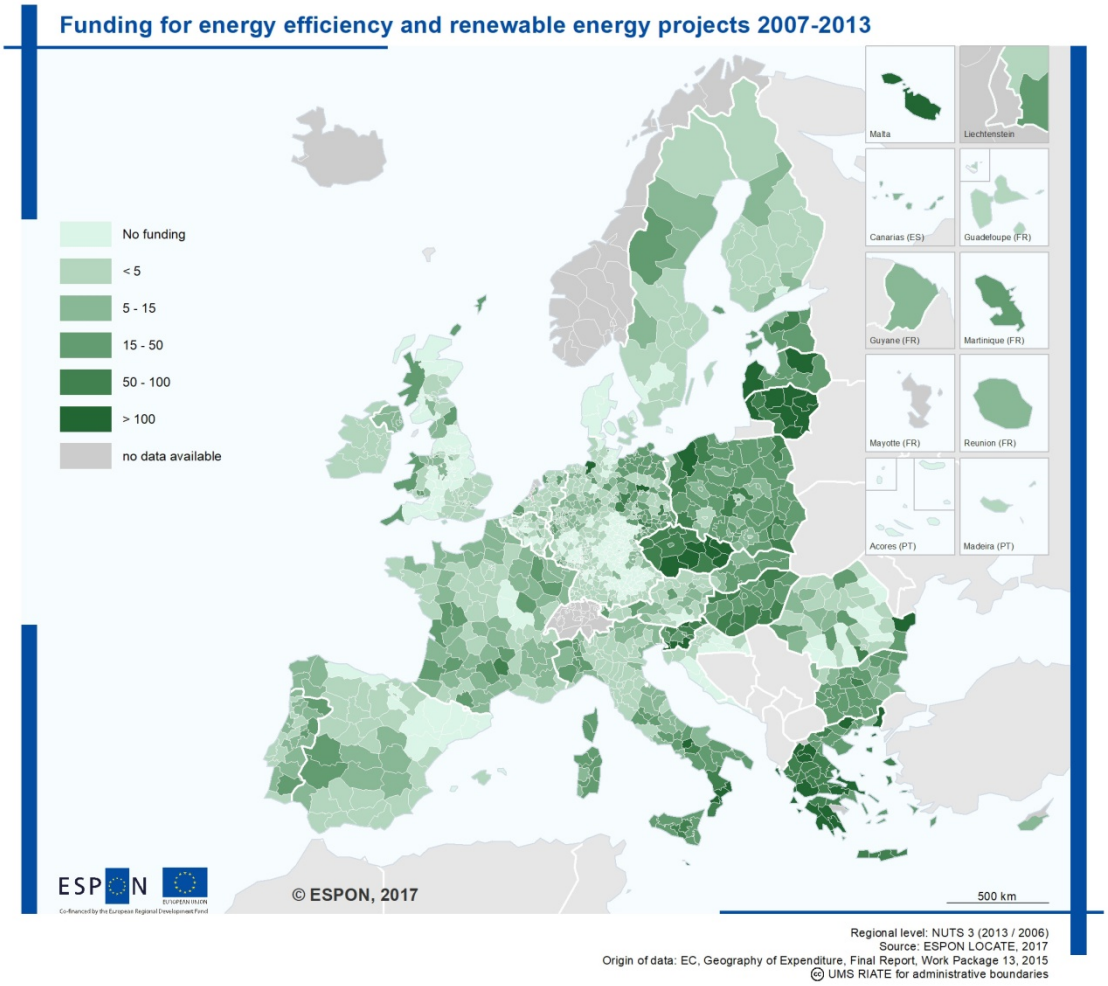
(1) Programmes need to clearly spell out the rationale for the use of EU funding to support investment in energy efficiency in buildings in response to national energy policy and support schemes
(2) With the long term energy cost reduction for building owners, loans are likely to be preferable for granting support, awareness-raising campaigns therefore might be needed.
(3) Energy audits should be a standard part of project selection criteria
(4) Financial support should be complemented by advice and guidance, certification schemes and building regulations.
(5) Indicators need to be more widely and uniformly applied to monitor the results of support.

Energy-related allocation of ERDF and CF funding in EU NUTS-3 regions, 2007-2013

The database for the programming period 2007-2013 derived from the comprehensive evaluation, allowed to analyze the regional distribution of ERDF and Cohesion Fund resources allocated to increasing energy efficiency and expanding the production and use of renewable energies at NUTS 3 level for the first time (see map 5.1, below).

[28] Brussels, 19.9.2016, SWD(2016) 318 final: COMMISSION STAFF WORKING DOCUMENT Ex post evaluation of the ERDF and Cohesion Fund 2007-13

Map 5.1: Funding for energy efficiency and renewable energy projects per NUTS 3 region in € per person, programming period 2007-2013 (CF and ERDF) [29] [30]



Funding for energy efficiency and renewable energy projects per NUTS 3 region per person, programming period 2007-2013 (Mio. Euro, CF and ERDF)

Notes: Data for EU Members corresponds to NUTS 3, version 2006, except HR (NUTS 3, version 2013)

The data on the regional distribution of Cohesion Policy funding indicated quite clearly, that

- most of the funds for energy related efficiency and renewable projects were spent in the EU-12 countries and in the Convergence Regions in the South of the EU (reflecting the Cohesion Policy regime) – in absolute terms and very significantly in funds per capita
- the relative share of funds for energy efficiency and renewable projects, however, was highest in the EU-15 countries like France, Italy, Germany, UK and Austria; there were some exemptions in Lithuania, Romania and Greece
- some regions in Poland, Romania and Greece had significant money allocated to fossil fuel projects; most regions in Europe, however, did not use EU Cohesion Policy money for fossil fuel projects; and
- in a handful of regions in Poland and Romania the funds used for fossil fuel energy projects were higher than the funds allocated to efficiency and renewable projects.

[29] Categorisation codes 39 to 43.

[30] For some regions this indicator could not be calculated, due to changes in the attribution of population and funds in some NUTS-3 regions.

Overall, the spatially detailed data and mappings displays where EU Cohesion Policy can have a significant impact in fostering energy efficiency and renewable energy production and use. While the general picture looks quite coherent with the EU objectives, it can be assumed that there is the potential to increase the share, and the efficiency of EU funds in many regions – in the subsequent (thus, current) period.

5.3 Cohesion Policy in the current 2014-2020 period

5.3.1 The shift from programming period 2007-2013 to the new objectives and guidelines for period 2014-2020

The Europe 2020 Strategy is a ten-year economic strategy introduced by the European Commission in March 2010 [31]. Its stated aim is to promote smart, sustainable, and inclusive growth. It identified eight headline targets to be attained by the end of 2020, with climate change and energy being the most prominently named. [32] [33].

The analysis of relevant regulations of EU cohesion policy (Common Provisions Regulation), of the eligible priority themes and beneficiaries during the period 2014-2020, shows that many of the lessons learnt have been taken up in the reform. Under the EU Cohesion Policy reform agreed at the end of 2013, all Member States are required to allocate significant shares of Cohesion Policy funding to support the shift towards a low-carbon economy.[34].

The spatial dimension and the differentiation of funding intensity between EU-15 and EU-13 countries remained relatively stable. While some of the Convergence Regions in the South were reduced due to economic progress, the general spatial pattern remained as in the previous period, with high EU support in the East and the South of the European Union. It was a specific innovation to stipulate a mandatory minimum spending for the low-carbon economy theme: 20% of national ERDF resources in the more developed regions, 15% in the transition regions and 12%[35] in the less developed regions.[36]

---

[31] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

[32] http://ec.europa.eu/regional_policy/en/projects/ALL?search=1&keywords=&countryCode=ALL&regionId=ALL&themeId=68&typeId=ALL&periodId=2&dateFrom

[33] http://ec.europa.eu/regional_policy/en/policy/evaluations/ec/2007-2013/

[34] Structural and Investment Funds Open data portal, https://cohesiondata.ec.europa.eu/

[35] Increased to 15% if Cohesion Fund resources are also allocated to investments in this area.

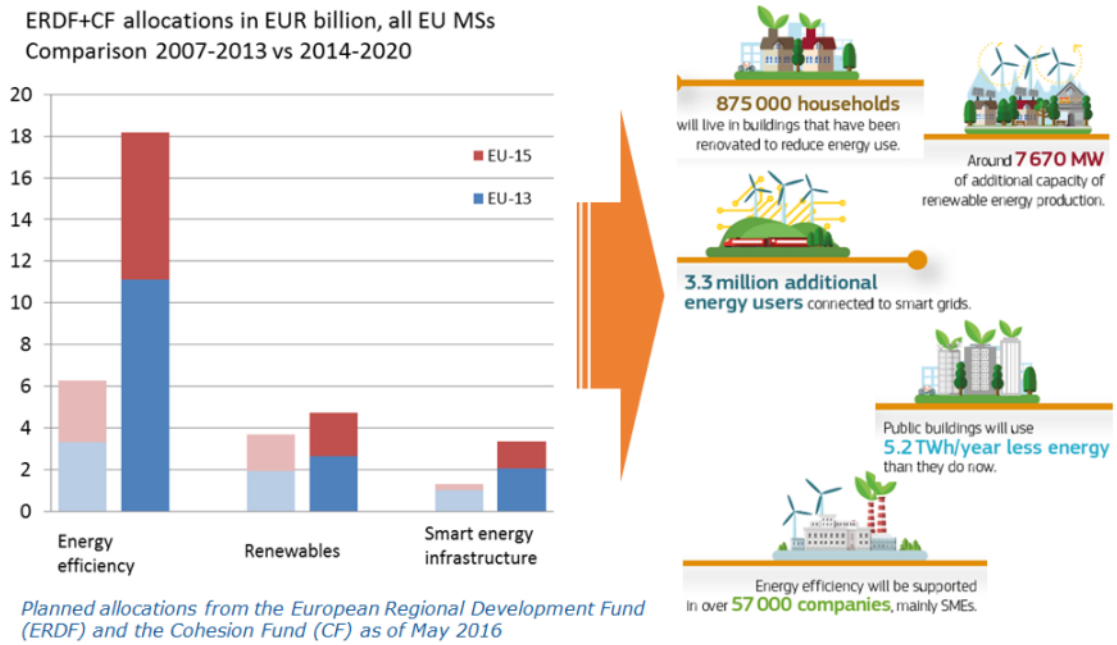
[36] How EU Cohesion Policy is helping to tackle the challenges of CLIMATE CHANGE and ENERGY SECURITY, paper by the European Commission's Directorate-General for Regional and Urban Policy, September 2014

5.3.2 Expected Impacts of Cohesion Programmes in the 2014-2020 period relating to the Thematic Objective "Low Carbon Economy" (TO LCE)

Given the overall changes in Cohesion Policy resource allocations and taking into consideration the difficulties in comparing data from the two programming periods, it is possible to estimate how much more money will go to low carbon investments in the current programming period.

Overall, the requirement of a minimum share of 12% to 20% for low carbon relevant projects has substantially increased the allocations to energy efficiency, renewable and smart energy infrastructure projects. This increase is especially significant in the energy efficiency sector and in the EU-13 countries. While energy efficiency sector allocations nearly tripled from € 6 to 18 billion, the increased allocation in the EU-13 countries was from about € 3 billion to over € 11 billion. By comparison, the increase in investments in renewable energy projects, was rather little, while smart energy infrastructure expenditures are planned to rise from € 1.5 to about 3.6 billion.

Figure 5.1: ERDF + CF allocations to energy efficiency, renewable and smart energy infrastructures 2014-2020 compared to 2007-2013

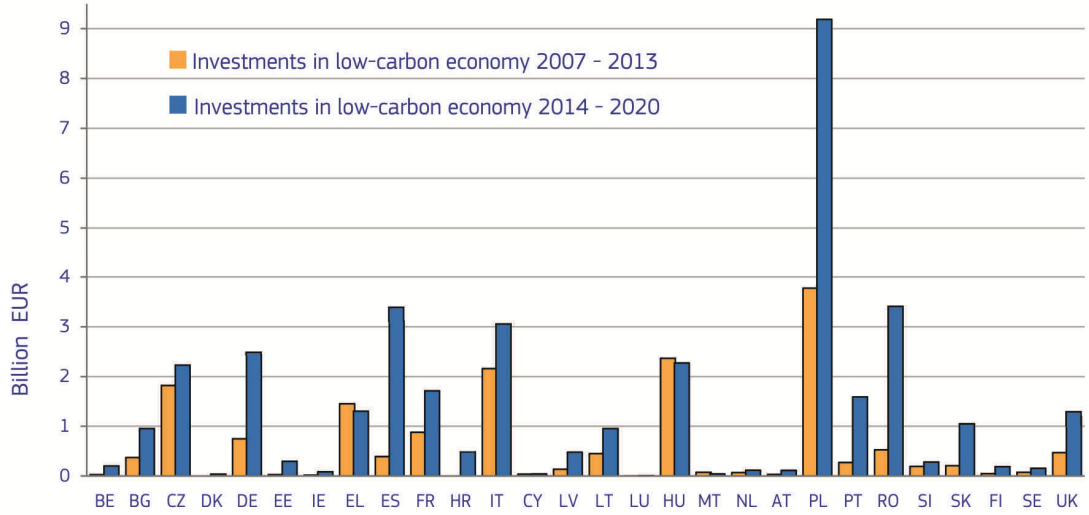


Source: Energy and Managing Authorities Network, Presentation: Maud SKÄRINGER (European Commission), Brussels, 22 November 2016.

A potential explanation for this allocation pattern is that energy efficiency projects in private enterprises are likely to form a new major focus in the current programming period, while investments in renewable energy production is set to be dominated by national aid schemes and regulations, which vary greatly between Member States.

The distribution of Cohesion Policy funding across Member States in 2014-2020 reflects the eligibility criteria (GDP per capita, similar to the previous period), with Poland being the greatest beneficiary (with over € 9 billion).

Figure 5.2: Cohesion policy allocations to low-carbon economy investments 2014-2020 compared to 2007-2013 In Billion Euro



The figure shows the ERDF and CF amounts allocated in the Partnership Agreements (PAs) to low-carbon economy investments 2014-2020, compared to an estimate of similar allocations in 2007-2013. Source: How EU Cohesion Policy is helping to tackle the challenges of CLIMATE CHANGE and ENERGY SECURITY, paper by the European Commission's Directorate-General for Regional and Urban Policy, September 2014, adapted by ÖIR according to the final allocation 2014-2020.

Similarly to the previous programming period, the allocation strategies differ widely between Member States. Some insights are:

- According to the programmed allocation of funds, the Commission has successfully and significantly increased the share for the Thematic Objective Low Carbon Economy.
- The contribution of Cohesion Policy money has been more relevant in the newer (EU-13) and southern Member States; in most of the EU-15 northern Member States, the economic impact of ERDF money has been rather low, particularly in relation to national policies.
- In some new Member States the increase has, however, been substantial. In Poland, Bulgaria, Romania, Slovakia, Croatia, Latvia and Lithuania, for example, low carbon economy-allocated funds more than doubled. Similar patterns have been found in Spain and Germany, as well.
- Minor contributions to the Thematic Objective Low Carbon Economy have resulted from EAFRD funding, with variations between Member States.

There are also great differences between Member States and regions regarding the composition of the investment priorities selected. This is caused by varying economic and natural conditions, by widely differing national energy systems and aid. As a particularly prominent example, Germany supported the development of renewable energy production through generous feed-in tariffs, resulting in over 20 times more investments than through direct aid money[37].

[37] Renewable Energy and Energy Efficiency of Housing, Synthesis Report, Terry Ward, applica sprl, 2011

5.4 Experience with CP in the five case study regions

Using a combination of local expertise and desk research, the case studies aimed to thoroughly investigate regional and practical implementation experiences. Through the comprehensive case study approach it was possible to consider the regional economic and policy backgrounds of five selected regions, including their respective national and regional level policies, and analyse Cohesion Policy in this context.

The case studies highlight that coherence between national, regional and European policies, particularly Cohesion Policies, is key to success. In most cases, RES and energy efficiency strategies started before and independently of Cohesion Policies, and were stimulated by other EU policies and national strategies. Within the case study framework,

- the potential contribution of Cohesion Policies to fostering more stringent and effective regional energy strategies was supported, even though the resources deployed were minimal,
- because CP has a clear impact on agenda setting, it sets priorities for low carbon policies and measures in a European context and
- CP leads to innovative search for other sources of funding for realizing energy/resource-related projects, be they R&D or innovation programmes or alternative funding for capital investments.

EU policies in general serve as guidelines and stimulus – the impact on the ground largely depends on the national and regional policies and actions. Well organized regions can have a major impact on how many innovative projects are developed and implemented. Close exchanges among key economic and municipal actors is important for stimulating change, and innovation.

The view of regional actors on the relevance of CP programmes depends largely on the budget of the programmes, which relates to the development status of the region:

- In the more developed regions, when compared to other sources of financing and support for low carbon-related projects, the relevance of Cohesion Policy programmes is marginal. Other programmes supporting innovative actions are more relevant, such as those that are national or EU-driven (research and innovation-related). Still, there is an impact in terms of agenda-setting and signalling transition to LC-economy to be important themes and regional development opportunity.
- By contrast, the less developed regions are profiting significantly from the allocation of special funds to priority themes, often putting low carbon economy at the forefront. Here Cohesion Policy has an immediate impact, as it establishes where and how local resources (public or private) are to be allocated.
- In the less developed regions with access to major Cohesion Policy funding, it is of great importance to understand how CP-programme administrations are established and how their operating is complemented with national/regional expert institutions who provide thematically focused support, consultation and planning, and prepare the ground for continuous project development. The examples of Pazardzhik in Bulgaria and Burgos in Spain show how small regional energy agencies can make a difference. Groundwork on a region-specific analysis on energy efficiency and RES-potential are the basis for developing a regional energy strategy. Furthermore, economic feasibility studies and

hands-on consultancy to municipalities and investors on legal issues and access to (EU-)funding, are the most relevant aspects for successful project development.

- In the case of the more developed regions, such as Manchester or Copenhagen, priorities, policy designs and development strategies have been explicit in their intents to transition towards a low carbon economy, independently from CP-programming. The overall package of national and regional policies and institutions was developed from the beginning with a wider concept of economic transformation, involving RTD and economic specialisation strategies, and citizen participation, awareness and consumer behaviour-oriented programmes. In the case of the capital region of Denmark, Copenhagen, to bring high speed technology changes on the ground (e.g. tariff subsidies for wind and biomass, legal requirements to link-up to district heating systems, tender procedures for innovative local energy systems etc.), the national strategy and policy package contributed to a large-scale specialisation in energy technologies and to the development of innovative legal frameworks.

With respect to procedural and administrative aspects of the Cohesion Policy programme development and implementation, there is a unanimous call for reducing the efforts for both, the administrators and the beneficiaries. In the more developed regions, procedural efforts are seen as a reason for avoiding Cohesion Policy-funds altogether, particularly for the more innovative and RTD-oriented projects. In most cases, when compared to national funding (as for instance, in Austria and Denmark), EU-Cohesion Policy-money does not provide higher support than national state support, making extra Cohesion Policy-procedures an additional burden (and risk) with no advantage. The risk on the side of beneficiaries and programme managers rests with the specifics of control procedures, during and after project implementation. In innovative and RTD projects, for example, the interpretation of eligible costs offers a wide range of uncertainties, on top of the innovation risks of the projects per se.

Summing up, lessons from low carbon transition oriented Cohesion Policy-programme implementation are threefold:

- Cohesion Policy-programmes and funds can be used for strengthening and orienting regional transition processes, which is particularly relevant in the less developed regions
- National policy frameworks are of the highest relevance for effective low carbon-transition strategies. If actively pursued and forward-oriented, these strategies can significantly contribute to “green growth”
- A complementary network of research, consultancy and innovative firms in a regional context, open for exchange and innovation with outside partners, is key to providing a continuous flow of project development and implementation – a Cohesion Policy programme administrative unit alone is not sufficient to initiate and support project development.

Depending on the regional economic structure, the size and availability of RTD-capacities and technology-oriented companies, a Smart Specialisation (S3) seems to be a realistic and potentially very successful approach to low carbon economy transition. The example of Denmark and of the region of Greater Copenhagen seems to be a leading example in Europe, but it is a realistic path even for smaller regions like Burgos and Pazardzhik, provided that national policy frameworks are supportive of such regional development strategy approaches (Annex/Scientific Report).

5.5 The view of CP-programme managements

Based on this background information, a series of in-depth interviews have been conducted with selected key representatives of national and regional authorities (acting as managing authorities, programme secretaries or other relevant experts working in the field of EU cohesion policy implementation at national/regional level). This was done:

- to gain knowledge on concrete experiences of stakeholders involved in cohesion funding programmes,
- to contrast results from the analysis of evaluation reports of previous programming periods and the perspective of regional stakeholders (from the selected case studies and policy assessment regions).

The interview findings form the background for recommendations for future adaptations, and for adding value to the regional implementation of low carbon economy through Cohesion Policy.

During the expert interviews, the need for simplification of EU Cohesion Policy was raised several times, though there was no consensus on the extent of the simplifications needed. While some stated that it would be only natural for beneficiaries to follow the rules of those giving the money, others argued that the procedural requirements of the Cohesion Policy are too strong, as they lead to smaller project impacts and longer implementation times. So far, only a few projects have been implemented in the current programming period. The Cohesion Policy therefore should be more result-oriented and focus less on procedures.

In countries where the financial impact of the Cohesion Policy is comparatively small, the added value of CP funding and regulations, is not seen. However, Cohesion Policy is regarded as most valuable in terms of agenda setting and creating an international framework for innovation.

While the popularity of Financial Instruments (FIs) is increasing, grants are still regarded important. This is especially the case for a country like Greece, where financial instruments can address market failures, but, as one interviewee explained, their use means negotiating loans for which special expertise is required. This in turn, could lead to other administrative burdens, and subsequently to another specialised layer of administration. The targets for renewable energies are regarded as quite high and as a long-term goal for society, so policy makers and society need to back up the transition to a low carbon economy.

For FIs it was further stated that the eligibility requirements are almost as high as for grants. While nobody expressed the need to reduce the requirements for obtaining grants, the requirements for FIs were seen as too high. If the risk of a failure could be accepted by lending institutions, FIs would be more useful for supporting innovation and a likely alternative to grants and private loans.

Energy efficiency and renewable energy are two sides of a coin, which should be complementary. While some renewable energies tend to become increasingly profitable, a balance between necessary support and market distortion remains difficult to achieve.

5.6 Smart Specialisation in Energy

The key approach for regional transition to a low carbon economy has been developed under the name of Smart Specialisation. The term reaches back to numerous approaches in Research and Innovation strategies and was established as a leading concept for regional economic development in 2009. Its main message comes from successful experiences, suggesting the need to concentrate development efforts in education, knowledge base, industrial research and innovation around specific, region-based themes or "specialisations", in order to reach sufficient size and competitiveness in the selected (technological, economic) field.

The Smart Specialisation approach started to become operative after a joint EU-OECD high level seminar in 2012 and "S3" was made an ex ante conditionality for the Cohesion Policy programming period 2014-2020. By mid July 2017, 17 countries and 170 regions registered; these included 66 EU regions which by June 2017, participated in "five interregional partnerships of smart specialisation in the fields of bioenergy, smart-grids, marine renewable energy, sustainable buildings and solar"[38].Only 7 Member States had national and regional strategies related to energy in S3.

The Joint Research Centre in Sevilla[39] operates the EC's Smart Specialisation Platform[40], which provides advice to EU Member States and regions for designing and implementing S3s. The platform not only provides material and information, it also trains policy makers, facilitates peer-reviews and mutual learning and is an access hub for relevant data.[41]

Overall it seems to be an innovative and potentially relevant approach to support regions in their economic development efforts, with particular focus on energy- and resource-related low carbon economy themes. Under the European policy framework and the long-term decarbonisation commitments, it seems worthwhile to strengthen the links between innovation-oriented regional development, concrete energy project developments and Cohesion Policy funds to be channelled to the regions. While the S3PEnergy platform cannot be evaluated by this project, it is, however, possible to note that it is already making an impact, and that there is great potential for the future.

[38] Smart Specialisation in Energy, Driving Societal Challenges. Presented at the Sustainable Energy Week in June 2017, Report at: http://www.eusew.eu/smart-specialisation-energy-driving-societal-challenges, last accessed on 15 July 2017

[39] DG Joint Research Centre

[40] http://s3platform.jrc.ec.europa.eu/

[41] http://s3platform.jrc.ec.europa.eu/

5.7 Conclusions and recommendations

5.7.1 Main results on the potential impact of CP

Based on the analyses conducted in task 5 and referring to the discussions with regional energy and programme experts, a number of conclusions on the use of Cohesion Policy funds in the regions across Europe can be formulated. In relation to the main question, how EU Cohesion Policy could bring added value and a faster transition to a low-carbon economy in Europe's regions, several aspects can be emphasised:

- Cohesion Funds and Cohesion Policy more general, has been shown to be relevant in creating momentum in the LCE-transition, by all elements of the research: through the comparison of Cohesion Fund allocation for the periods 2007-13 and 2014-20; through the ex-post evaluations; and finally through the Locate (and other) case study results,
- While the immediate impact of CP in less developed regions in Europe is obvious, it is the coherent message from several policy fields that have a guiding impact in the more developed regions, where the inflow of CP funds plays only a marginal role. EU 202020 targets, Horizon2020, SET-Plan and other programmatic initiatives as well as the legal framework of EU-directives are stimulating and supportive for regions to form their development strategies.

This does not mean that there is not enough room for improvement. As has been indicated in the case studies, illustrative cases and expert interviews conducted in this and other projects, the coherence between EU and national policy frameworks varies greatly between Member States, with the interaction between EU and national policy mixes little researched and understood. Under the assumption that only effective interaction with national regulatory and aid schemes will be able to provide substantial impacts, systematic cross-checking with national policies and measures is needed. This is because there are still a number of contradictory rules and support schemes in operation (e.g. in the proverbial state aid to install oil tanks for heating in private houses).

5.7.2 Recommendations for CP-implementation in the current period

When looking for recommendations for the best use of CP funds in European regions, innovative network structures for promoting a low carbon economy transition is potentially a key factor. *Overarching networks and platforms*, such as the Smart Specialisation Platform on Energy[42], the EU Urban Agenda focusing on concrete challenges in cities including energy transition, the European Network for Rural Development and the European Innovation Partnership etc., can all play an important role in promoting low carbon economy-strategies and supporting the development of innovative projects in the regions. To increase the impact of these networks and partnerships, it is necessary to better understand how they work and analyse what they would need to do to have a wider roll out and contribution to regional activities. Based on this – *measures to support the support structures* should be designed.

[42] established by DG Regional and Urban Policy, DG Energy and the Commission"s Joint Research Centre to support regional energy innovation and broad adoption of cohesion policy energy projects

Many of the barriers to a successful LCE strategy relate to the overarching question of conflicting policy goals and strategies on national and EU levels. Clear priority setting is therefore needed to strengthen the RES sector and encourage private households as well as businesses and energy providers to step in and contribute to such a transformation process. The CP system as well as other policies will have a mixed effect, supporting contradictory technologies and energy systems in parallel, still under the same label of “innovative” strategies.

Cohesion Programme implementation experiences from regional agencies, managing authorities and involved stakeholders show that it has a clear impact on agenda setting and strategic priorities. As mentioned above, the European policy context also leads to an innovative search for other financing sources to realize energy/resource-related projects, as in RTD, innovation or capital investment support schemes.

Concluding from the case studies and the meta-case study review (task 3), a number of *essential governance prerequisites* have to be provided in successfully implement a regional transition strategy for a low carbon economy :

- The commitment of key stakeholders in the region to cooperate in this transition process
- Research groundwork, providing essential information on the local energy system (production, consumption, distribution, investment, RES potential etc.) in highly detailed spatial resolution
- Energy transition strategy, including the analysis of economically and technically feasible projects, priority setting and support schemes
- A regional Energy Agency as key institution for managing data, strategy, stakeholder communication and technical expertise
- A multi-stakeholder partnership as the basis for implementation, with special emphasis on enabling municipalities and coordinating with private sector firms (in a wide range of involved sectors).

It is these regional governance prerequisites that are needed first. CP programmes can be drafted and implemented effectively only, if such institutional groundwork is put in place. Good governance here includes an all-stakeholder process in the region, including the establishment of a regional Energy Agency as a key institution for providing better coherence with national support schemes. Only then can good quality projects and a wider economic impact be delivered.

A methodological guideline to foster the regions’ knowledge base and innovative capacity by using all support mechanisms (EU and national) is provided by the Smart Specialisation approach. Specifically, the S3PEnergy approach is an example of what could become an EU-wide tool to help countries and regions meet institutional prerequisites. The *S3PEnergy-approach* seems to be a promising way of supporting regional economies in their transition to low carbon economy. It seems particularly apt for regions lagging behind in economic development, but showing potential in either renewable energy generation or in energy efficiency measures. In such regions, active knowledge transfer with other regions working in a similar direction, facilitated through the support of the S3 Energy platform (or other tools providing this function), would lead to project development on the ground. This activity would stimulate

the project potential relevant for CP-funding support, and would generate employment and tax revenues through “green growth”.

In some regions, where such innovative impulses are new, there is a need to actively provide *introductory phases* to the approach. This may include some training on how to create supportive administrative and governance structures around the S3 Energy strategy.

Innovation leaders, such as the Copenhagen region, have shown that an all-stakeholder approach is necessary to achieve significant changes in the use of resources. Less developed regions will need all the more support to bring their local actors together and to bring in knowledge and information from national and international networks – such as through an actively rolled out S3PEnergy.

5.7.3 Recommendations for the post-2020 programme framework

The new regulations developed to deliver the ambitious EU 2030 targets as part of the next programming period, must contend with a reduction in CP money as a result of Bexit. Taking this into account it is reasonable to suggest that the [EU]:

- learn from the experience of the current period, especially in terms of the active regional deployment of smart development strategies,
- address the administrative barriers and problems of national co-financing,
- adapt to budgetary restrictions for the policy mix to be used and
- link and expand new financial instruments in coordination with current regional policy instruments.

Following this line of logic, the proposal from the authors of the “Mainstreaming RES”-report to establish a user-oriented RES-finance portal, which could lead project developers through the maze of options, towards an optimal financing and aid package, could be applied in a more general, “transition to LCE”-perspective. A *generic approach to LC-project finance in the framework of post-2020 Cohesion Policy* would include:

- a generic project finance portal, including all relevant EU support schemes (ERDF, Horizon, EIB etc.), adapted and differentiated to national and regional specifics (in terms of approachable project support schemes, taxation etc.)
- linked to this portal, an advisory service helping project developers to analyse economic feasibility of their proposals under optimal financing conditions
- Smart Specialisation Platforms with tailored thematic and spatial (regional) scope, focusing on RTD-efforts relating to the transition to Low Carbon Economy
- CP financial support schemes with substantial grants to LCE-infrastructures, investments in RTD and SME-development
- A CP focus on least and less developed regions, providing support to the introduction of governance structures as a prerequisite for LCE transition strategies.

This conclusion and proposal was developed from the viewpoint and experience of regions as promoting institutions for regional economic development, taking experience from CP programme managers into account. The intention of this new setup of CP is

- to guarantee all regional actors full access to all sources of project support and

- to systematically build a European exchange and information platform for regions and actors attempting to develop and implement projects.

Both sides, EU programme managers and regional project developers, would profit from a new level of project quality and better support to implementation. This, finally, would lead to a more effective use of EU funds and resources in the regions who need European support and can manage them effectively.

6 Future demand for research in the subject area of the activity

Regional patterns of energy consumption, renewable energy potential and deployment

Responding to the ToR, the study at hand provides "comprehensive evidence of energy consumption patterns covering the past 10 years, broken down into different consumers and at NUTS3 level. Moreover, it provides similar evidence on renewable energy production and exploitation at the regional level". Nevertheless, as stated in our offer, such a task posed a major challenge for the project team. Research providing this evidence is highly innovative since disaggregated data on energy consumption, production and renewable potential are not provided by official statistics, and for many countries not even at the national level.

The research team has put major effort in collecting available information, in modelling and in elaborating such comprehensive evidence. Therefore this research activity has to be perceived as a pilot study at European level and a large range of further research needs should be addressed in the future.

Implementation of low-carbon economy at regional level

What we learned from the meta analysis on existing case studies is that – at least in the context of low carbon economy – regional case studies have been often elaborated with the aim to support regional implementation (e.g. in the framework of Interreg-projects). Therefore, the focus of the major share of reports has been directed to forward-looking challenges and opportunities: How to make use of future opportunities and/or describe different scenarios of possible future development including recommendations for their (future) implementation. Only a few reports focus on the holistic collection of data about recent developments and provide (written) explanations or interpretations of past developments and specific experiences within the region. In order to provide regional actors with information and experiences from good practice, research is needed to analyse the specific framework and key conditions for successful project/strategy implementation. Such knowledge would form a relevant basis for improved regional low-carbon transition strategies, governance structures and legal framework conditions.

This is also an issue with maintaining an archive of case studies. Many case study reports disappear from the public domain within a short space of time. Case study web pages are maintained for a limited period. This means valuable data and information is lost, increasing the risks of regions of repeating the same mistakes of those who have tried a particular intervention before.

Future research demands on regional patterns of energy consumption, renewable energy potential and deployment

Research on regionally disaggregated evidence is highly innovative, since such data on energy consumption, production and renewable potential are not provided by official statistics – for many countries not even at national level. The information made available by ESPON

Locate, provides a sound scientific basis for assessing regional differences and trends throughout Europe. Nevertheless, uncertainties remain which should be taken into consideration[43]. This especially refers to the impact of successful implementation by regional policy makers and stakeholders and also to the attitude and behaviour of the population.

- Detailed information on such specific differences will only be possible if regions start to collect and publish standardized quantitative information according to key performance indicators, including explanatory information on strategies and measures applied. Today, even specialized regional actors do not have sufficiently detailed data available and if they do, the area of the respective region might not comply with the delimitation defined by the European statistical units (NUTS).
- Collected data on energy consumption and renewable energy potentials are highly relevant to get a first insight on the capabilities of a region towards decarbonisation. However, as soon as more detailed analysis is carried out, a higher temporal resolution is essential. E.g. the solar potentials are much higher in summer whereas the energy consumption for space heating is higher during winter. Moreover, other end-uses as well as renewable energy generation potentials show significant fluctuations. These temporal fluctuations need to be taken into account properly and should be analysed and documented in more detail, also in regional high resolution in future research projects.
- Case studies related to low carbon transition in the energy field should be required to include a standardized collection of energy consumption and renewable energy data (as provided in this study) in order to make comparisons and adaptation of good practice strategies possible. It is essential to present regional experience and examples with sufficient context information, providing key data on relevant framework conditions for project development and implementation (legal framework, functioning of economic aid schemes, tariffs, taxation etc.).

Since project and case study reports often vanish from accessibility soon after a projects' ending, it would be a great improvement to establish thematic open access libraries documenting the efforts of European research on LCE transition in a systematic way.

[43] To provide an example, for instance the share of retrofit and implied building standards after renovation are decisive for the level of consumption of space heat but hardly available – even at national level and less so for different regions.

References

Bio-Sustain project ("Sustainable and optimal use of biomass for energy in the EU beyond 2020 – An Impact Assessment") (https://eeg.tuwien.ac.at/index.php?option=com_wrapper&view=wrapper&Itemid=86)

Boie, I.; Kost, C.; Bohn, S.; Agsten, M.; Bretschneider, P.; Snigoviy, O.; Pudlik, M.; Ragwitz, M.; Westermann, D. (2014) Opportunities and challenges of an inter-North African-European electricity exchange – Scenarios for renewable energy deployment and transmission infrastructure in 2030 and 2050. In: Energy Policy.

Building Observatory: Support for setting up an Observatory of the buildings stock and related policies (EC service contract ref. ENER/C3/2014-543), to be completed mid 2016

Bürger et al. (2011) RES-H-Policy – Policy development for improving RES-H/C penetration in European Member States, IEE project.

Castilla y León Region. Statistical energy data, http://www.energia.jcyl.es/web/jcyl/Energia/es/Plantilla66y33/1261039021854/_/_/_.

CE Delft (2015) Mid-term evaluation of the Renewable Energy Directive, A study in the context of the REFIT programme, Prepared for: European Commission DG ENER, (submitted by CE Delft, Ecologic Institute, Ricardo-AEA, REKK, E-Bridge), Report, Delft, April 2015.

Charron, N., Dijkstra, L., & Lapuente, V. (2014) Regional Governance Matters: Quality of Government within European Union Member States. Regional Studies, 48(1), 68–90.

CORINE Land Cover 2012, available at: http://land.copernicus.eu/pan-european/corine-land-cover/clc-2012/view.

COUNCIL REGULATION (EC) No 1083/2006 of 11 July 2006 laying down general provisions on the European Regional Development Fund, the European Social Fund and the Cohesion Fund and repealing Regulation (EC) No 1260/1999.

Covenant of Mayors, Overview of financing opportunities for local sustainable energy, http://www.covenantofmayors.eu/IMG/pdf/Financing_Opportunities_Matrix.pdf.

DG REGIO and Joint Research Centre Seville (2016) The impact of cohesion policy 2007-2013: model simulations with RHOMOLO, SUMMARY OF SIMULATION RESULTS, WORK PACKAGE 14b, Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), May 2016.

DG Regional and Urban Policy (2015) Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and Cohesion Fund (CF) – Work Package Zero: Data collection and quality assessment (Submitted by: t33 srl, ÖIR GmbH, Spatial Foresight GmbH), Final report, March 2015.

DG Regional and Urban Policy (2015) Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and Cohesion Fund (CF) – Energy efficiency in public and residential buildings, Work Package 8 (Submitted by: Ramboll and IEEP), Final Report, October 2015.

DG Regional and Urban Policy (2015) Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and Cohesion Fund (CF) – Geography of Expenditure, Work Package 13 (Submitted by: WIIW, Ismeri Europa), Final Report, August 2015.

DG Regional and Urban Policy (2016) WP1: Synthesis report, Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), Authors: Applica and Ismeri Europa (Terry Ward (Applica) assisted by Lydia Greunz, Ruggero Fornoni, Francesca Liberati, Fadila Sanoussi (Applica), Enrico Wolleb, Andrea Naldini, Andrea Ciffolilli and Marco Pompili (ISMERI Europa)) August 2016.

Dii (2013) 2050 Getting Started. Manual for renewable electricity in MENA. München. (https://eeg.tuwien.ac.at/index.php?option=com_wrapper&view=wrapper&Itemid=86)

EEA (European Environment Agency) (2015) Overview of reported national policies and measures on climate change mitigation in Europe in 2015, Luxemburg, EEA.

Eichhammer, W., Braungardt, S., Elsland, R., Fleiter, T., Klobasa, M., Krail, M., Pfluger, B., Reuter, M., Schlomann, B., Sensfuss, F., Tariq, S., Kranzl, L., Dovidio, S., Gentili, P., 2014. Study evaluating the current energy effi-ciency policy framework in the EU and providing orientation on policy options for

realising the cost-effective energy-efficiency/saving potential until 2020 and beyond. By order of the European Commission, Karlsruhe/Vienna/Rome.

Eichhammer, W., Braungardt, S., Elsland, R., Fleiter, T., Klobasa, M., Krail, M., Pfluger, B., Reuter, M., Schlomann, B., Sensfuss, F., Tariq, S., Kranzl, L., Dovidio, S., Gentili, P. (2014) Study evaluating the current energy effi-ciency policy framework in the EU and providing orientation on policy options for realising the cost-effective energy-efficiency/saving potential until 2020 and beyond. By order of the European Commission, Karlsruhe/Vienna/Rome.

Energy and Managing Authorities Network (2016) Presentation: Maud SKÄRINGER (European Commission), Cohesion Policy support for Sustainable Energy –State of Play of Energy Efficiency in the Cohesion Policy Operational Programmes, Energy and Managing Authorities Network Brussels, 11 May 2016, https://ec.europa.eu/energy/en/events/meeting-european-network-energy-and-managing-authorities-cohesion-policy-2014-2020.

Energy and Managing Authorities Network (2016) Presentation: Maud SKÄRINGER (European Commission), State of Play of Energy Efficiency in the Cohesion Policy Operational Programmes, Energy and Managing Authorities Network Brussels, 22 November 2016, https://ec.europa.eu/energy/en/events/meeting-european-network-energy-and-managing-authorities-cohesion-policy-2014-2020.

Ente Regional de la Energía de Castilla y León (EREN), www.eren.jcyl.es.

ENTRANZE: Enforcing the transition to nearly zer#o energy buildings, IEE-Project; completed 2014, ENTRANZE database (www.entranze.eu).

ESPON GREECO, https://www.espon.eu/export/sites/default/Documents/Projects/AppliedResearch/GREECO/FR/GREECO_FR_-_Vol_1.2_Main_Report.pdf.

Eurolectric (2010): Hydro in Europe. (http://www.eurelectric.org/media/26690/hydro_report_final-2011-160-0011-01-e.pdf)

European Commission – Inforegio, http://ec.europa.eu/regional_policy/en/.

European Commission (2014) How EU Cohesion Policy is helping to tackle the challenges of CLIMATE CHANGE and ENERGY SECURITY, A paper by the European Commission's Directorate-General for Regional and Urban Policy.

European Commission (2014) Technical Guidance, Financing the energy renovation of buildings with Cohesion Policy funding, Final Report, A study prepared for the European Commission, DG Energy, (submitted by: ICF International, CE Delft, Hinicio), February 2014.

European Commission (2015) Contribution of the European Structural and Investment Funds to the 10 Commission Priorities – Energy Union and Climate, December 2015.

European Commission (2015) ENERGY UNION PACKAGE, Communication from the Commission to the European Parliament, the Council, the European Economic And Social Committee, the Committee of the Regions and the European Investment Bank, A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM(2015) 80 final, Brussels, 25/02/2015.

European Commission (2015) European Structural and Investment Funds 2014-2020: Official texts and commentaries, November 2015.

European Commission (2015) Regional Focus, A series of short papers on regional research and indicators produced by the Directorate-General for Regional and Urban Policy 01/2015, Regional and Urban Policy THE EUROPE 2020 INDEX: THE PROGRESS OF EU COUNTRIES, REGIONS AND CITIES TO THE 2020 TARGETS (Lewis Dijkstra and Stergios Athanasoglou), May 2015.

European Commission DG Energy (2016) Study on the impact assessment for a new Directive mainstreaming deployment of renewable energy and ensuring that the EU meets its 2030 renewable energy target, Final task 1 & 2 report: "Mainstreaming RES" (ENER/C1/2014-668), Authors ECN/Oeko Institute/Eclareon/REBEL/SUER/BBH, November 2016.

European Commission, Brussels, 03/03/2010, COM(2010) 2020 final, Communication from the Commission EUROPE 2020, A strategy for smart, sustainable and inclusive growth http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF.

European Commission, Climate Action, http://ec.europa.eu/clima/policies/strategies/2030/index_en.htm.

European Commission, DG Employment, social affairs & equal opportunities, DG Regional Policy (2015): Cohesion Policy 2007-2013: Energy, EU Cohesion Policy – The Thematic Pages.

European Commission, DG Employment, social affairs & equal opportunities, DG Regional Policy (2015) EU Cohesion Policy – The Thematic Pages: http://ec.europa.eu/regional_policy/themes/index_en.htm.

European Commission: European Structural and Investment Funds, Open data portal, https://cohesiondata.ec.europa.eu/themes/4.

European Commission: http://ec.europa.eu/contracts_grants/pdf/esif/key-energy-union-climate_en.pdf.

European Parliament, Directorate-General for Internal Policies of the Union (2006) Energy and Structural and Cohesion Policies, Note, Policy Department Structural and Cohesion Policies, Brussels 2006.

European Structural and Investment Funds 2014-2020: Supporting the shift towards a low-carbon economy, European Commission Non-paper, 13701/15 AS/AD/cs 13 ANNEX II.

European Union/Committee of Regions (2011) Low Carbon Energy 2050 – Local and Regional Impact and Perspectives, written by Progress Consulting S.r.l. and Living Prospects Ltd.

EUROSTAT (2016a) Dwellings by type of housing, building and NUTS 3 regions, Last update: 26-06-2013, http://data.europa.eu/euodp/en/data/dataset/6fyDc7ngKlhXLF2bQc4Fw.

EUROSTAT (2016b) Heating degree-days by NUTS 2 regions – annual data [nrg_esdgr_a], Last update: 26-06-2013.

EUROSTAT (2016c) Population on 1 January by broad age group, sex and NUTS 3 region [demo_r_pjanaggr3], Last update: 05-08-2016.

EUROSTAT 2013: Rural development statistics by urban-rural typology, 2013. Available from: http://ec.europa.eu/eurostat/statistics-explained/index.php/Rural_development_statistics_by_urban-rural_typology based on: Raggi et al., A classification of European NUTS3 regions, JRC report no. JRC85163, Joint Research Center, 2013.

Eurostat 2015, http://ec.europa.eu/eurostat/de/web/nuts/overview.

Expert Evaluation Network delivering policy analysis on the performance of Cohesion Policy 2007-2013: YEAR 1 – 2011, Renewable energy and energy efficiency of housing, synthesis report (Terry Ward, Applica sprl).

FORECAST (FORecasting Energy Consumption Analysis and Simulation Tool), http://www.forecast-model.eu/forecast-en/index.php

Fujiwara, N.; Tuerk, A.; Spyridaki, N.A.; Williges, K. (2017): Contextual factors affecting EU climate policies and their outcomes, CARISMA Discussion Paper No.1, February 2017

Geoelec, Jon Limberger (2014) Geoelec data supplement. Utrecht University. Dataset. https://doi.org/10.4121/uuid:91fe7c44-9798-491e-a807-5ca40b9f2093

GRDC (2015) – Long-Term Mean Monthly Discharges and Annual Characteristics of GRDC Stations/ Online provided by the Global Runoff Data Centre of WMO. 2015 ed. Koblenz: Federal Institute of Hydrology (BfG), [Date of retrieval: 2016-11-25].

Greater Manchester Combined Authority (GMCA), Low Carbon Hub, http://gmlch.ontheplatform.org.uk/.

Greater Manchester Under 2 MOU Appendix, http://under2mou.org/wp-content/uploads/2015/05/Greater-Manchester-appendix.pdf.

Greiving, S., Fleischhauer, M., Lindner, C., Lückenkötter, J., Peltonen, L., Juhola, S. & Tesliar, J. (2013) ESPON CLIMATE-Climate Change and Territorial Effects on Regions and Local Economies. The ESPON, ESPON online resource available at: (http://www.espon.eu/export/sites/default/Documents/Projects/AppliedResearch/CLIMATE/inceptionreport_final.pdf.

Hooghe, Liesbet, Gary Marks, Arjan H. Schakel, Sandra Chapman Osterkatz, Sara Niedzwiecki, Sarah Shair-Rosenfield (2016) A Postfunctionalist Theory of Governance. Volume I: Measuring Regional Authority. Oxford: Oxford University Press.

Housing Europe, the European Federation for Public, Cooperative and Social Housing (2015) The Implementation of the European Structural and Investment Funds for Housing Projects in the European Union, Structural Funds and Housing in 2014-2020, Brussels, 2015.

InfoRegio, Evaluations of the 2007-2013 programming period, http://ec.europa.eu/regional_policy/en/policy/evaluations/ec/2007-2013/#1.

Jimenez Navarro, Juan Pablo; Uihlein, Andreas (JRC, 2016) “Mapping regional energy interests for S3P-Energy”. Publications Office of the European Union

Mapping_HC: Mapping and analysis of the current and future (2020-2030) heating/cooling fuel deployment (fossil and renewables), (EC service contract ENER/C2/2014-641/SI2.697512); the consortium has been involved in the project and has full access to the data

Mork, G. et al. (2010) ASSESSING THE GLOBAL WAVE ENERGY POTENTIAL. In: OMAE2010 – 20473

OECD, Linking Renewable Energy to Rural Development, Executive Summary Brief for Policy Makers.

progRESsHEAT (Fostering the use of renewable energy for heating and cooling), ongoing H2020 project, www.progressheat.eu

Pudlik, Martin & Schubert, Gerda (2016) Renewable Energy potential for Wind onshore and PV in Europe and the MENA countries. In: Geosimulations.

Regional Energy Agency of Pazardjik, http://www.reap-bg.eu/index.html.

Regional Municipality Council of the Capital Region, Climate strategy for the capital region (2012), https://www.regionh.dk/english/environment/Documents/16582_KLIMA_pixi_2012_engelsk.pdf.

Regulation (EC) No 1080/2006 of the European Parliament and of the Council of 5 July 2006 on the European Regional Development Fund and repealing Regulation (EC) No 1783/1999.

Regulation (EU) No 1303/2013 of the European Parliament and of the Council of 17 December 2013 laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund and laying down general provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund and the European Maritime and Fisheries Fund and repealing Council Regulation (EC) No 1083/2006.

RES-H-Policy – Policy development for improving RES-H/C penetration in European Member States, IEE project completed 2011, (Bürger et al., 2011)

Rosa, E. A. & Dietz, T. (1998) Climate change and society: Speculation, construction and scientific investigation. International Sociology, 13(4), 421–455.

Smart Specialisation Platform – Energy, http://s3platform.jrc.ec.europa.eu/s3p-energy

Somanathan E., et al. (2014) National and Sub-national Policies and Institutions. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of of the IPCC [Edenhofer, O., R. et al (eds.)]. Cambridge University Press, Cambridge.

Stefan Thomas et.al. (Wuppertal Institut)/Ecofys/OÖ Energiesparverband/Eufores/Energy Cities/Fedarene/eceee (2016) FEEDBACK LOOP REPORT, Progress in energy efficiency policies in the EU Member States, Findings from the Energy Efficiency Watch 3 Project.

Strategic Report 2013 – Programme implementation 2007-2013, Factsheet: Energy, http://ec.europa.eu/regional_policy/sources/how/policy/doc/strategic_report/2013/factsheet4_energy.pdf.

Vision Rheintal, www.vision-rheintal.at.

Vollaard (2013) New Reality, Final Report LoCaRe-Project 2010-2013.

Winkler; J.; Sensfuß, F.; Winkler; J.; Pudlik, M. (2015) Leitstudie Strommarkt: Analyse ausgewählter Einflussfaktoren auf den Marktwert Erneuerbarer Energien. Berlin.

Zebra2020 (Nearly Zero-Energy Building Strategy 2020), ongoing IEE project, www.zebra2020.eu

Case Study Meta-Analysis sources

100% RES Communities, http://www.100-res-communities.eu/communities2.

ANSWER – A North Sea Way to Energy-Efficient Regions (2012), http://archive.northsearegion.eu/ivb/projects/details/&tid=73.

CEP-REC – Regional Energy Concepts (http://www.cep-rec.eu/project-results/).

Climate Alliance, http://www.klimabuendnis.org/aktivitaeten/projekte/repowermap.html & http://www.repowermap.org/.

COOPENERGY, http://www.coopenergy.eu/good-practice-resources.

Co-Power, http://www.communitypower.eu/en/.

Covenant of Mayors (CoM) for Climate & Energy, http://www.covenantofmayors.eu/media/case-studies_en.html.

EEA database, http://pam.apps.eea.europa.eu/?source={%22query%22:{%22match_all%22:{}},%22sort%22:[{%22Country%22:{%22order%22:%22asc%22}},{%22ID_of_policy_or_measure%22:{%22order%22:%22asc%22}}]}.

EEA, 2016 (Land Cover 2006), http://discomap.eea.europa.eu/map/EEABasicviewer/?webmap=690ed174e8ad45f88bc03092440045f0).

EnercitEE, http://enercitee.eu/About-EnercitEE/Good-practices-from-the-regions,958/.

ENERGY REGION (2014), http://www.energy-region.eu.

EREN Ente Público Regional de la Energía de Castilla y León, statistical information available under: http://www.energia.jcyl.es/web/jcyl/Energia/es/Plantilla66y33/1261039021854/_/_/_.

ESPON 2.1.4. Territorial trends of energy services and networks and territorial impact of EU energy policy, http://www.espon.eu/main/Menu_Projects/Menu_ESPON2006Projects/Menu_PolicyImpact Projects/energy.html.

ESPON CLIMATE, http://www.espon.eu/main/Menu_Projects/Menu_ESPON2013Projects/Menu_ AppliedResearch/climate.html.

ESPON Energy ReRisk, http://www.espon.eu/export/sites/default/Documents/Projects/Applied Research/ReRISK/RERISK-Interim-Report-Updated-Scenarios.pdf.

ESPON GREECO, http://www.espon.eu/main/Menu_Projects/Menu_ESPON2013Projects/Menu_ AppliedResearch/greeco.html.

EU Parliament ThinkTank, http://www.europarl.europa.eu/thinktank/en/home.html;jsessionid= F4D7418795DF679D6F230898DE4C9806.node2.

EU2020goingLOCAL, http://www.eu2020goinglocal.eu/.

Europe2020 Monitoring Plattform, https://portal.cor.europa.eu/europe2020/Surveys/Pages/A-Resource-Efficient-Europe.aspx.

FEDARENE, http://www.fedarene.org/best-practices/page/4?country&region&topic=Multi-level%20 governance&project#038;region&topic=Multi-level+governance&project.

Fedarene (2015) Policy recommendations, Innovative Financing Schemes for Local and Regional Energy Efficiency Policies, Brussels, October 2015.

Fedarene (2016) Data4Action, Facilitating public authorities access to energy data for better implementation and monitoring of SEAP actions through effective and structured collaboration with energy data providers, Policy recommendations, Improving energy data sharing for Effective sustainable energy planning at sub-national levels.

go100percent, http://www.go100percent.org/cms/index.php?id=94.

GreenPartnerships – Local Partnerships for Greener Cities and Regions (2015), http://www.green partnerships.eu/.

IEE projects database, http://ec.europa.eu/energy/intelligent/projects/en/project-search?sort=field_ project_duration%3Avalue2&order=asc&search_api_views_fulltext=region.

KEEP-Database, http://www.keep.eu/keep/, Integrated information on the projects and partners of Interreg, Interreg IPA cross-border and ENPI/ENI cross-border cooperation programmes.

LoCaRe – Low Carbon Economy Regions (2013), http://www.locareproject.eu.

ManageEnergy, http://www.managenergy.net/casestudies.html.

Matrix Insight and Ecologic Institute (2010) Executive Agency for Competitiveness and Innovation – Energy agencies: evaluation of the relevance of Community funding of local and regional energy agencies, Final Report, May 2010.

North SeaSEP – North Sea Sustainable Energy Planning (2013), http://www.northseasep.eu/home/

Policy Learning Database, http://ec.europa.eu/regional_policy/en/projects/map/.

recharge.green – Reconciling Renewable Energy Production and Nature in the Alps (2015), http://www. recharge-green.eu/.

Region202020, http://regions202020.eu/cms/home/pioneers/; http://www.regions202020.eu/cms/home/ find-regions-communities/Region/.

SEAP+, *https://ec.europa.eu/energy/intelligent/projects/en/projects/seap-plus#lesson*

Smart Cities Info, http://smartcities-infosystem.eu/.

smilegov, http://www.sustainableislands.eu/library/publishable-factsheets.html.

SPECIAL, http://www.special-eu.org/knowledge-pool.

UK Government BEIS, EnergyEfficiency.Stats@beis.gov.uk,online at: https://www.gov.uk/government/ statistical-data-sets/regional-and-local-authority-electricity-consumption-statistics-2005-to-2011, https://www.gov.uk/government/statistical-data-sets/total-final-energy-consumption-at-regional-and-local-authority-level-2005-to-2010.

Under2MOU, http://under2mou.org/?page_id=238.

VISNOVA – Clean energy from rural regions (2014), http://visnova.energie-zentrum.com/.

References for illustrative examples

Rheinland-Pfalz – Germany

Gailing, L. and Röhring, A. (2016) Germany's Energiewende and the Spatial Reconfiguration of an Energy System, in Gailing, L. and Moss, T. (eds) *Conceptualising Germany's Energy Transition*, DOI 10.1057/978-1-137-50593-4_2.

https://mueef.rlp.de/de/startseite/

https://www.energieagentur.rlp.de/

IRENA (2015), Renewable Energy Prospects: Germany, REmap 2030 analysis. International Renewable Energy Agency (IRENA), Abu Dhabi, www.irena.org/remap

Kuzemko, C. (2016) Governing for demand management innovations in Germany: Politics, policy and practice, EPG Working Paper 1601, IGov, DOI: 10.13140/RG.2.1.2726.1847, available at www.exeter.ac.uk/igov (last viewed 08/06/2017).

Moss, T.; Becker, S. and Naumann, M. (2015) Whose energy transition is it, anyway? Organisation and ownership of the Energiewende in villages, cities and regions, *Local Environment*, 20(12): 1547-1563.

Ohlhorst, D. (2015) Germany's energy transition policy between national targets and decentralised responsibilities, Journal of Integrative Environmental Sciences, 12(4): 303-322.

Toke, D. and Lauber, V. (2007) Anglo-Saxon and German approaches to neo-liberalism and environmental policy: The case of financing renewable energy, Geoforum, 38: 677-687.

Scotland – UK

BBC (2016) *Scotland "leads UK" on climate* change, available at http://www.bbc.co.uk/news/uk-scotland-37340555 (last viewed 20/06/2017).

Cowell, R.; Ellis, G.; Sherry-Brennan, F.; Strachan, P.A. and Toke, D. (2013) *Promoting Renewable Energy in the UK What Difference has Devolution Made?*, A research project funded by the Economic and Social Research Council (RES-062-23-2526), available at https://www.rgu.ac.uk/.../promoting-renewable-energy-in-the-uk-what-difference-has-devolution-made (last viewed 23/06/2017).

Cowell, R.; Ellis, G.; Sherry-Brennan, F.; Strachan, P.A. and Toke, D. (2017) Energy transitions, sub-national government and regime flexibility: How has devolution in the United Kingdom affected renewable energy development?, *Energy Research & Social Science*, 23: 169-181.

Cowell, R.; Ellis, G.; Sherry-Brennan, F.; Strachan, P.A. and Toke, D. (2015) Rescaling the governance of renewable energy: lessons from the UK devolution experience, *Environmental Policy and Planning*, DOI: 10.1080/1523908x.2015.1008437.

Hamilton, P. (2002) The greening of nationalism: nationalising nature in Europe, *Environmental Politics*, 11(2): 27-48.

HM Government (2009) *The UK Low Carbon Transition Plan – National Strategy for Climate and Energy*, available at https://www.gov.uk/government/publications/the-uk-low-carbon-transition-plan-national-strategy-for-climate-and-energy (last viewed 20/06/2017).

IEA (2016) *United Kingdom renewable energy policy framework summary*, available at https://www.iea.org/policiesandmeasures/renewableenergy/?country=United%20Kingdom (last viewed 20/06/2017.

Ofgem (2017) *About the RO*, available at https://www.ofgem.gov.uk/environmental-programmes/ro/about-ro (last viewed 23/06/2017).

Shaw, R.; Attree, M. and Jackson, T. (2010) Developing electricity distribution networks and their regulation to support sustainable energy, *Energy Policy*, 38: 5927-5937.

Thomas, M. and Ellis, G. (2017) Subnational governance for the low carbon energy transition: Mapping the UK's "Energy Constitution", *Environment and Planning C: Government and Policy*, DOI: 10.1177/2399654416687999.

Antwerp – Belgium

Happaerts, S. (2015) Climate governance in federal Belgium: modest subnational policies in a complex multi-level setting, *Journal of Integrative Environmental Science* Vol. 12(4) pp285-301.

International Energy Agency (2016) *Energy Policies of IAE Countries: Belgium.* Paris: IAE.

Flanders Environment Agency (2015) *MIRA: Climate Report 2015.*

Province of Antwerp (Undated) *Province of Antwerp, your dynamic partner.* Antwerp: Province of Antwerp.

Nordwestschweiz – Switzerland

Gerigk, J et al. (2012) The Current Climate and Energy Policy in the EU and in Switzerland, Working Paper ETH Zurich [Online]. Available at: http://www.off4firms.ethz.ch/wp-content/uploads/2013/01/Off4Firms-Working-Paper-D1-3.pdf (Accessed: 24/06/2017).

IEA (2017) Policies and Measures Databases – Switzerland [Online]. Available at: www.iea.org/policies andmeasures/energyefficiency/?country=Switzerland (Accessed: 24/06/2017).

Sager, F., Bürki, M., Luginbühl, J. (2014) "Can a policyprogram influence policy change? The case of the Swiss EnergieSchweiz program" *Energy Policy* 74, pp. 352–365. [Online]. Available at: www.science direct.com/science/article/pii/S0301421514004091 (Accessed: 27/06/2017).

SFOE (2017a) [Online]. Available at http://www.bfe.admin.ch/org/index.html?lang=en (Accessed: 27/06/2017).

SFOE (2017b) Energy Strategy 2050 [Online]. Available at: http://www.bfe.admin.ch/energiestrategie 2050/06445/index.html?lang=en (Accessed: 27/06/2017).

SFOE (2017c) Energy Strategy 2050. Measures for increasing energy efficiency [Online]. Available at: http://www.bfe.admin.ch/energiestrategie2050/06447/06457/index.html?lang=en (Accessed: 27/06/2017).

Switzerland, Federal Chancellery (2017) *The* Swiss Confederation – a brief guide [Online]. Available at: www.bk.admin.ch/dokumentation/02070/index.html?lang=en (Accessed: 27/06/2017).

The Building Programme (2017) [Online]. Available at: http://www.dasgebaeudeprogramm.ch/index.php/ de/das-gebaeudeprogramm/ziele (Accessed: 01/07/2017).

Åland – Finland

ÅSUB (2016) *Åland in figures: 2016.* ÅSUB: Mariehamn.

bärkraft.ax (2016) *Development and Sustainability Agenda for Åland* Available from www.bärkraft.ax [Date Accessed 26/06/2017].

Kinnunen, J & Lindström, B. (2010) *A Study of Cluster Impacts and the Future of the Shipping Industry in Åland Islands* ÅSUB: Mariehamn.

Lindström, B. (2005) *Sub-National Insular Jurisdictions (SNIJs) as Configurations of Jurisdictional Powers and Economic Capacity: A study of Åland, The Faroe Islands and Greenland.* ÅSUB: Mariehamn.

Moravian Silesian – Czech Republic

Jirous, F. (2013) Assessment of climate change policies in the context of the European Semseter. Country Report: Czech Republic. Brussels: DG Climate Action.

Hooghe, L., Marks, G., Schakel, A., Osterkatz, S., Niedzwiecki, S. & Shair-Rosenfield, S. (2016) *Measuring Regional Authority: A Postfunctionalist Theory of Governance, Volume 1.* Oxford: Oxford University Press.

South Aegean – Greece

Getimis, P. & Demetropoulou, L. (2004) Towards New Forms of Regional Governance in Greece: The Southern Aegean Islands. *Regional and Rederal Studies* Vol 14(3) pp355-378.

Mondol, J. & Koumpetsos, N. (2013) Overview of challenges, prospects, environmental impacts and policies for renewable energy and sustainable development in Greece. *Renewable and Sustainable Energy Review.* Vol. 23 pp 431-442.

Siamanta, (2017) Building a green economy of low carbon: the Greek post-crisis experience of photovoltaics and financial "green grabbing". *Journal of Political Ecology* Vol. 24 pp200-341.

Zafeiratou, E. & Spataru, C. (2015) Investigation of high renewable energy penetration in the island of Syros following the interconnection with the national grid system. *Energy Procedia* Vol. 83 pp 237-247.

Southern Region – Republic of Ireland

FitzGerald, J (2014), Ireland's Recovery from Crisis, *CESifo Forum*, Vol. 5(2), p 8-13.

Murphy, E. & Scott, M. (2013) Mortgage-related issues in a crisis economy: Evidence from rural households in Ireland. *Geoforum* Vol. 46 pp 34-44.

Noonan, M (2016), Ireland's economy: A solid recovery. *OECD Observer No 305*, (Available at http://oecdobserver.org/news/fullstory.php/aid/5440/Ireland_92s_economy:_A_solid_recovery.html. [Date accessed, 21/06/2017].

Interviewees for the illustrative examples

Rheinland-Pfalz – Germany
Dr. Dirk Gust from Ministry for Environment, Energy, Nutrition and Forests

Scotland – UK
Dr. Andy Kerr, Co-Director, Centre of Expertise on Climate Change – ClimateXChange (CXC)

Antwerp – Belgium
Gitte de Vries, Policy Advisor Province of Antwerp
Ludwig Caluwé, Deputy in the Province of Antwerp, Economics and Development

Nordwestschweiz – Switzerland
Christian Mathys from Office for Environment and Energy of the Canton Basel-Stadt
Stefan Hass from the Department for Construction and Environmental Protection of the Canton Basel-Landschaft

Åland – Finland
Micke Larsson, Development and Sustainability Strategist, Government of Åland
Robert Mansén, Member of the working group Åland Energy and Climate Strategy

Moravian Silesian – Czech Republic
Not possible to conduct any interviews

South Aegean – Greece
Not possible to conduct any interviews

Southern Region – Republic of Ireland
Prof. John Fitzgerald – Chair National Climate Action Committee
Paula Gallagher – deputy CEO at the Tipperary Energy Agency (TEA)

List of Annexes

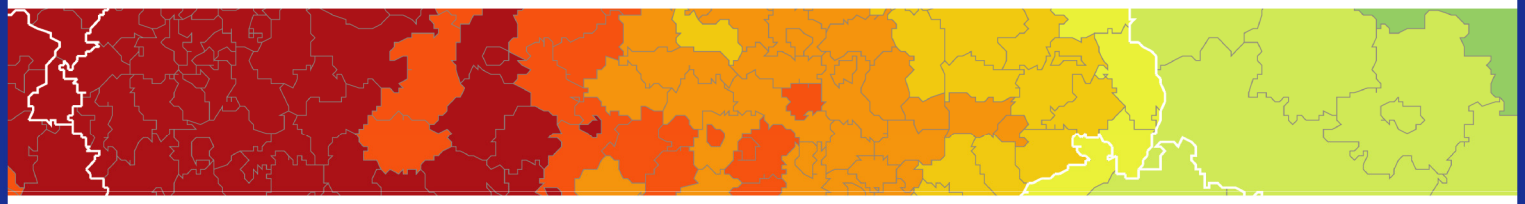
Scientific report with detailed information on

- Energy consumption – change of regional patterns throughout Europe (task1)
- Potential for renewable energy and its exploitation at a regional level (task 2)
- Regional action towards a European low-carbon economy – experiences from case study regions (task 3)
- Regional policy approaches and actions that facilitate the transition to a low-carbon economy (task 4)
- The role of cohesion policy for regional low-carbon economy (task 5)

Case study reports (presented separately)

- Province of Burgos, Spain
- Greater Copenhagen, Denmark
- Greater Manchester, United Kingdom
- Pazardzhik Province, Bulgaria
- Rheintal, Austria

Report on the situation of regional energy data collection in the Balkan countries



ESPON 2020 – More information

ESPON EGTC
4 rue Erasme, L-1468 Luxembourg - Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: **info@espon.eu**
www.espon.eu, **Twitter**, **LinkedIn**, **YouTube**

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.