ESPON

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Inspire policy making by territorial evidence

Territories and low-carbon economy (ESPON Locate)

Applied Research

Annex to the Final Report (Scientific Report)

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Territories and low-carbon economy (ESPON Locate)

Scientific Report

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Abbreviations

AESOP	Association of the European Schools of Planning
agenbur	Agencia provincial de la energia de burgos, provincial energy agency, Spain
APNE	Aktionsplan für nachhaltige Energie, partnership action plans for sustainable energy
AT	Austria
BE	Belgium
BEE	Biomass Energy Europe
BG	Bulgaria
BPIE	Buildings Performance Institute Europe
CEC	Central and Eastern European Countries
CEP	Central Europe Programme
CF	Cohesion Fund
CH	Switzerland
CITIES Centre	Centre for IT-Intelligent Energy System in Cities
CO_2eq	CO_2 equivalent
CoM	Covenant of Mayors (for Climate & Energy)
COP	Conference of the Parties
CoR	Committee of the Regions
CORINE	Coordination of Information on the Environment
COSMO	Consortium for Small Scale Modelling
CSP	Concentrated Solar Power
CURDS	Centre for Urban and Regional Development Studies, Newcastle University
CY	Cyprus
CZ	Czech Republic
DCLG	(UK government) Department for Communities and Local Government
DE	Germany
DECC	(UK government) Department of Energy & Climate Change
DEFRA	(UK government) Department for Environment, Food & Rural Affairs
DFG	Deutsche Forschungsgemeinschaft
DG ENER	European Commission's Directorate-General for Energy
DG Environment	European Commission's Directorate-General for Environment
DG Regio	European Commission's Directorate-General for Regional and Urban Policy
DG Research	European Commission's Directorate-General for Research and Innovation
DK	Denmark
DTU	Danmarks Tekniske Universitet, Technical University of Denmark
DW	Dwelling
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EDGAR	Emissions Database for Global Atmospheric Research
EE	Energy Efficiency
EEA	European Environment Agency
EEC	European Economic Community
EED	Energy Efficiency Directive
EEG	Energy Economics Group
EIA	Environmental Impact Assessment
EL	Ellas, Greece
EMFF	European Maritime and Fisheries Fund
ENPI/ENI	European Neighbourhood and Partnership Instrument/European Neighbourhood Instrument
ENTSO-E	European Network of Transmission System Operators for Electricity
EPBD	Energy Performance of Buildings Directive
ERDF	European Regional Development Fund
EREN	Ente Regional de la Energía, regional energy agency of Castilla y León
ES	Spain
ESCO	Energy Service/Savings Company
ESF	European Social Fund
ESI funds	European Structural and Investment Funds

ESRC	Economic and Social Research Council
ETC/ACM	European Topic Centre on Air Pollution and Climate Change
EU	European Union
EU ETS	European Union Emission Trading System
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
FI	Finland
FLH, flh	Full Load Hour
FP7	7th Framework Programme
FR	France
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographical Information System
GMCA	Greater Manchester Combined Authority
GURU	Global Urban Research Unit, Newcastle University
GW	gigawatt
H/C	heating/cooling
HR	Croatia
HU	Hungary
ICLEI	Local Governments for Sustainability (former: International Council for Local Environmental Initiatives)
ICT	Information and Communications Technology
IE	Ireland
IEA	International Energy Agency
IEE	Intelligent Energy Europe
Interreg	Community initiative aiming at stimulating interregional cooperation
IPA	Instrument for Pre-accession Assistance
IPAT	Main drivers for energy consumption (I) can be defined as population (P), economic activity (A) and technology (T); formula for analysing environmental impacts
IPCC	Intergovernmental Panel on Climate Change (UN Climate Panel)
IPMA	International Project Management Association
IRENA	International Renewable Energy Agency
IS	Iceland
ISI	(Fraunhofer) Institute for Systems and Innovation research
IT	Italy
IUCN	International Union for Conservation of Nature and natural resources
JRC	Joint Research Centre
JTS	Joint Technical Secretariat
KEEP	source of aggregated information regarding projects and beneficiaries of European Union programmes
KSSENA	Energy Agency of Savinjska, Šaleška and Koroška Region, Slovenia
ktoe	kilotonne of oil equivalent
LCE	Low Carbon Economy
LCOE	Levelized Costs of Electricity
LIFE	EU's financial instrument supporting environmental, nature conservation and climate action projects
LT	Lithuania
LU	Luxembourg
LULUCF	Land Use, Land Use Change and Forestry
LV	Latvia
MENA	Middle East & North Africa
MERRA	Modern Era Retrospective-analysis for Research and Applications
MMR	Monitoring Mechanism Regulation
MODIS	Moderate-resolution Imaging Spectroradiometer
MoU	Memorandum of Understanding
MS	Member State
MT	Malta
MW, MWh	Megawatt, Megawatt hour

NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne, statistical classification of economic activities in the European Community
NALAS	Network of Associations of Local Authorities
NATURA	ecological network composed of sites designated under the Birds Directive and the Habitats Directive
NEEAP	National Energy Efficiency Action Plan
NGO	Non-Governmental Organisation
NL	The Netherlands
NO	Norway
NUTS	Nomenclature des Unites Territoriales, nomenclature of territorial units for statistics
NZFR	New Zealand Forest Research
OECD	Organisation for Economic Co-operation and Development
PA	Partnership Agreement
PaM	Policies and Measures
PL	Poland
POP	population
PowerACE	Agent-based Computational Economics, detailed model for calculating and optimizing electricity systems in Europe and MENA
pp	percentage points
PT	Portugal
PV	photovoltaic
RAI	Regional Authority Index
RE	Renewable Energy
REAP	Regional Energy Agency of Pazardjik
REC	Regional Energy Concept
RED	Renewable Energy Directive
REF	Research Excellence Framework
RES	Renewable Energy Source
RMIT	Royal Melbourne Institute of Technology
RO	Romania
RTPI	Royal Town Planning Institute
RUE	Rational Use of Energy
RURENER	Network of small Rural communities for Energetic neutrality
RWTH Aachen	Rheinisch-Westfälische Technische Hochschule Aachen, Aachen University
S3PEnergy	The Smart Specialisation Platform on Energy
SE	Sweden
SEA	Strategic Environmental Assessment
SEAP	Sustainable Energy Action Plan
SEP	Sustainable Energy Project
SET-Plan	Strategic Energy Technology Plan
SETIS	Strategic Energy Technologies Information System
SI	Slovenia
SK	Slovak Republic
SME	Small and Medium-sized Enterprise
SPESP	Study Programme on European Spatial Planning
SRTM	Shuttle Radar Topography Mission
SSP	smart specialisation process
TC	Territorial Cooperation
TIA	Territorial Impact Assessment
TO	Thematic Objective
ToR	Terms of Reference
TU Wien	Technical University Vienna
TW, TWh	Terawatt, Terawatt hour
UK	United Kingdom
UN	United Nations
Under2MOU	Sub-national Global Climate Leadership Memorandum of Understanding
UN-ILO	United Nations-International Labour Organisation
US	United States

Introduction

Objectives of the research activity

The project on “Territories and low-carbon economy” aims at proving 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 laid 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. With respect to the great variation of regional spatial and economic features in Europe, it is a valuable innovation to compile such database and make it accessible for analysis and policy formulation. Furthermore, in an attempt to understand the variation of regional powers for policy making and implementation with focus on energy, the study provides an overview on policies and energy-relevant regional competencies. Together with case study experience on innovative policy approaches at the regional level, ideas and recommendations have been developed for policy formulation towards the transition to low-carbon economy. In doing so, it has been of special interest, 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, also informal cooperation arrangements, initiatives and joint actions have been of interest. The contribution of the regional level is of major importance for the success and intensity of transition processes, particularly relating to the success of private sector involvement, including enterprises and households.

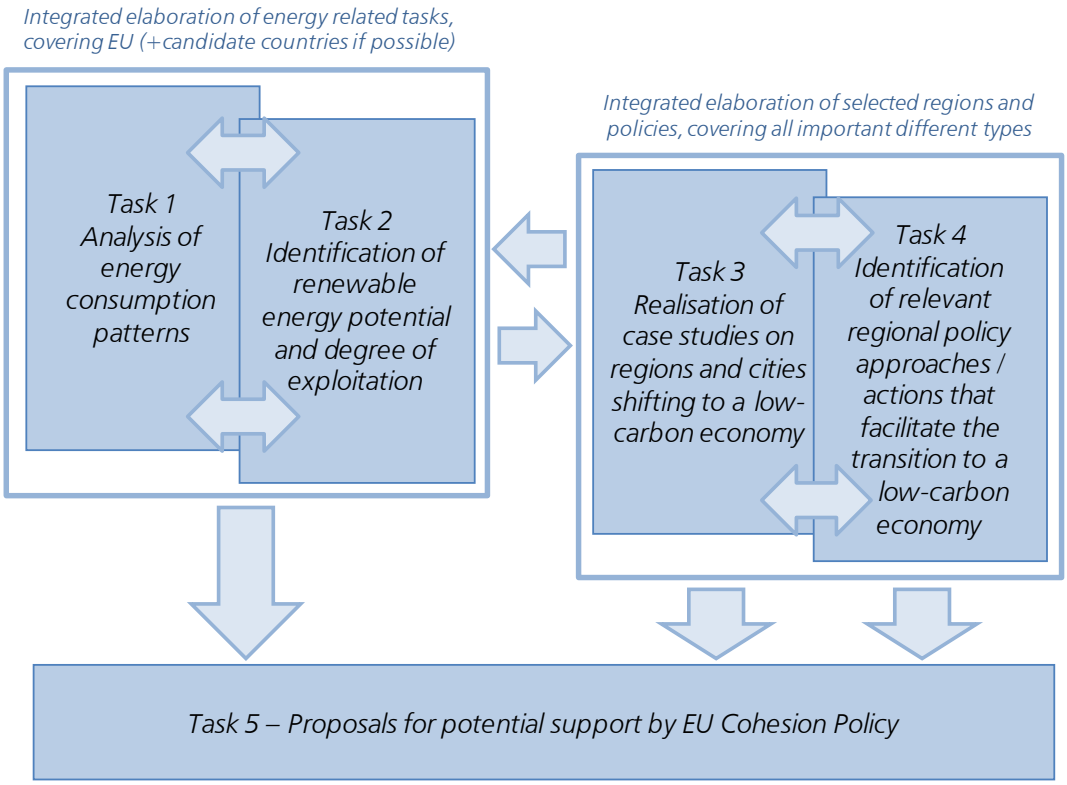
EU cohesion policy is focusing on economic development, research and innovation activities across Europe. In the current period a special focus is on low-carbon relevant activities, explicitly as contribution to EU 202020 targets – implementation has begun recently. Experience with this approach and 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 potential to act in full. In this project it is the ambition to bring together the views and needs from different levels in order to make regional-level policy making more effective.

To have a good understanding of how different regional potentials are to generate renewable energies is one key, 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 and methodological framework – general understanding of the tasks

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

Conceptual framework of the project – combining quantitative and qualitative tasks



Source: Consortium 2016.

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.

Conclusions and recommendations have been drawn from both strands of research, relating to data availability and demand, necessary governance structures and policy designs and also to further research needed.

Quantitative research and modelling: Creating an energy database on NUTS 3 level

Tasks 1 and 2 have elaborated a spatially inclusive and comprehensive evidence of energy consumption and of the potential generation of renewable energy as well as its exploitation. Since only very restricted regional data at the level of NUTS3 is available concerning these issues, the results are based on modelling and econometric estimates derived from national or NUTS2 data (if available).

Research and modelling on regional energy consumption patterns and regional renewable potential and its exploitation is closely linked, because a number of common data bases for modelling has been used and common steps of approximation have been undergone. A number of spatially more disaggregated indicators has been used for modelling and estimations, e.g. relating to demographic features, land use, building types, economic structures etc. Some of the data has been useful for assessing the potential for generating renewable energy, e.g. as (urbanized) land use is a restriction to the use of wind power.

Qualitative research on selected regions and different regional policies

Tasks 3 and 4 are highly interlinked, both are dealing with successful polices and initiatives. Whereas task 3 is depicting the regional perspective and describing regional experiences on recent region-based policies and initiatives (assessed in case studies), task 4 is dealing with the perspective of policy making and the success of different policies and initiatives in relation to varying legal, planning and political frameworks across different levels of government. Regions have different political and administrative powers across Europe, and this needs to be considered when making recommendations for regional policy designs. Thus, in order to make use of synergies, an integrated development of conceptual frameworks and accompanying exchange of results between these tasks has been conducted.

Above this, both tasks, 3 and 4, have provided additional information and lessons learned for task 5, by considering instruments of cohesion policy as key element in regional development policy and also with the specific focus on energy transition to low carbon economy. Therefore, task 5 has been able to use the synthesis from all tasks, considering the varying economic and physical features of regions and also the variations in governance structures and policy designs.

1 Energy consumption – change of regional patterns throughout Europe

The objective of this chapter is to provide detailed data, analysis 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.

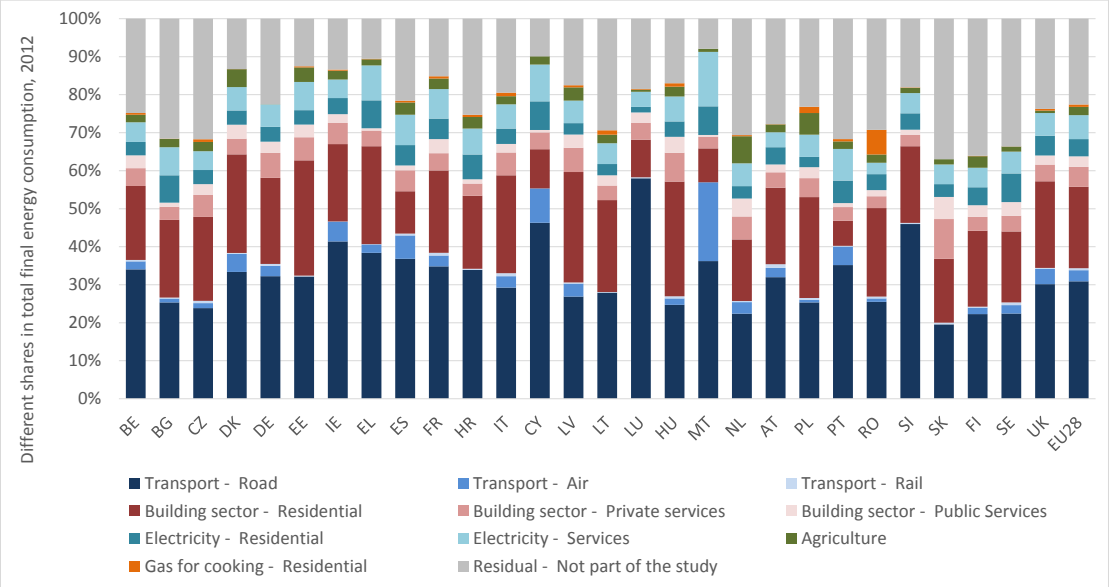
Up to now no such data, showing consumption patterns over different end use sectors, exists on NUTS3 level in this form. Since no primary data collection was possible within this project, the results build on modelling methods, combining different data sources for the regional distribution of energy consumption data. Thus, for some of the maps and data uncertainties exist, which should be taken into account. By properly explaining our method, approach and assumptions we want to make these uncertainties transparent (see chapter 0).

The results are checked for consistency with results from the regionalized renewable potential and degree of exploitation analysis (see chapter 2) in this report. Moreover, 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, we have reached consistency of the our results with 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 (section 1.1.3) and transport energy consumption (section 1.1.4). Finally, we show the renewable shares in these end-use sectors (section 1.1.5). 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.

The datasets, presented in the subsequent chapters, have been elaborated in ESPON Locate. The major share of these datasets has been elaborated at the disaggregated level of NUTS 3 (highlighted in dark green colour), for some datasets we had to stay with less disaggregated provision of data due to lacking available data sources and information at smaller regional level (highlighted in light green colour).

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



The category "Heating & Cooling" 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.

Table 1.1: Overview of elaborated datasets

SECTORS of Energy consumption	Household sector	Tertiary sector		Agriculture and forestry	Transport			
Sub sectors	Residential buildings	Public non-residential buildings	Other non-residential buildings		Road	Rail	Air	Water
HEATING AND COOLING								
space heating and domestic hot water, cooling								
OTHER END USES (excl. Space heating, cooling and domestic hot water)								
electric appliances, lighting and process energy demand								
RES-H/C share								
RES-E share								
TRANSPORT								
RES-T share								

1.1 Regional results over time (2002-2012) for energy consumption patterns on NUTS3 level

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.

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 air conditioning of the residential and non-residential building stock on the level of NUTS3 regions are shown (see Map 1.1 – Map 1.6).

The six maps in this chapter indicate results for the final energy consumption for space heating, domestic hot water production and air conditioning on the spatial level of NUTS 3 regions per capita, each for 2012 and the difference between 2002-2012 and for (1) residential buildings, (2) the private service sectors and (3) public buildings.

It should be taken into consideration that the maps show *final* energy consumption. This means, that also 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.

The trend from 2002-2012 is mainly driven by following factors:

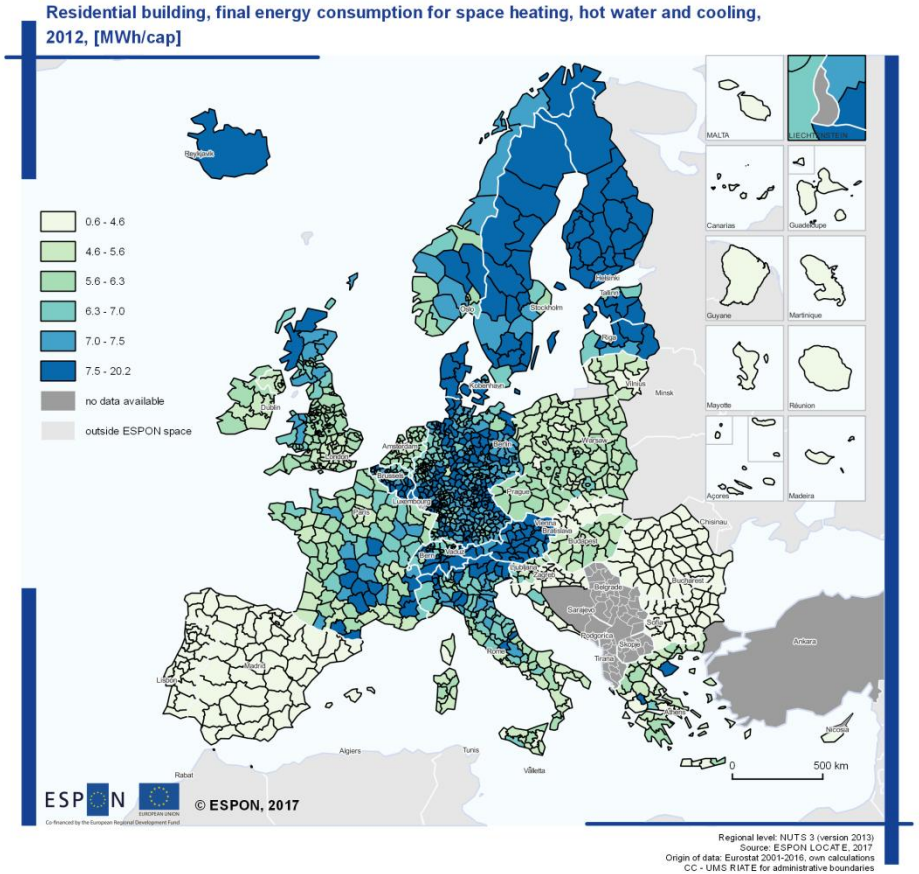
- Change in the energy performance of the building stock by thermal building renovation and installation of other (more efficient) heating systems.
- Change in the overall supply of energy services, e.g. the related floor area of the building stock of a certain region. However, also the comfort level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

Thus, different trends in different regions can be explained through these drivers. In many regions, e.g. in Germany, the improvement of the energy performance of buildings outweighs the growth in supplied energy service. However, in other regions the opposite has happened[1].

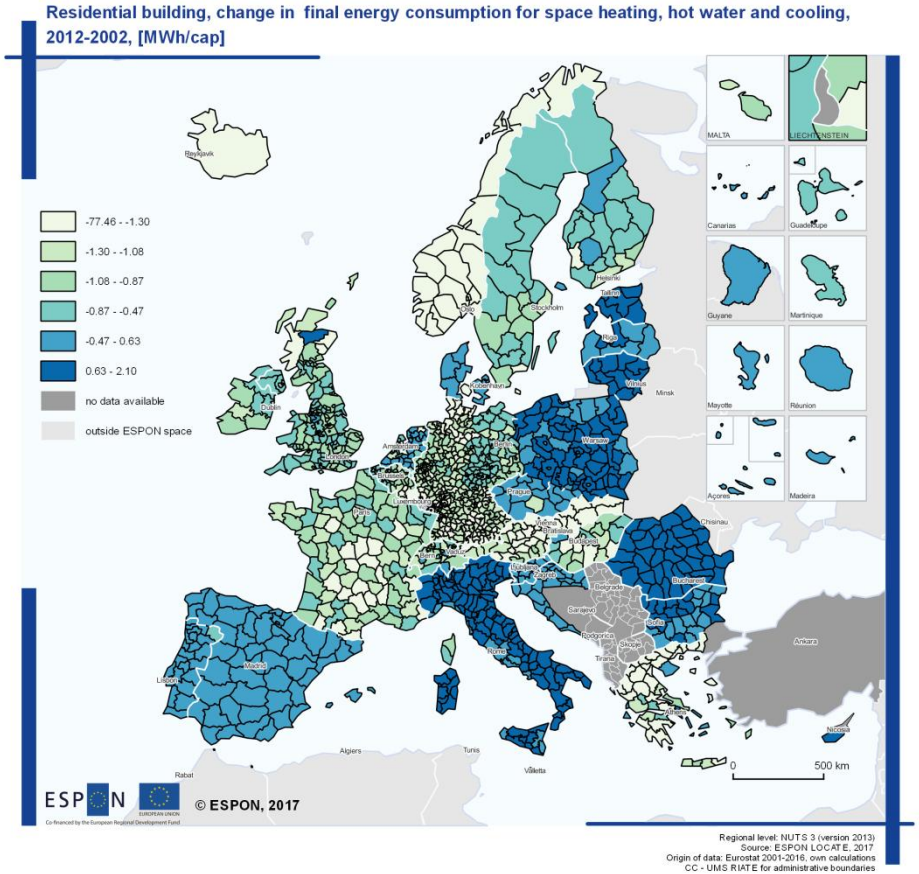
We want to emphasize that the development of energy consumption maps from 2002 to 2012 is not distorted by the change of heating degree days and cooling degree days. For both years we applied the same climate data. We believe it is essential to make use of the same heating and cooling degree days for both years 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.

[1] 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.

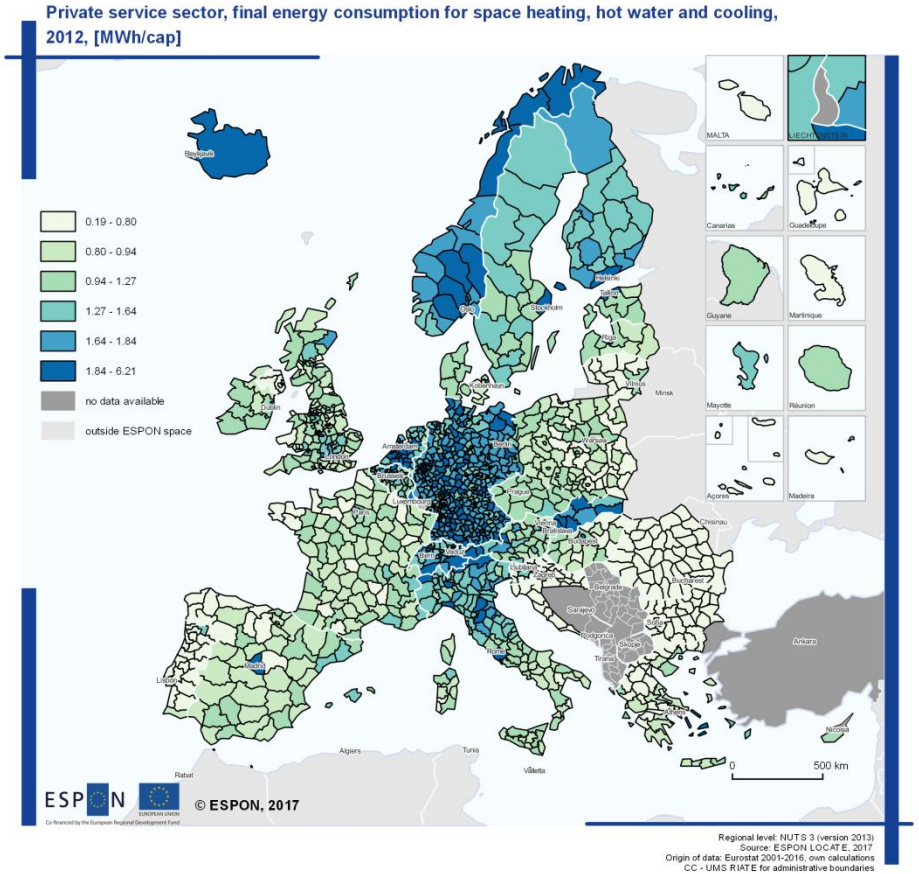
Map 1.1: Final energy consumption for space heating, domestic hot water production and cooling of residential buildings in 2012, MWh per capita



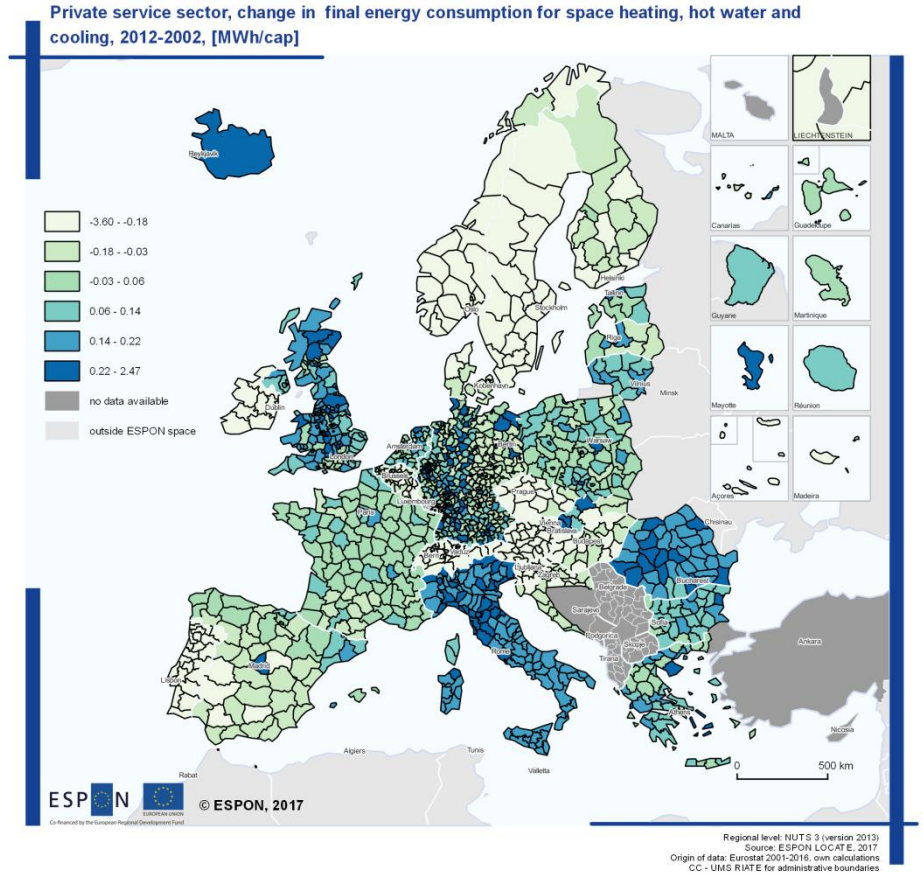
Map 1.2: Absolute change in final energy consumption for space heating, domestic hot water production and cooling of residential buildings 2012-2002, MWh per capita



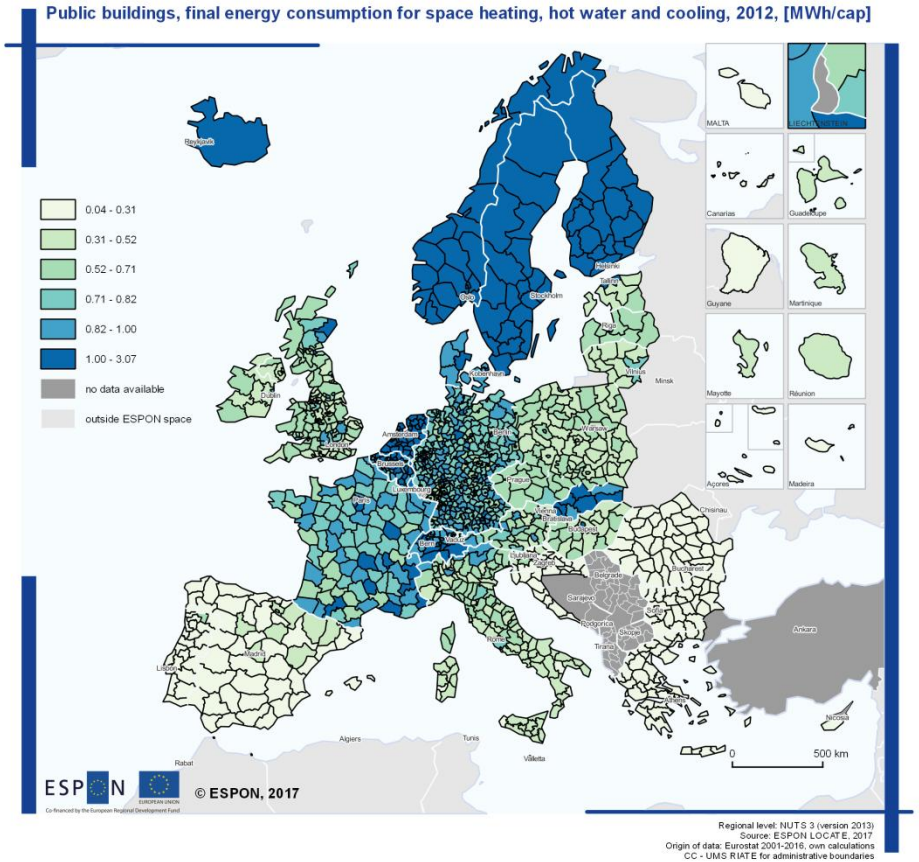
Map 1.3: Final energy consumption for space heating, domestic hot water production and cooling in buildings of the private service sectors in 2012, MWh per capita



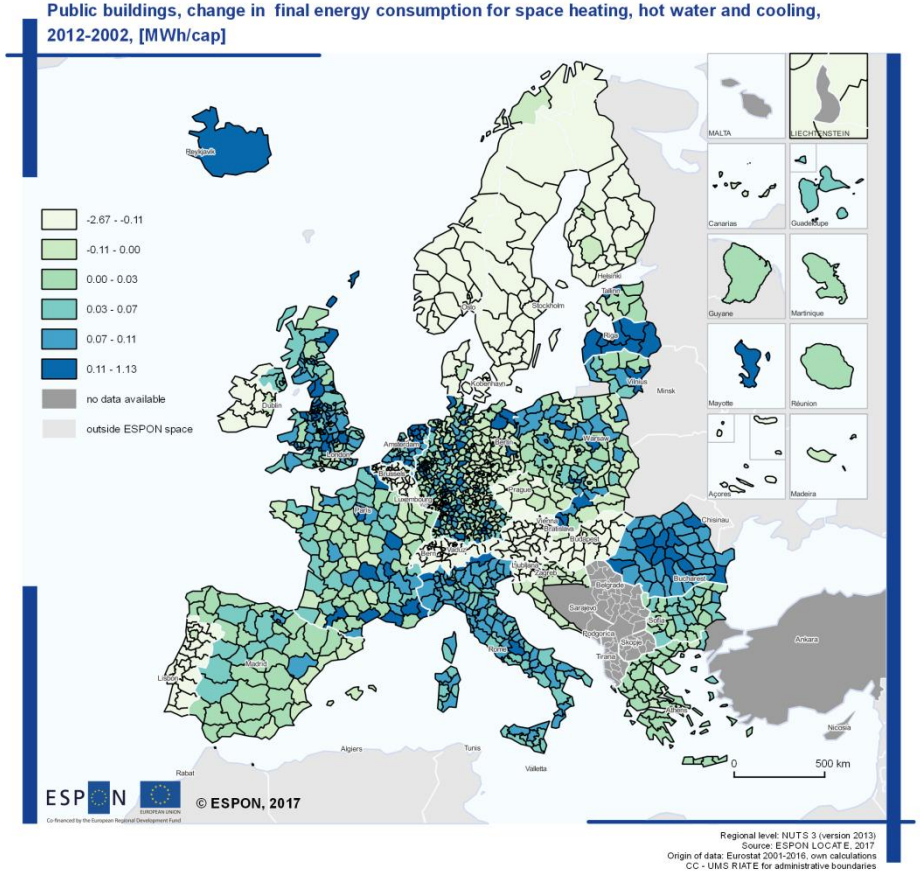
Map 1.4: Absolute change in final energy consumption for space heating, domestic hot water production and cooling in buildings of the private service sectors 2012-2002, MWh per capita



Map 1.5: Final energy consumption for space heating, domestic hot water production and cooling in public buildings in 2012, MWh per capita



Map 1.6: Absolute change in final energy consumption for space heating, domestic hot water production and cooling in public buildings, 2012-2002, MWh per capita

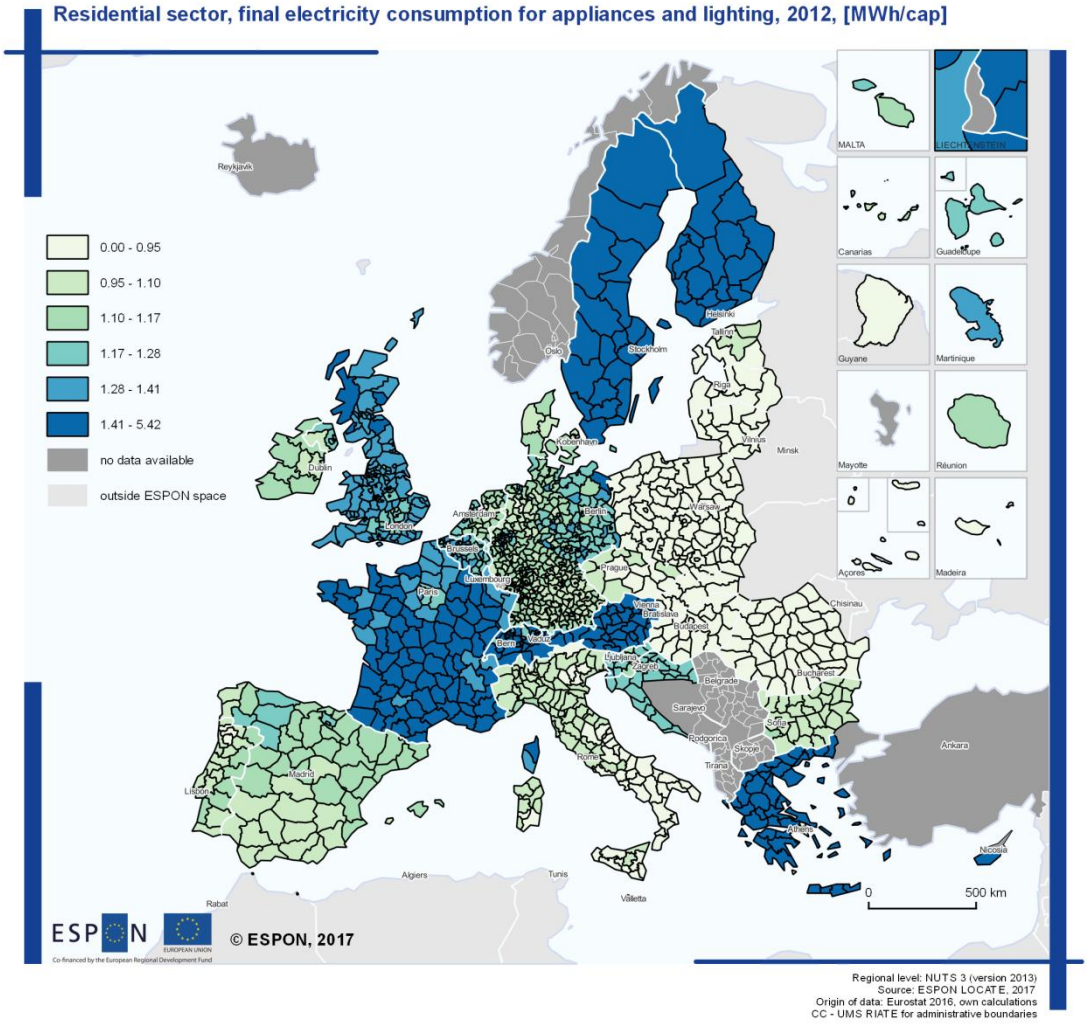


1.1.2 Energy consumption for appliances, lighting and cooking

In this chapter, energy consumption for appliances, lighting and cooking in the residential and service sector is analysed.

The electricity consumption of the residential sector is essentially attributed to household appliances such as refrigerators and washing machines, lighting and electricity-related heating devices. In the following, energy consumption for appliances and lighting are analysed. Please refer to Section 1.1.1 for the depiction of energy consumption for space heating, hot water and cooling.

Map 1.7: Electricity consumption per capita for appliances and lighting in the residential sector in 2012, in MWh/capita

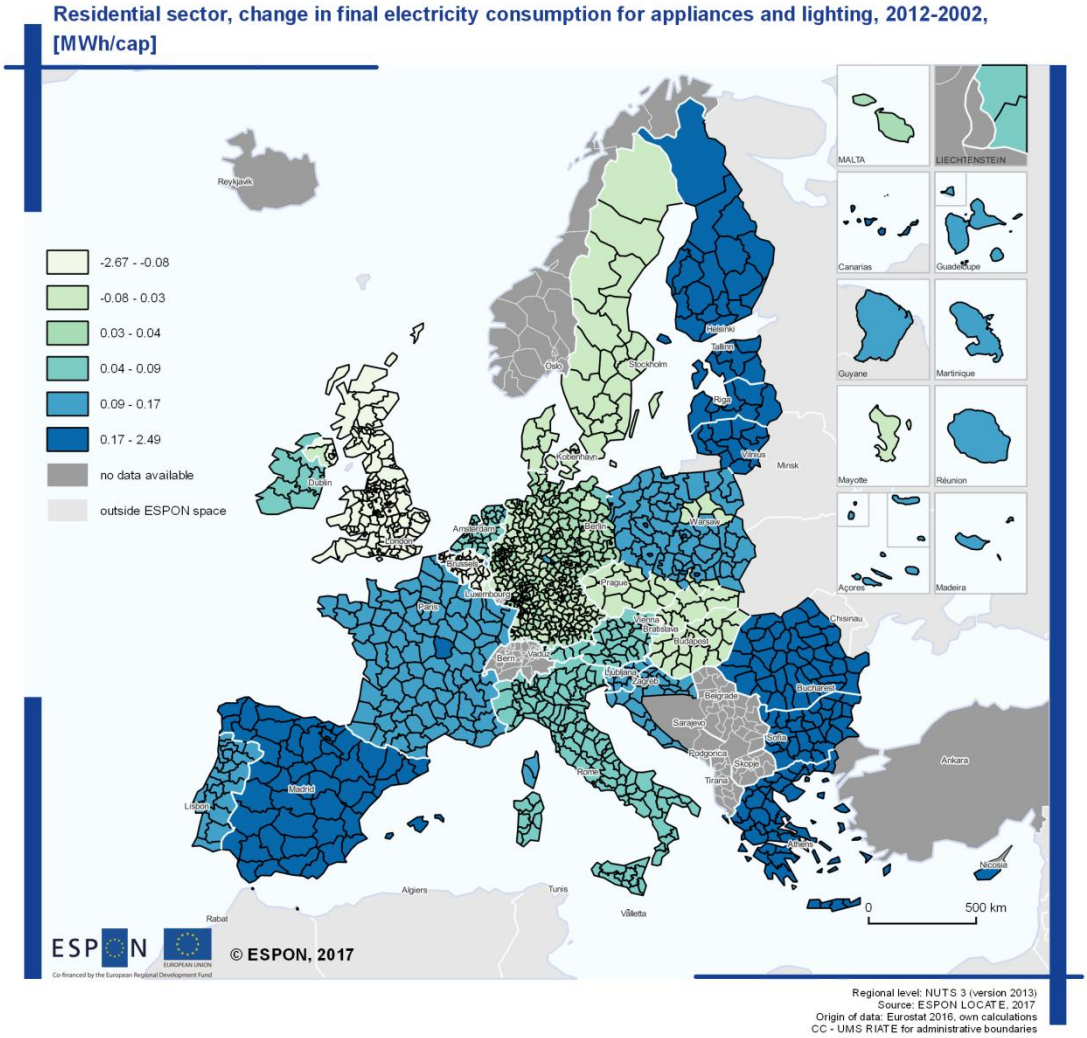


As indicated in Map 1.7 annual electricity consumption of these end-uses is higher than 3-4 MWh per capita in some regions. Especially in Sweden, the electricity consumption per capita is above 3,000 kWh per capita in many regions. On the other hand, many eastern Europeans countries and parts of Spain exhibit very low specific electricity consumption for appliances and lighting that is even below 1,000 kWh per capita. The map reveals also that in some

countries the consumption per capita is distributed equally (e.g. Poland) compared to other countries such as Germany with much more heterogeneous distribution.

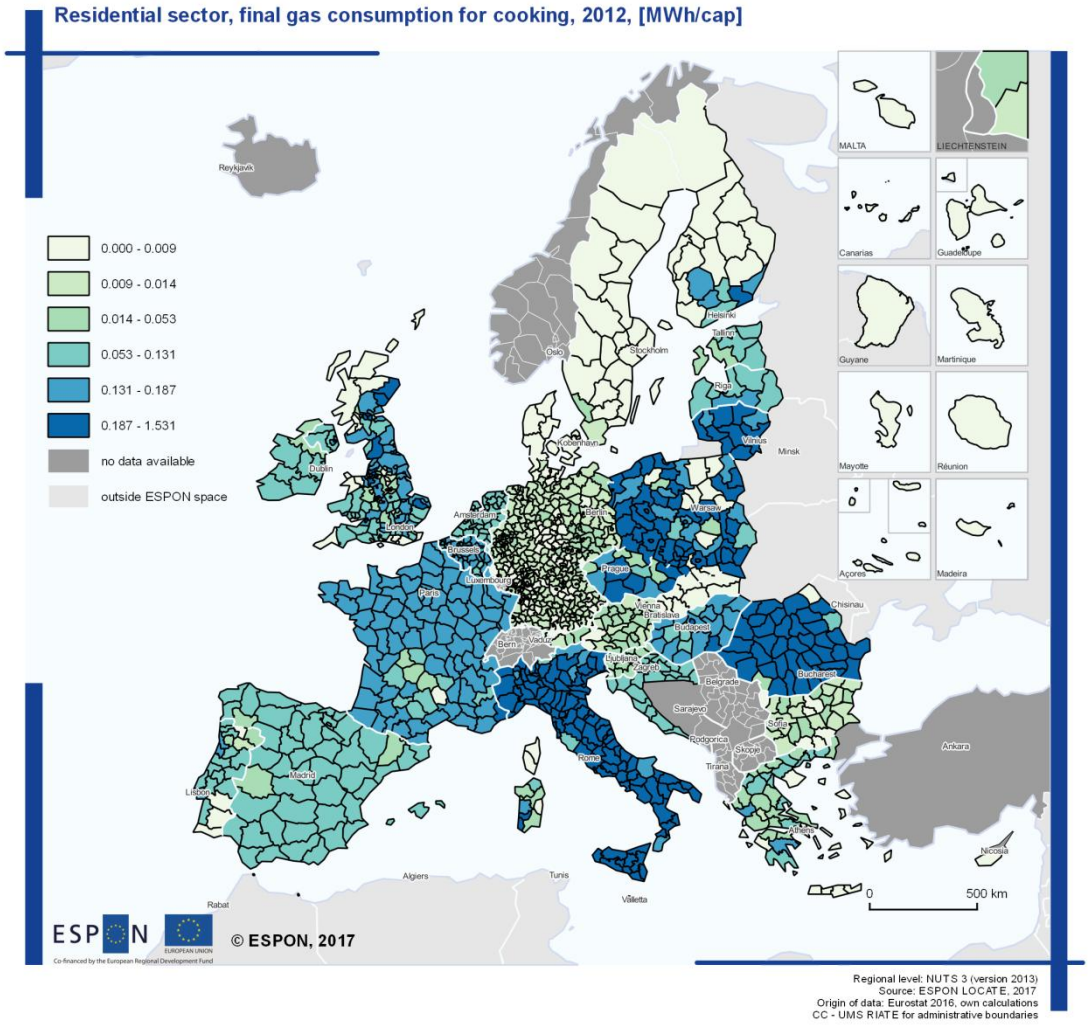
The comparison between 2012 and 2002 shows an increase of electricity consumption per capita in almost all of the countries (Map 1.8). The strongest increase can be observed in many regions of Greece, Romania and Lithuania. Furthermore, the comparison to 2002 shows that especially in Germany the consumption per capita remains very unequal whereas in many other regions the consumption per capita converged over time. The only countries with regions in which electricity consumption is decreasing are Luxembourg, Denmark, the United Kingdom and Belgium.

Map 1.8: Change in electricity consumption per capita for appliances and lighting in the residential sector 2012-2002, in MMWh/capita



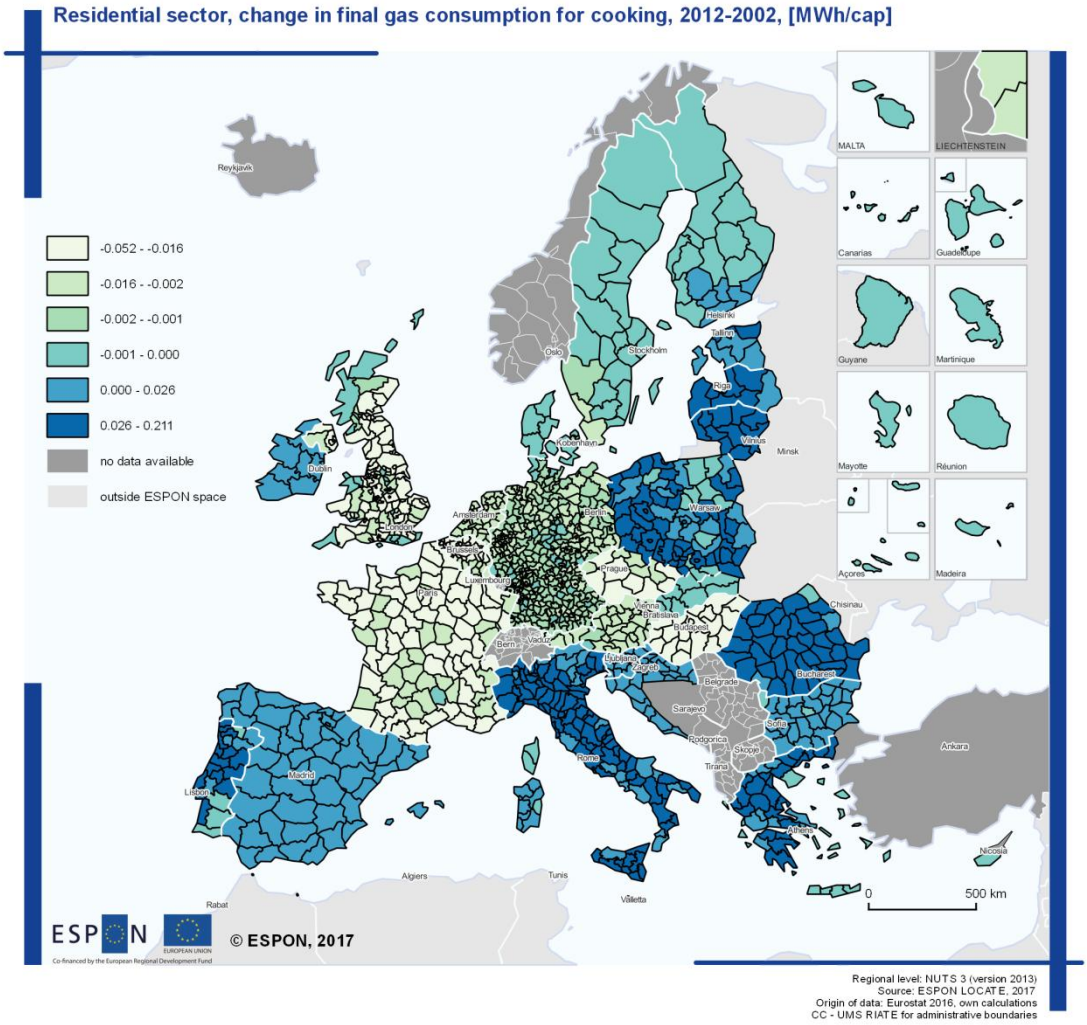
The gas consumption for cooking per capita is shown in the following map. As indicated in Map 1.9 the highest consumption by far is in Romania and many regions of Poland. In comparison, more than half of the analysed regions have a gas consumption per capita below 100 kWh. The lowest consumption per capita can be observed in Norway, Sweden, Finland and Island.

Map 1.9: Gas consumption per capita for cooking in the residential sector in 2012, in MMWh/capita



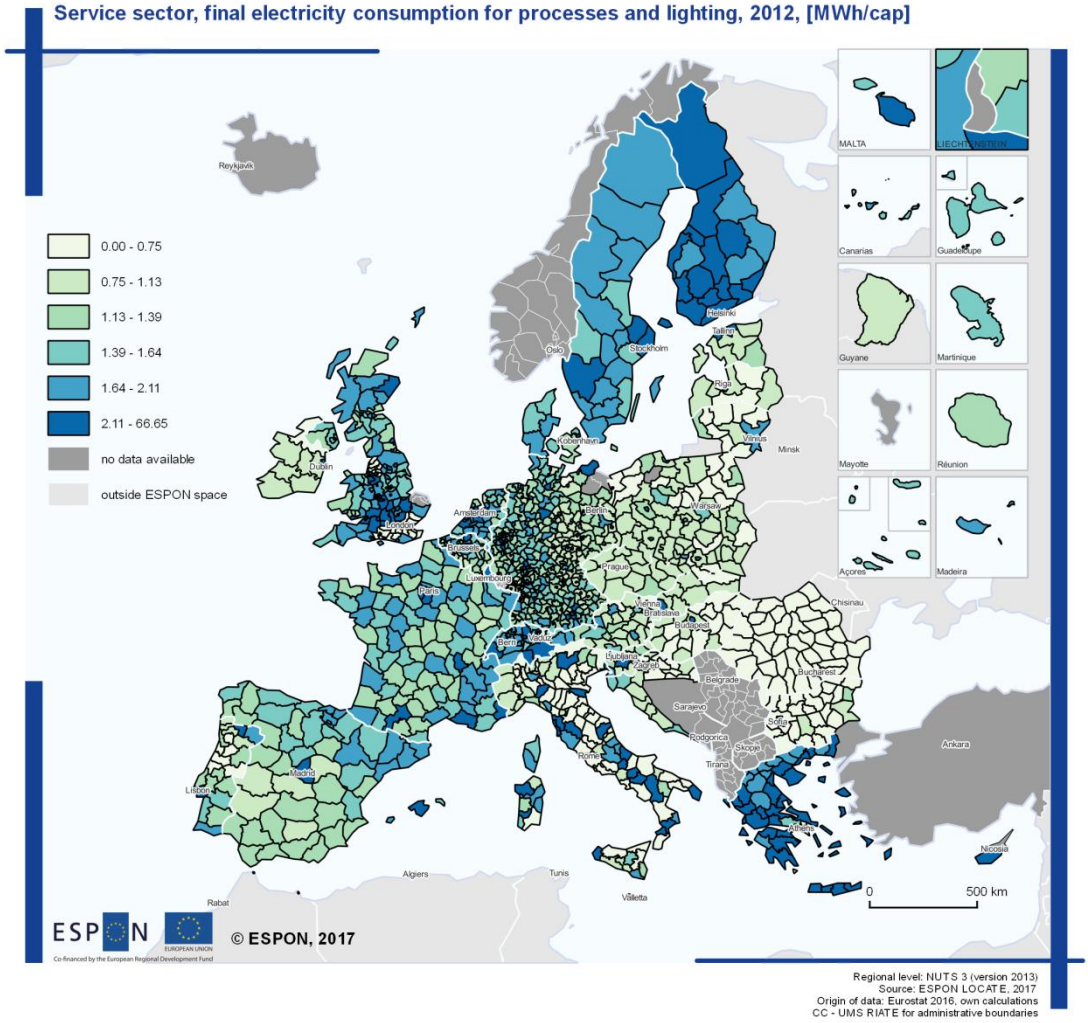
When comparing 2012 to 2002, it can be seen that the degree of heterogeneity remains fairly equal within these 10 years (Map 1.10). On the other hand, there are countries such as France, Denmark, Germany and Hungary with a decreasing gas consumption per capita for cooking.

Map 1.10: Change in gas consumption per capita for cooking in the residential sector 2012-2002, in MWh/capita



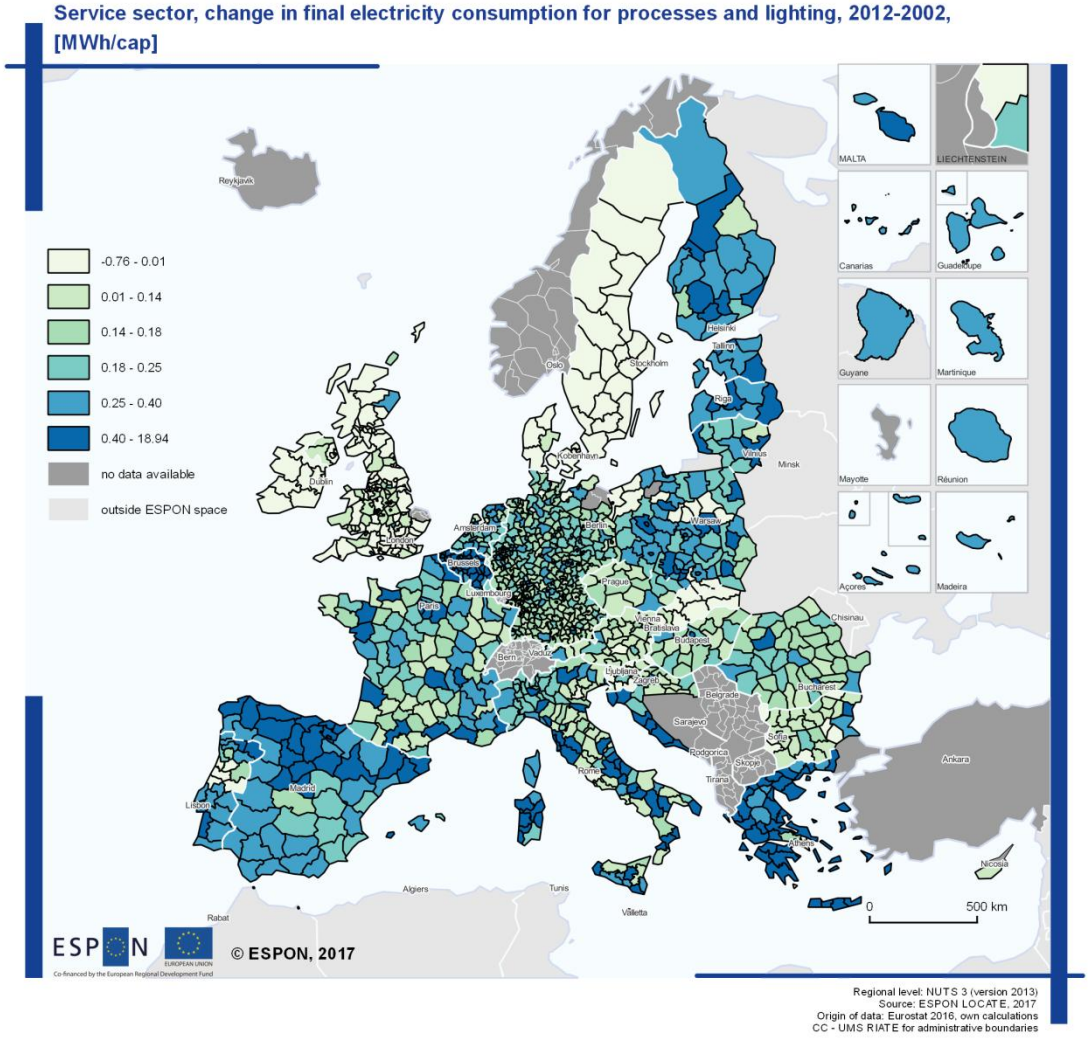
In the following, the results are discussed for the electricity consumption per capita attributed to appliances, lighting and processes in the service sector. This is the entire energy consumption of the service sector except for heating-related purposes and transport. As illustrated in the legend of Map 1.11 the level of electricity consumption per capita increases up to 100,000 kWh and even above. This is due o the fact that entire metropolises like Paris, Madrid or Berlin are capture by single NUTS3 regions, which are also the regions with the highest level of electricity consumption by far.

Map 1.11: Electricity consumption per capita for processes in the tertiary sector in 2012, in MWh/capita



Until 2012, electricity consumption per capita even increases in the service sector (Map 1.12). Analysing the regions with the highest consumption per capita in 2012 reveals, that the ranking of regions largely have not changed since 2002. The strongest increase since 2012 can be observed in Romania and Belgium. For Island, Norway and the Czech Republic no data are available for the 2002 balance.

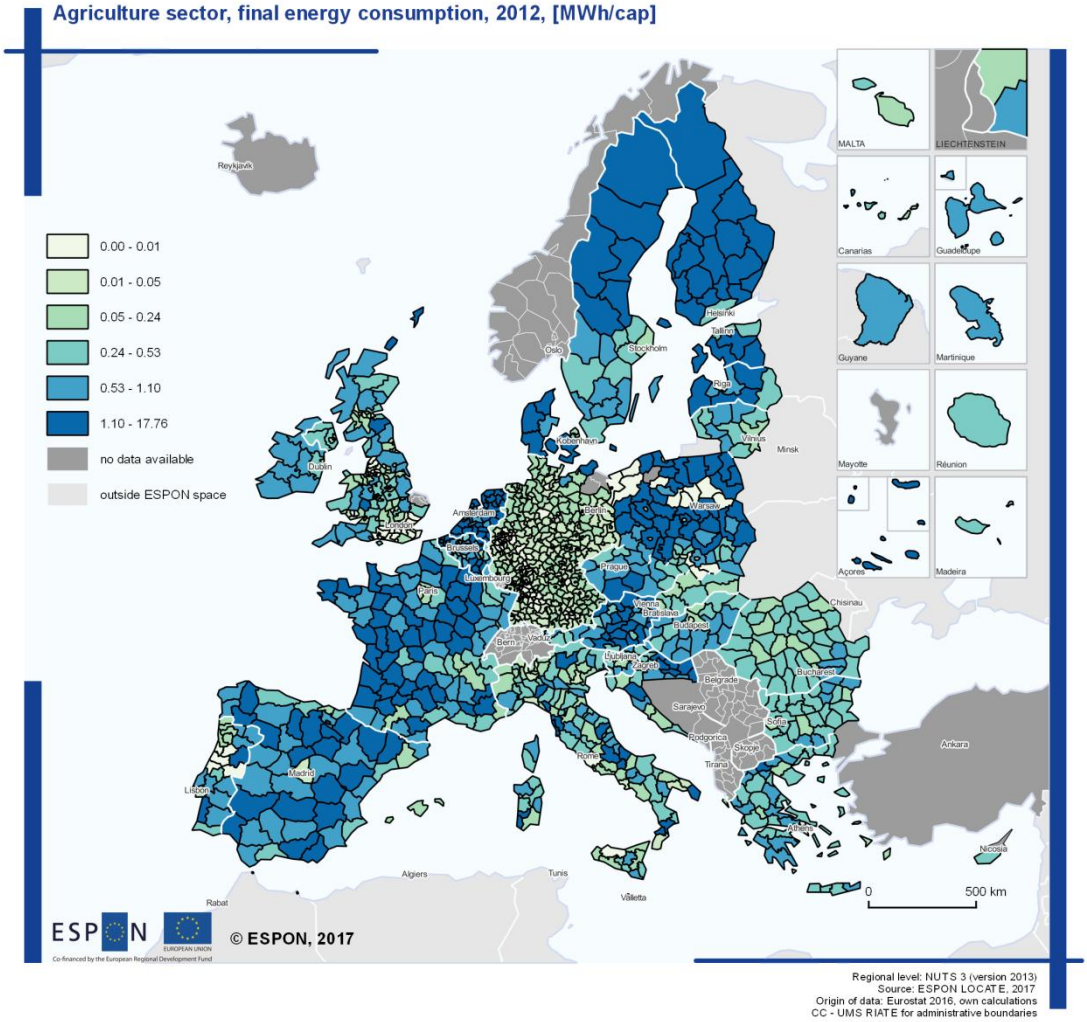
Map 1.12: Change in electricity consumption per capita for processes in the tertiary sector 2012-2002, in MWh/capita



1.1.3 Energy consumption for agriculture

The total final energy consumption of the agriculture and forestry sector is related to the population per region. As the study reveals, the highest consumption per capita can be seen in the Netherlands and in Poland with values even above 5,000 kWh per capita (Map 1.13). For instance, total final energy consumption in Germany is mainly below 100 kWh per capita, due to the fact of a high population density compared to the overall consumption. As for the service sector, there are data gaps for Norway and Island.

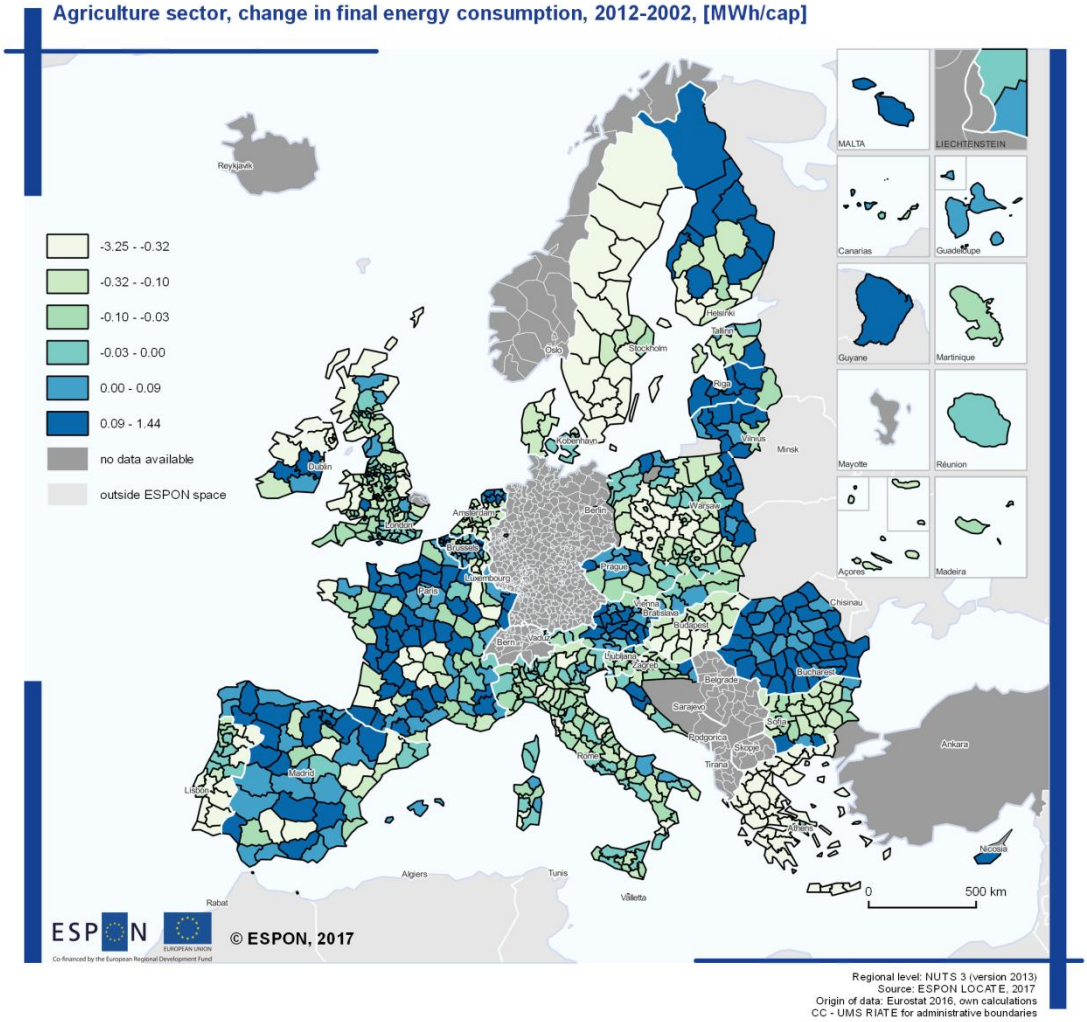
Map 1.13: Total final energy consumption per capita in the agriculture and forestry in 2012, in MWh/capita[2]



Total final energy consumption of the agriculture and forestry sector has decreased since 2002. This is also the case for the total final energy consumption per capita in 2012 which is slightly below the level 2002 (Map 1.14). Furthermore, we see that the distribution of total final energy consumption per capita largely remains stable until 2012. However, there are some exceptions such as Romania. The total final energy consumption of the sector is distributed more heterogeneously in 2012 than it was in 2002. Other countries like Ireland became more homogenous over time.

[2] For Germany, no data regarding gross value added of the agriculture sector by NUTS3 regions is available for 2012. Thus, we built the map on the data for 2002 only.

Map 1.14: Change in total final energy consumption per capita in the agriculture and forestry 201-2002, in MWh/capita[3]



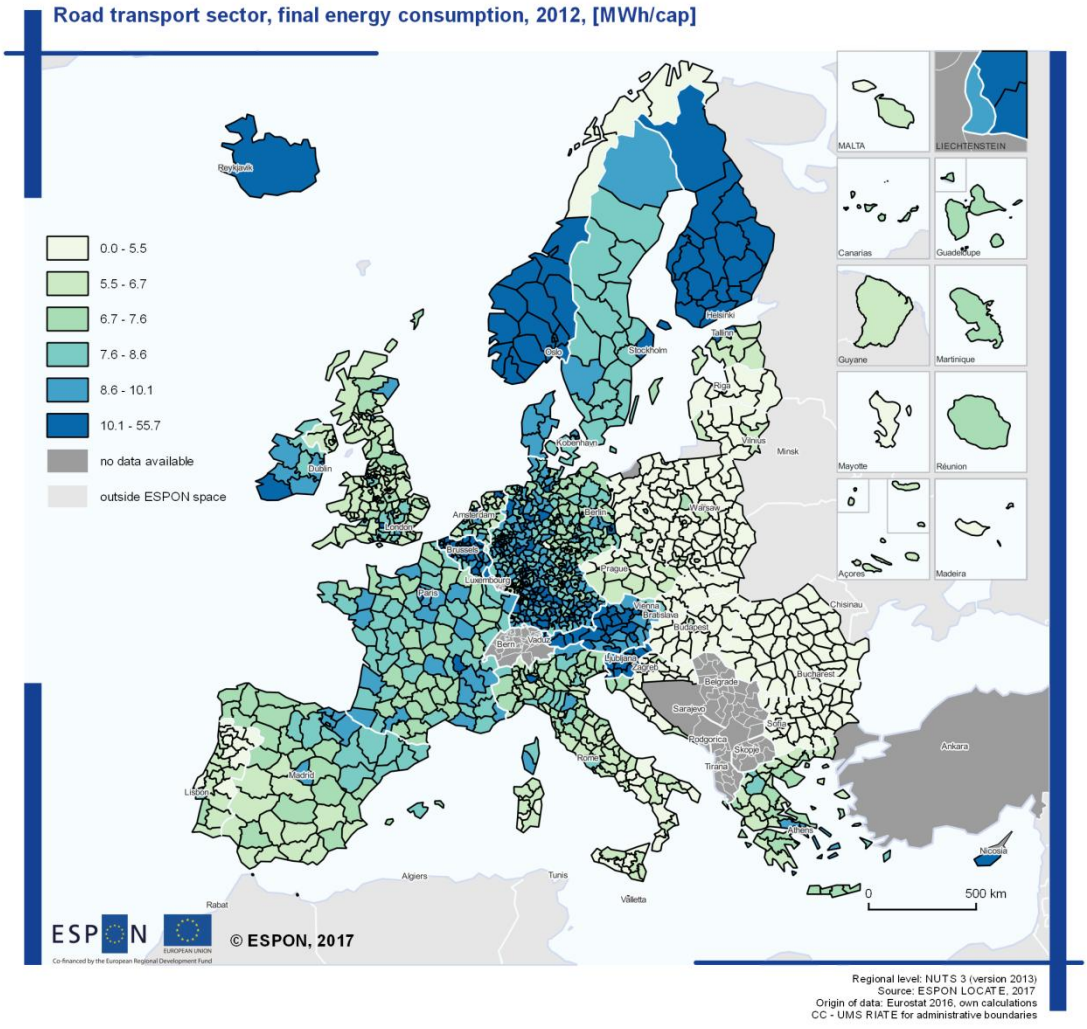
1.1.4 Energy consumption for transport

In order to derive regional consumption patterns of the transport sector, different methodologies are applied for road, rail and air transport. Passenger and freight road transport includes According to transport modelling theories, the significant influences on freight transport are GDP and for passengers transport the population as well as the number of jobs (Ortúzar/Willumsen 2001 and Schade 2005). Since both indicators are available on NUTS-3-level, they are used to derive regional energy consumption patterns of road transport all diesel and gasoline driven vehicles on roads as well as special off-road vehicles. As gasoline and diesel consumption is monitored separately an isolated calculation of both fuel types is

[3] For Germany, no data regarding gross value added of the agriculture sector by NUTS3 regions is available for 2012. Thus, we built the map on the data for 2002 only and no data for the change from 2002-2012 is available.

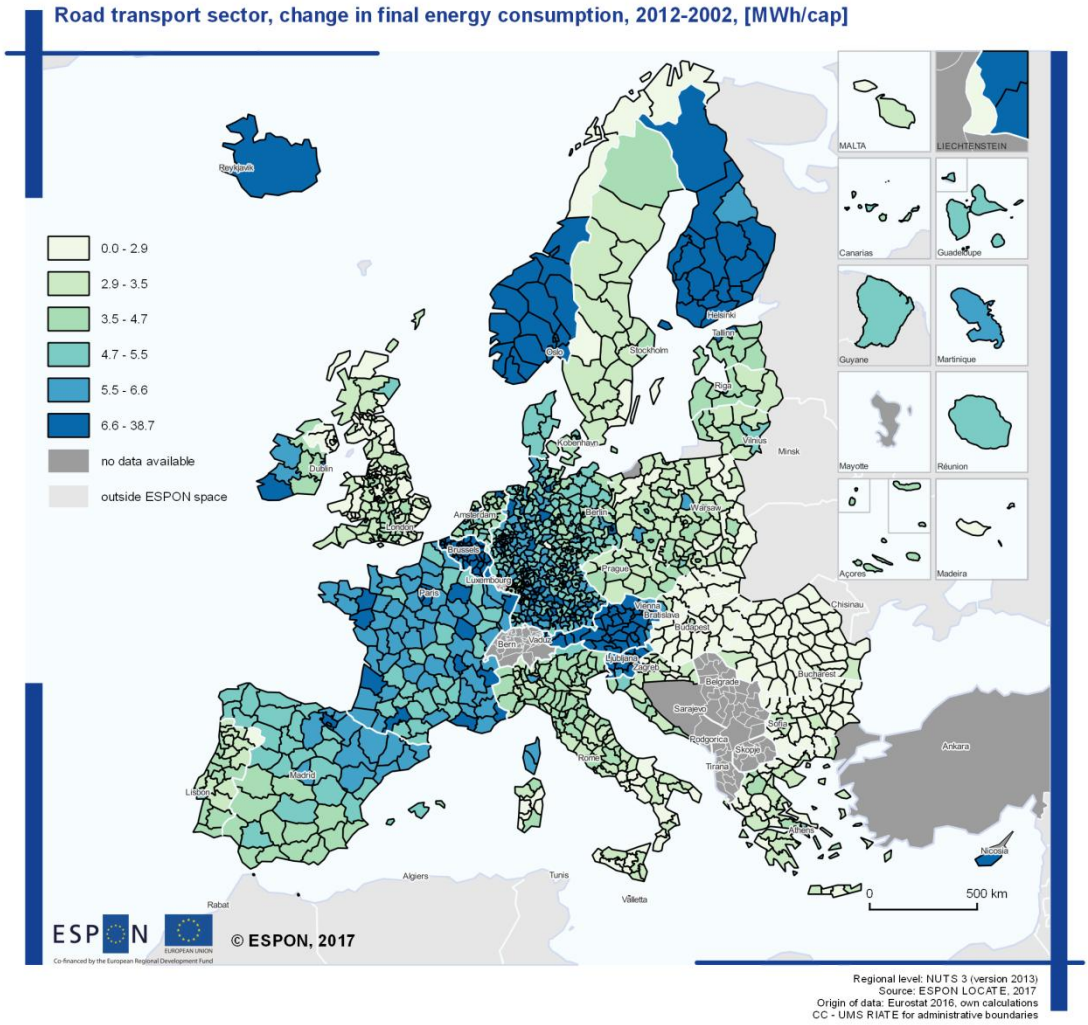
possible. Commercial and duty vehicles are driven by diesel engines only, hence gasoline is purely used by passenger roads transport. According to mobility surveys about 20% of the transport volume is related to the trip purpose “work” (MOP 2010). This leads to the estimation, that 20% of the transport volume and hence gasoline consumption is related to the number of jobs (and GDP) and 80% to the population The following map shows the result of the analysis with regard to energy consumption of road transport on NUTS 3 level.

Map 1.15: The energy consumption for road transport in 2012, MWh per capita



Despite more efficient technologies the energy consumption per capita has increased in the period 2002 to 2012 (Map 1.16). The structural differences between eastern and central have not changed.

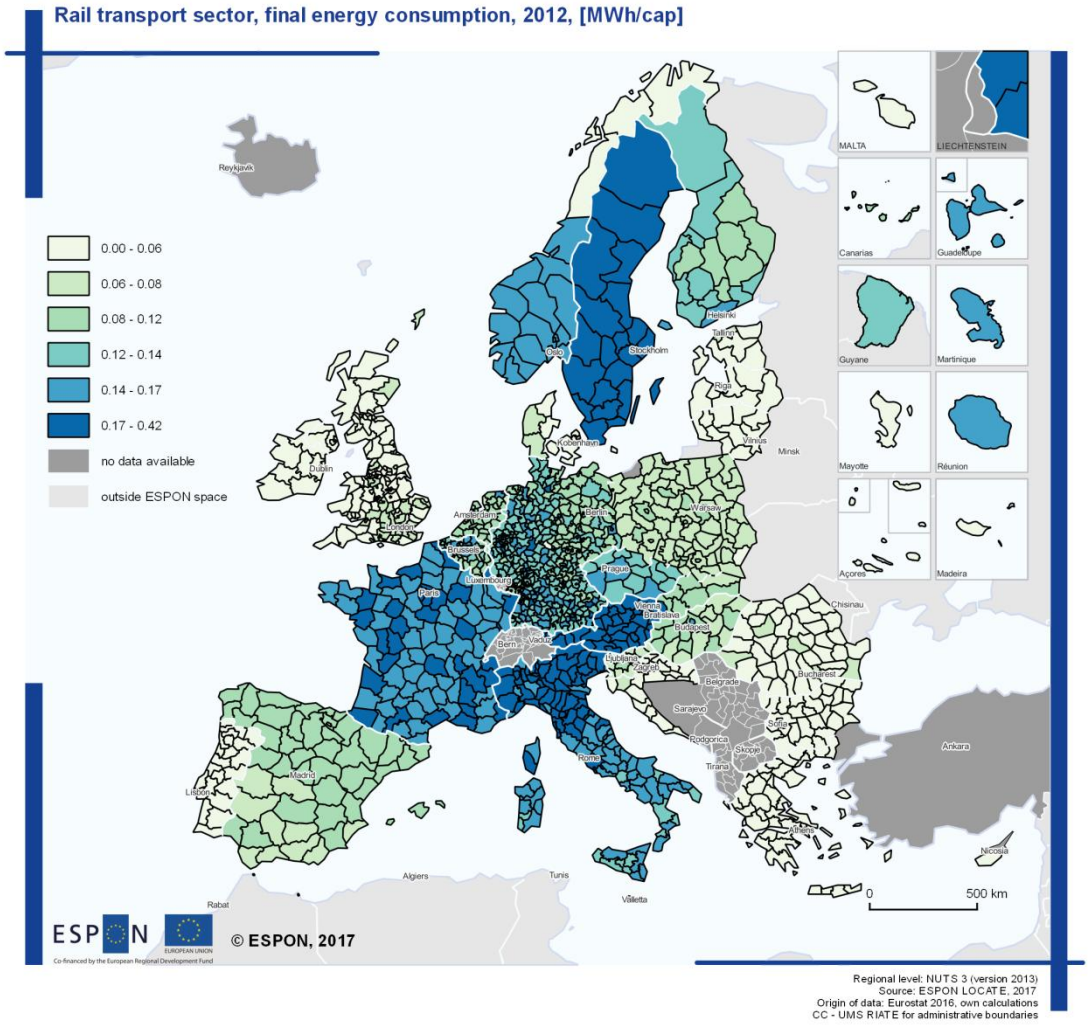
Map 1.16: The change in energy consumption for road transport in 2012-2002, MWh per capita



Rail transport

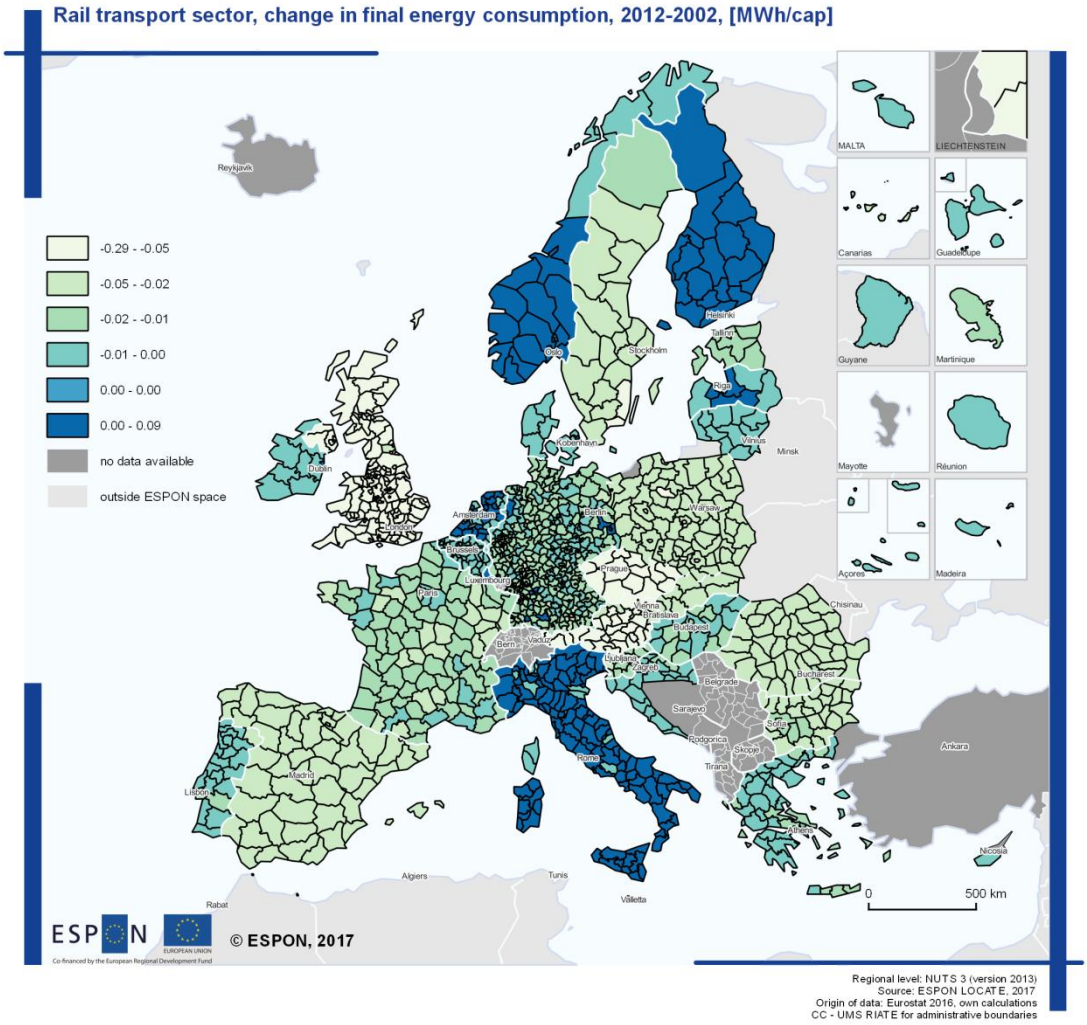
As for the most countries, the modal share of rail is tremendously lower as the share of road transport, the energy consumption of rail transport per capita is only about one tenth of the road transport energy consumption. A comparison of the results for the years 2002 and 2012 (Map 1.17 and Map 1.18) shows that also rail energy consumption has declined during the past decade. The main reason is the growing efficiency of passenger and freight trains.

Map 1.17: The energy consumption for rail transport in 2002, MWh per capita



Compared to road transport energy consumption, there is no clear difference between Central and eastern Europe especially Czech Republic and parts of Slovakia exhibit a similar energy consumption per capital as Central Europe.

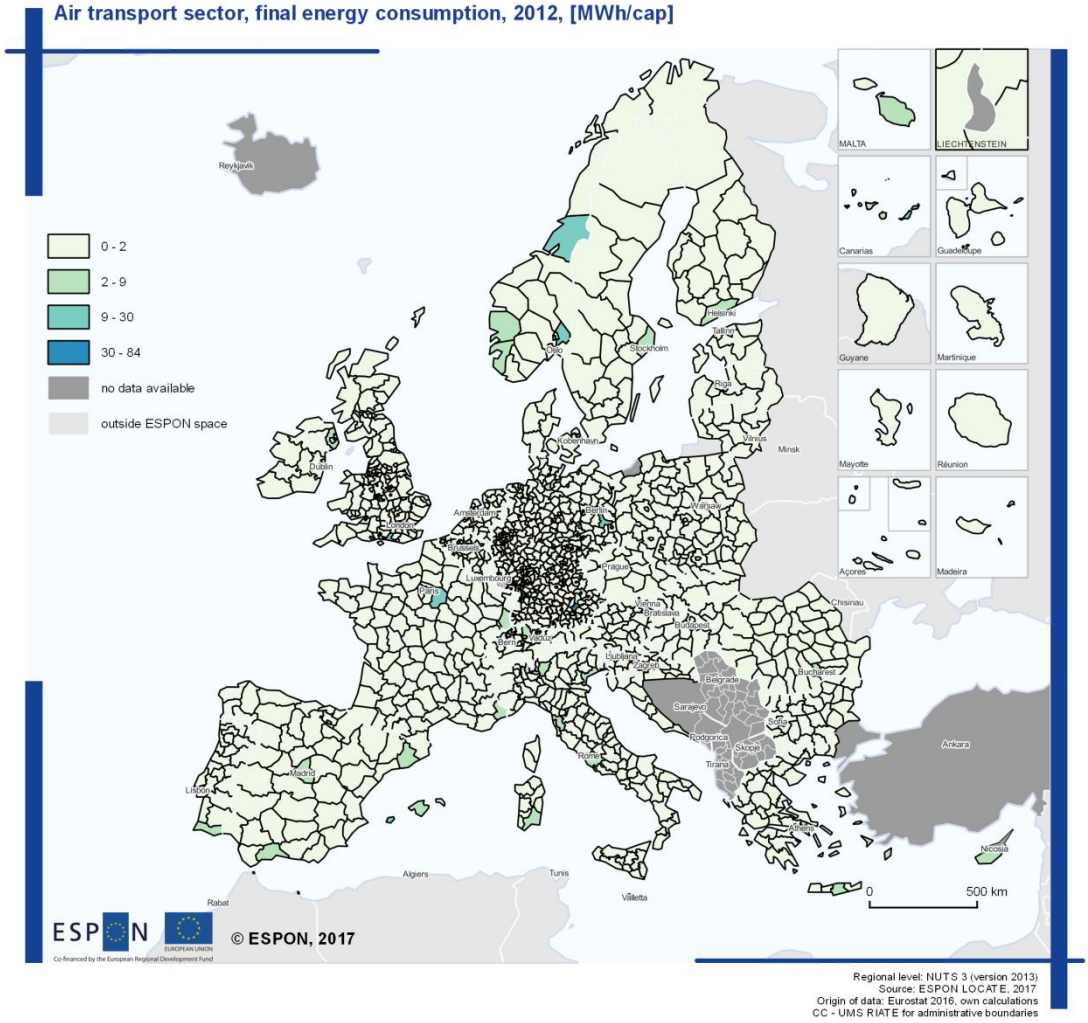
Map 1.18: The change in energy consumption for rail transport 2012-2002, MWh per capita



Air Transport

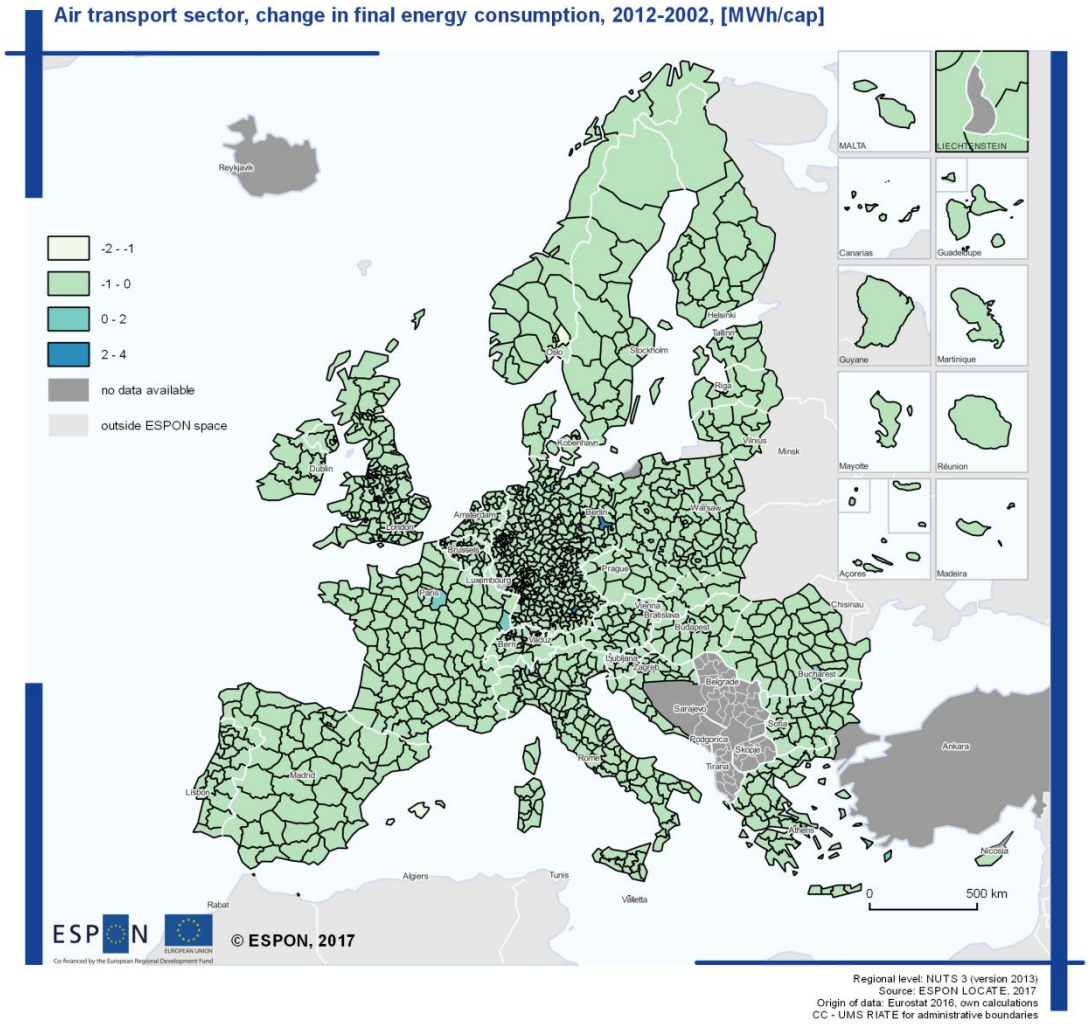
The results for air transport energy consumption are different compared to the other modes. Kerosene consumption is related to the aircraft movements at the airports. Map 1.19 shows that this leads to a selected number of NUTS 3 regions with relatively high energy consumption per capita whereas no energy consumption is accounted in other regions. The energy intensity also depends on the number of inhabitants of the NUTS 3 zones. That is why the specific consumption is comparably low in London despite of having the largest European airport (Map 1.19).

Map 1.19: Energy consumption for air transport in 2012, MWh per capita



In general, the energy consumption of air transport has not declined in the same amount like the consumption of the other transport modes. On the one hand, long holding periods of air-crafts slow down the diffusion of efficiency technologies, on the other hand air transport is the most dynamic growing transport sector. That why there are barely remarkable differences between the year 2002 (Map 1.19) and 2012 (Map 1.20).

Map 1.20: Absolute change in energy consumption for air transport 2012-2002, MWh per capita



1.1.5 Share of renewable energy in different sectors

Renewable heating/cooling share in residential and non-residential buildings

The following maps show the share of renewable heating/cooling for 2012 and 2002 and the different sectors (residential buildings, private service sectors, public buildings). As explained above (0), 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.

For the interpretation of Map 1.21 to Map 1.24 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

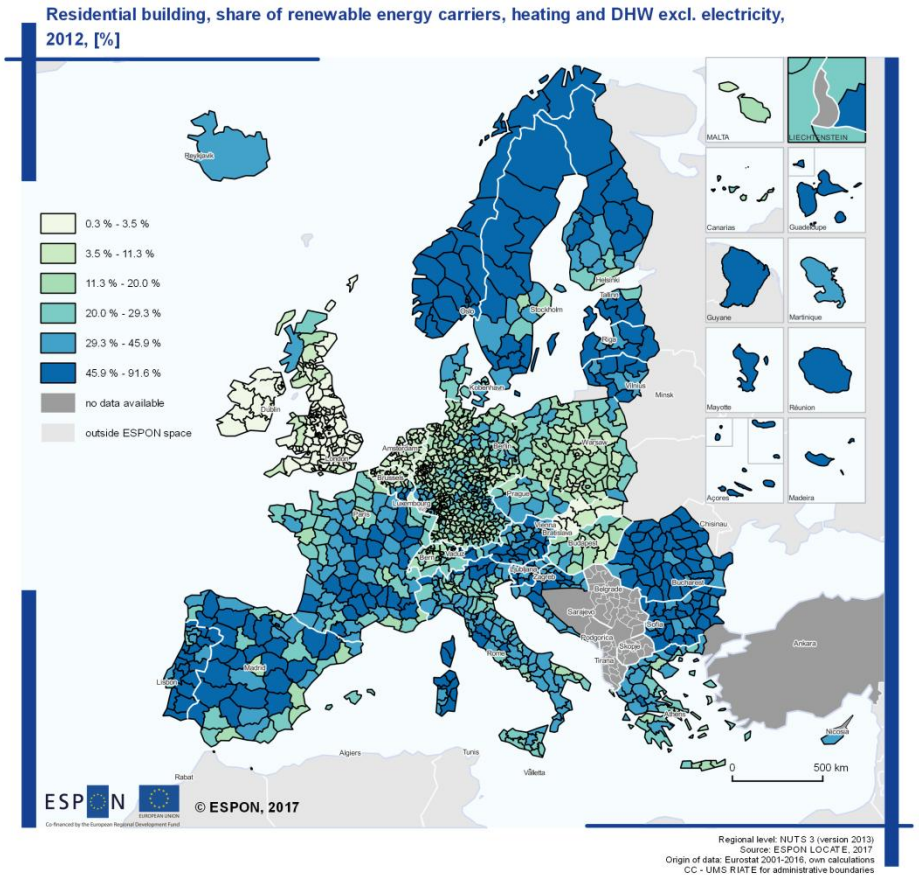
estimated availability and applicability of different energy carriers in the different regions. This implies presumptions such as the assumption that district heating systems are prevailingly applied in urban areas, whereas biomass is predominantly used in rural areas, or the assumption that the availability 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 equals 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, Rumania, Bulgaria and Austria primarily stems from a 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 in the formula we applied to derive the share of renewable energy carriers this energy carrier is excluded, the calculated share only refers to a minor share of the actual delivered energy for heating and cooling. In other countries which are commonly known for having a high share of electric heating systems such as France, Spain or Portugal, this effect is not significantly influencing the calculated renewable share, as electricity in these countries only contributes to about 20-30% of the total energy for space heating and domestic hot water production.

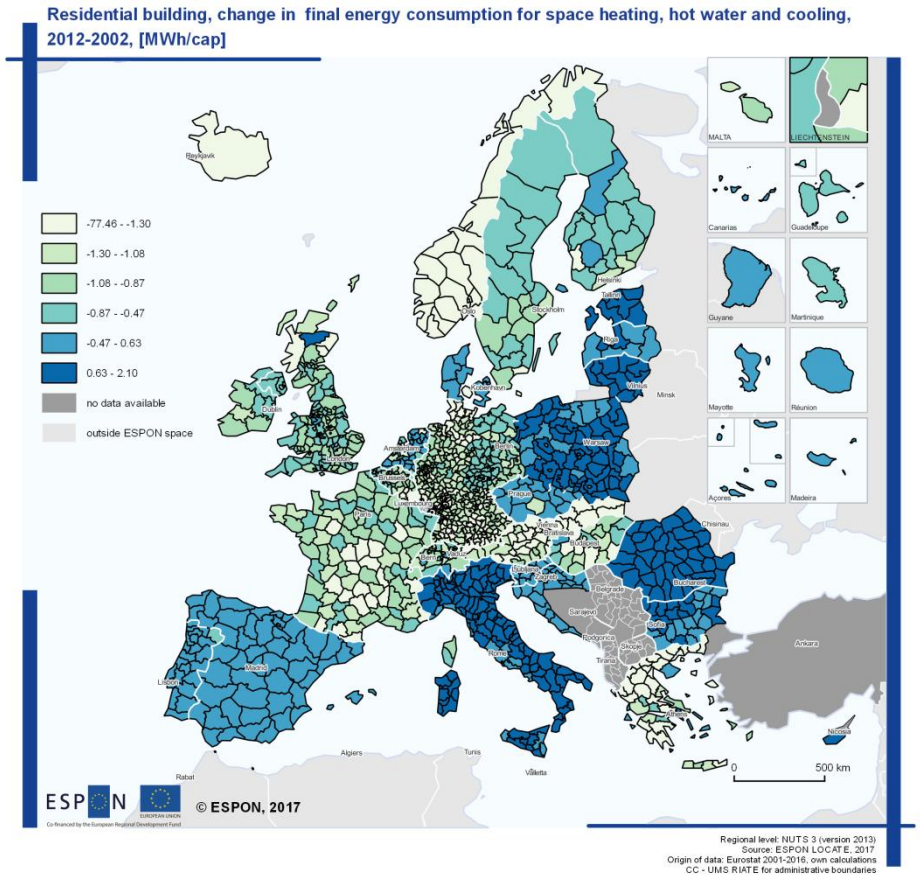
Countries with a very low domestic wood biomass potential or/and a long tradition of a widely distributed natural gas network show considerably lower shares of renewable energy carriers. Accordingly, Ireland and Belgium show the lowest share of renewable energy carriers (first category), followed by Great Britain and The Netherlands (second category, see following maps).

In contrast to the energy consumption patterns in 2012, there is a general trend towards an increasing share of RES-H/C in most regions from 2002-2012 (see Map 1.22 for the change of the RES-H/C share in the residential sector and Map 1.24 for the change in the private service sector). At the same time, in general the non-residential building stock lags behind the stock of residential buildings in terms of renewable heating and cooling (see Map 1.21 for the RES H/C share in the residential sector in 2012 in comparision to Map 1.23 for the private service sector).

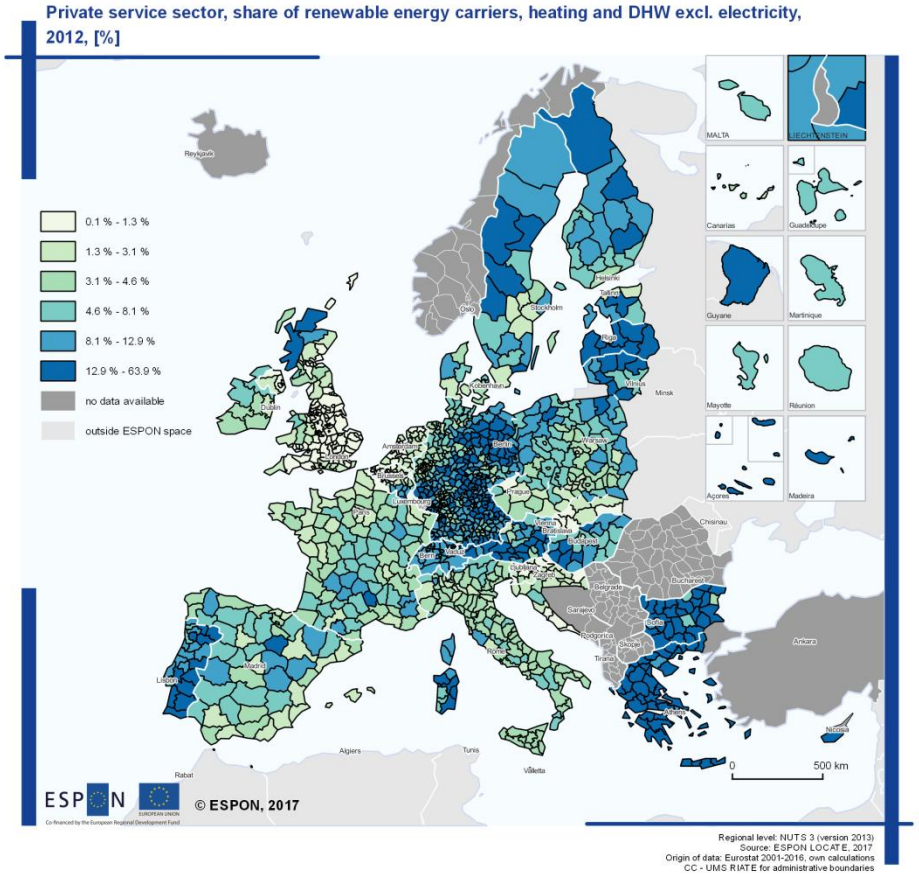
Map 1.21: Share of renewable energy carriers for space heating and domestic hot water production of residential buildings in 2012, %



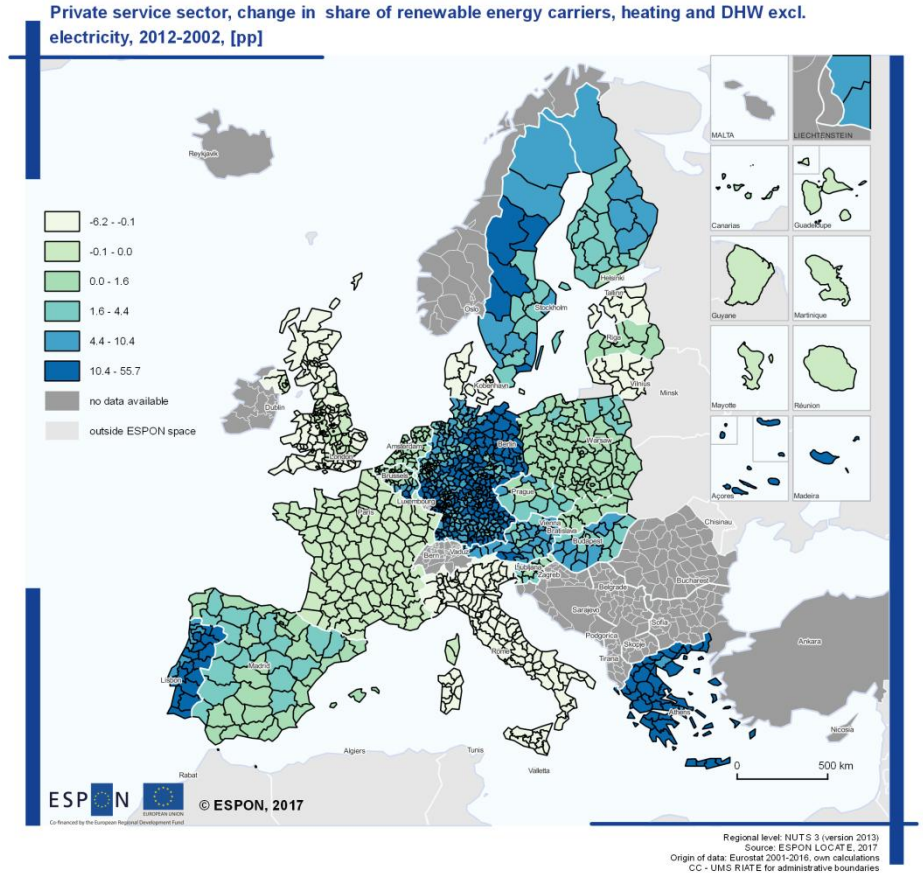
Map 1.22: Change in share of renewable energy carriers for space heating and domestic hot water production of residential buildings in 2012-2002, in percentage points



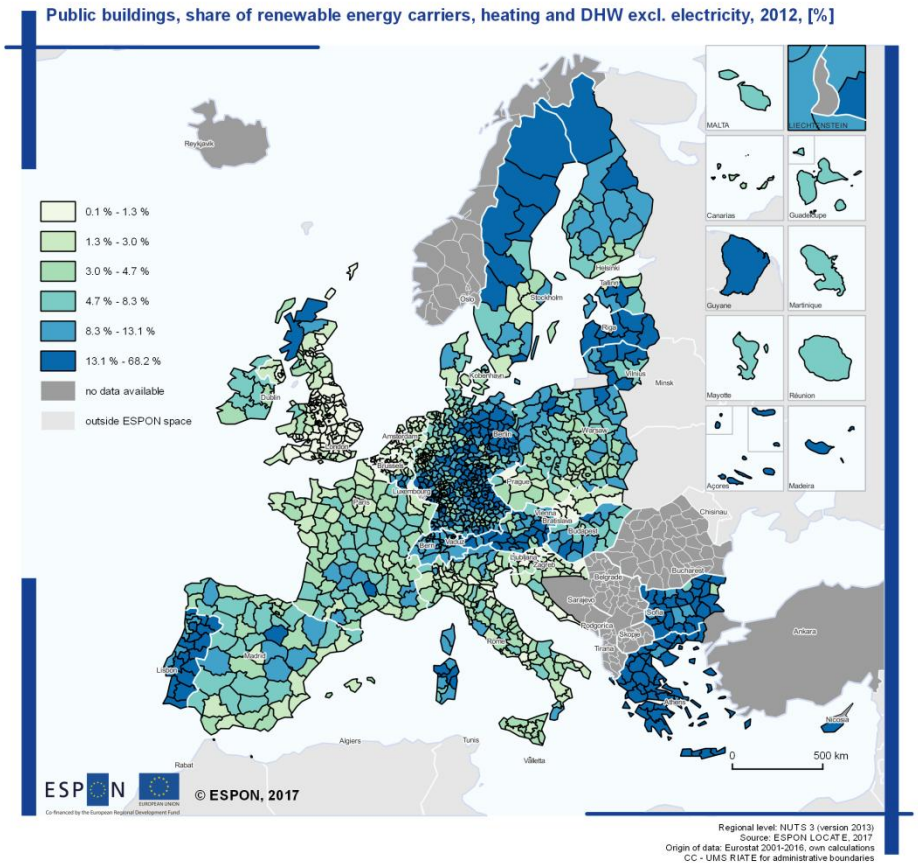
Map 1.23: Share of renewable energy carriers for space heating and domestic hot water production in buildings of the private service sectors in 2012, %



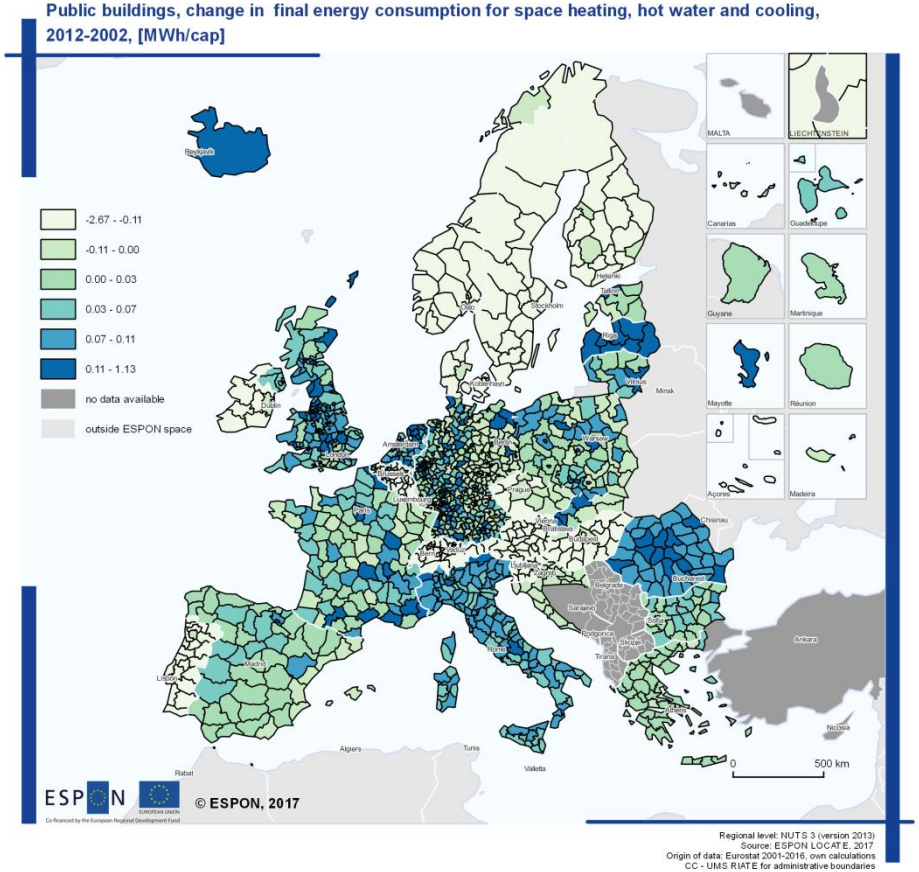
Map 1.24: Change in share of renewable energy carriers for space heating, domestic hot water production and air conditioning in buildings of the private service sectors in 2012-2002, in percentage points



Map 1.25: Share of renewable energy carriers for space heating, domestic hot water production and air conditioning in public buildings in 2012, MWh per capita



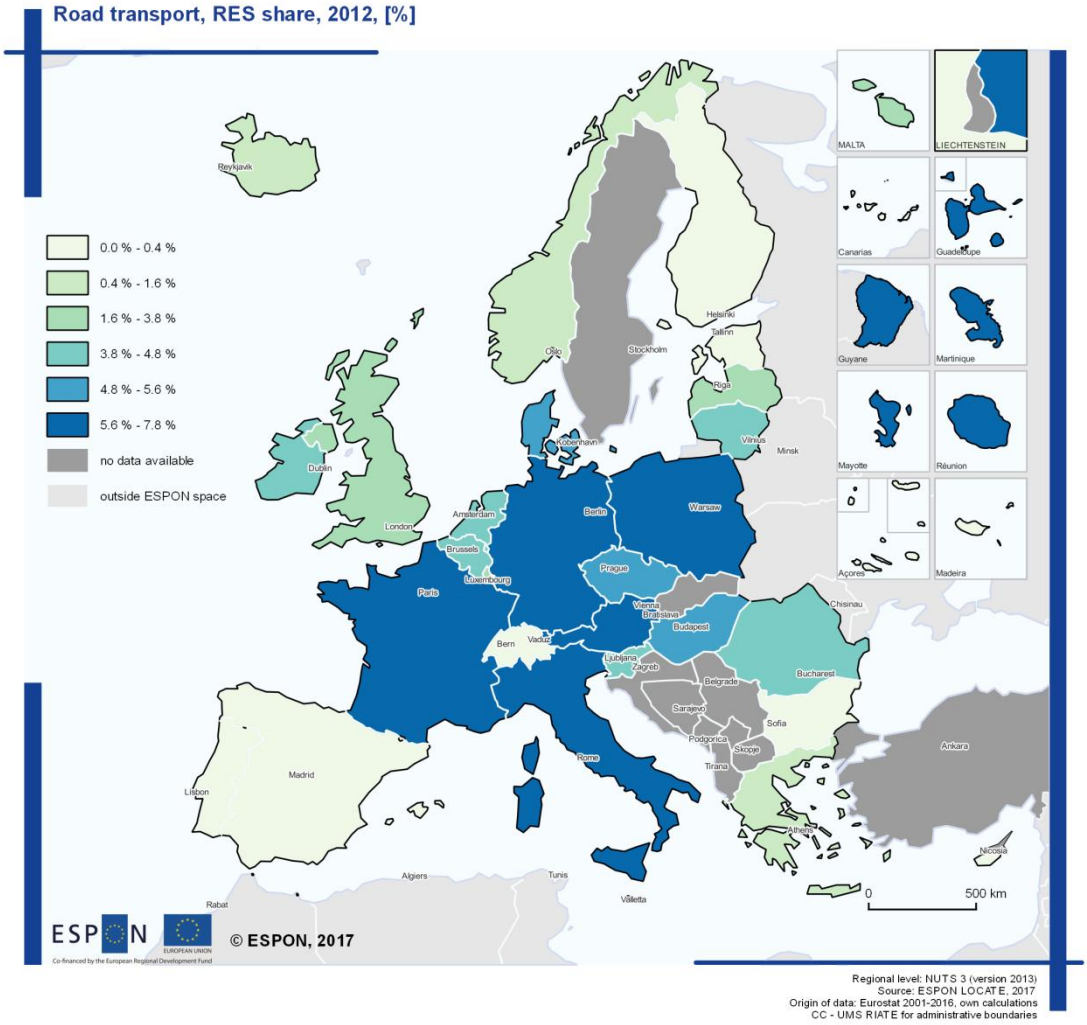
Map 1.26: Change in share of renewable energy carriers for space heating, domestic hot water production and air conditioning in public buildings in 2012-2002, MWh per capita



RES-share within road transport

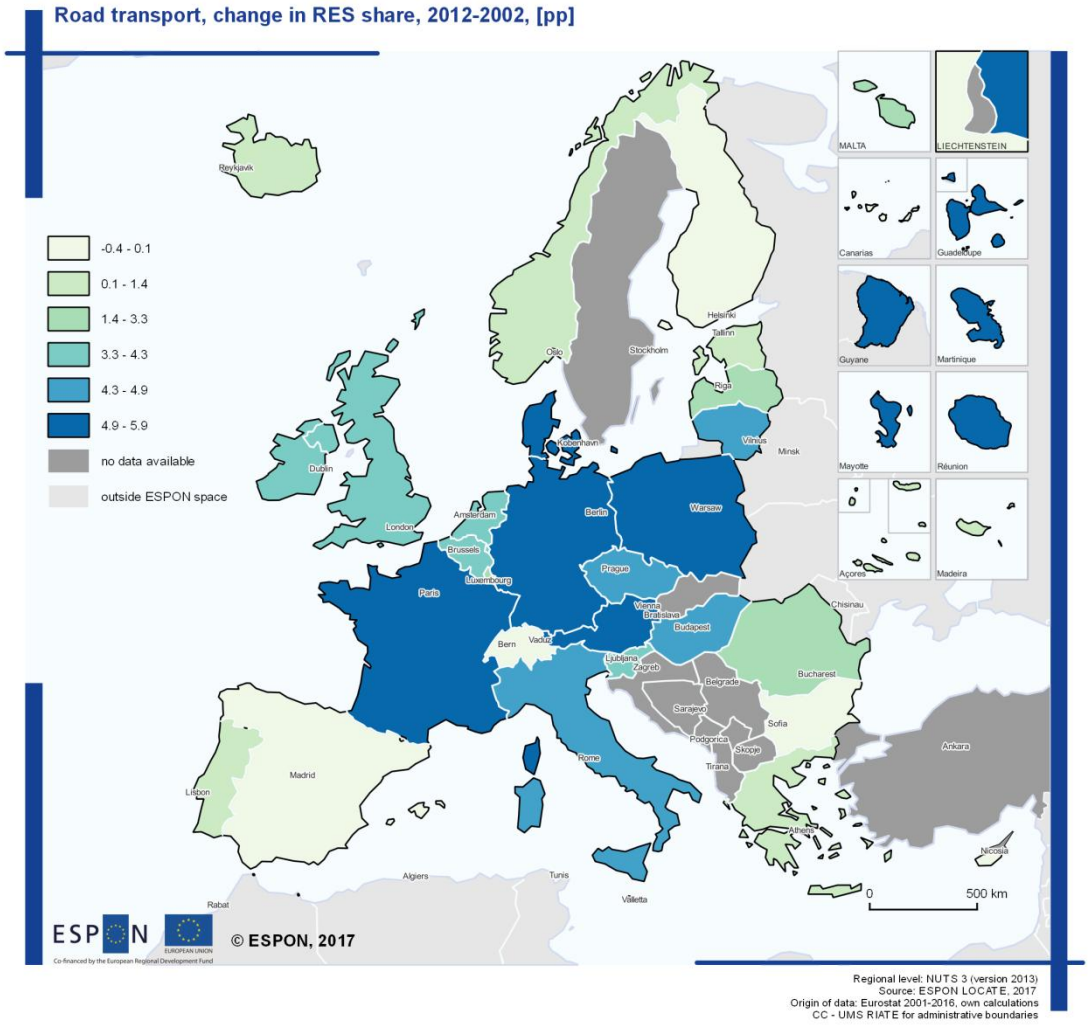
Due to a lack of official statistics the RES-share can only be displayed on a NUTS 0 level. Between the years 2002 and 2012 in all European countries the share of RES within road transport has increased obviously (Map 1.27 and Map 1.28).

Map 1.27: RES-share within road transport in 2012 on the spatial level of NUTS 0 regions



Especially countries like Sweden, Norway, Austria and Germany already had shares of RES which are above the average in 2002. Together with France, these countries are also leading the RES shares within Europe in 2012 (Map 1.31).

Map 1.28: Change in RES-share within road transport in 2012-2002 on the spatial level of NUTS 0 regions (percentage points)

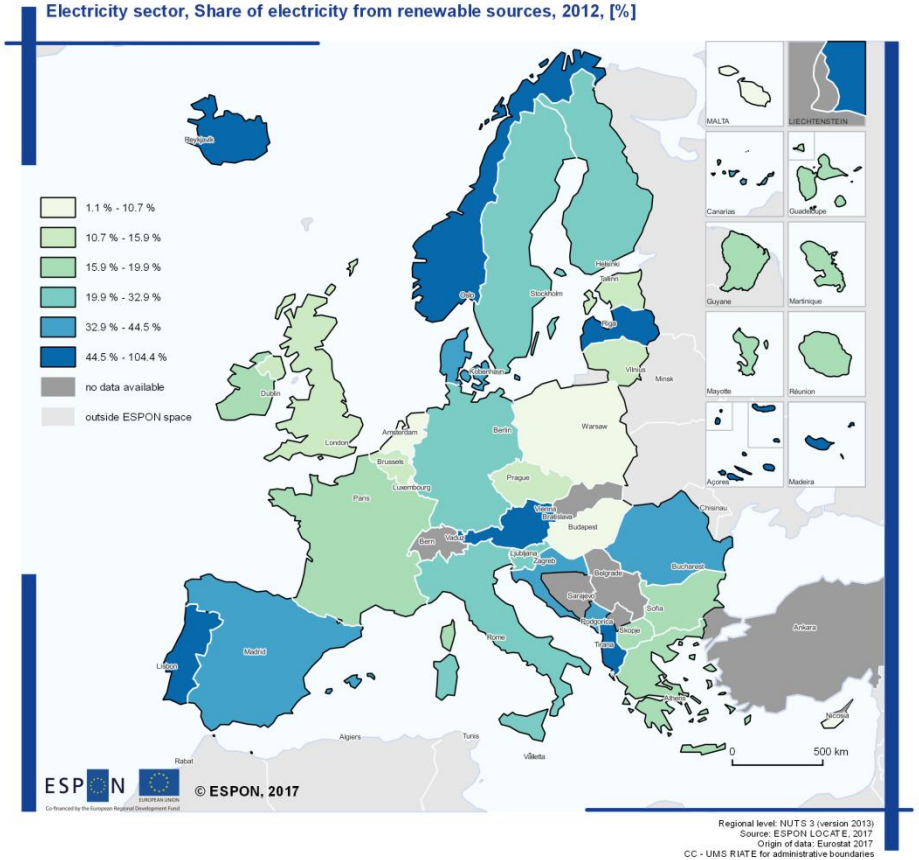


RES-share within gross final electricity consumption

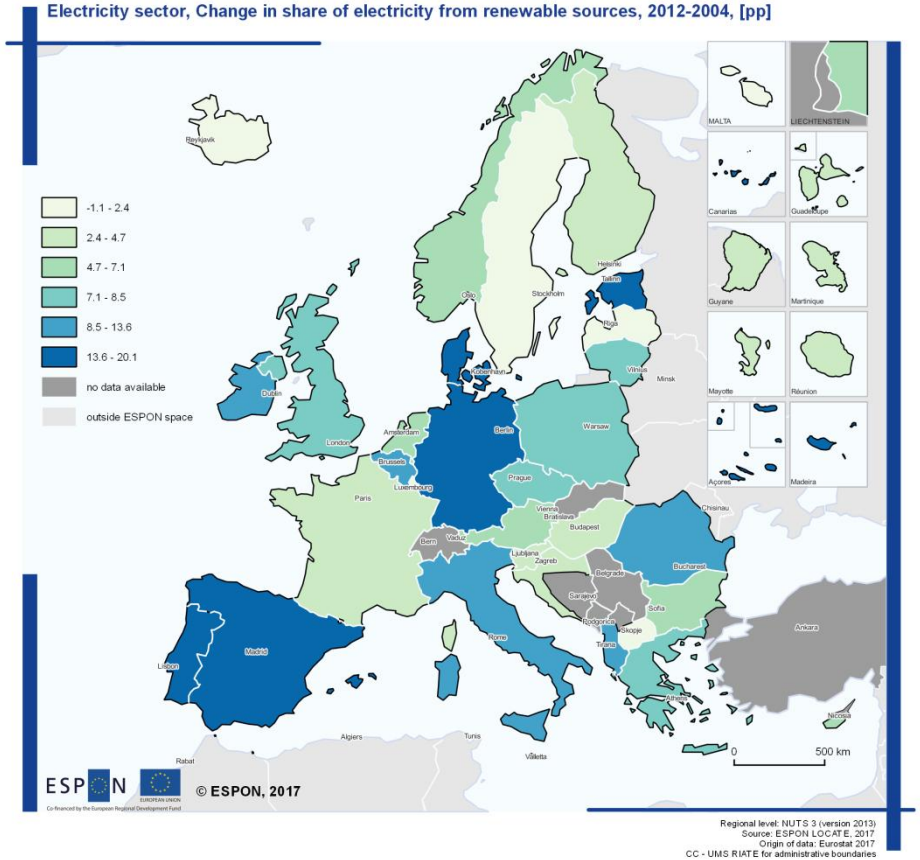
Due to a lack of official statistics the RES-share within gross final electricity consumption (RES-E share) can only be displayed on a NUTS 0 level. The RES-E share is calculated by Eurostat. For this report the latest version of the calculation was used: SHARES 2015 results (Eurostat, 2017). In 2012 Norway shows a RES-E share of 104.4% (see Map 1.29). This is the case, because the country produces more electricity from renewable sources, than it consumes within the country. The excess electricity is exported to its neighbouring countries. Norway is followed by Iceland (95.4%), Albania (72.4%), Austria (66.5%) and Sweden (95.9%). The lowest 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 with a RES-E share from 10% to 50%.

The highest positive change in percentage points between 2004 and 2012 was realized in Portugal (20.1 pp), Estonia, Denmark, Span and Germany (all show an increase of 14.2 to 15.2 pp). Latvia is the only country with an decreasing RES-E share (-1.1 pp) (see Map 1.30).

Map 1.29: Share of energy from renewable sources for electricity (RES-E) in 2012, %



Map 1.30: Change in share of energy from renewable sources for electricity (RES-E), 2012-2004, %

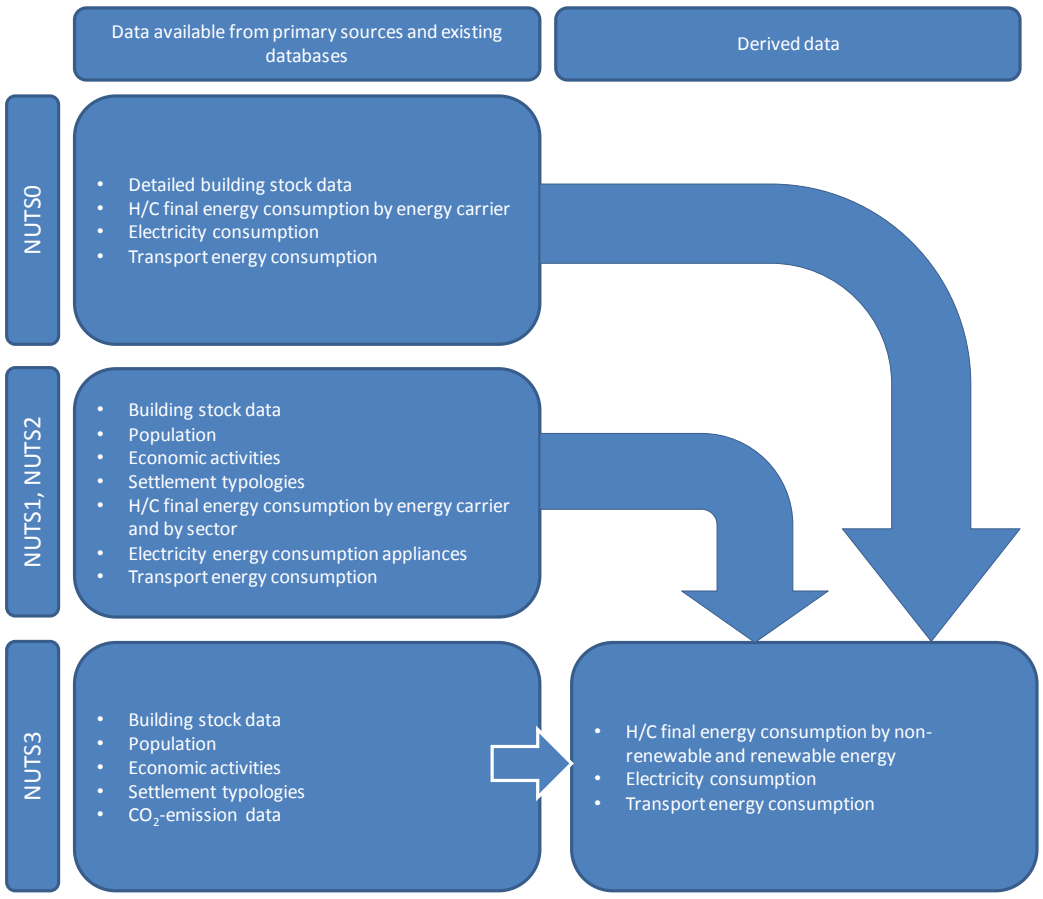


1.2 Methodological approach

In this chapter we document the methodological approach how the detailed energy consumption patterns in European regions had been developed. The approach is described in four separate subchapters, each covering different approaches needed to account for the peculiarities of all prescribed sectors of energy consumption. To start with, the econometric analysis may be applied across all energy consuming sectors as it incorporates the key driving forces of energy consumption. The simulation approach is used for energy consumption patterns of space heating and cooling, hot water preparation and electric appliances. In a third step, the approach for the regional assessment of the electricity consumption of the residential sector (without heating), service sector (without heating) and agriculture/forestry is described. At last, the approach to cover the regional transport energy consumption is explained.

Figure 1.2 shows schematically the proposed approach for deriving the consumption patterns on NUTS3 level on a general and not sector specific level. From various data sources, previous projects and research activities detailed data are available on the level of NUTS0, NUTS1 and NUTS2. For deriving the required data on NUTS3 level, regional conversion matrices were developed, splitting up the aggregated data on NUTS0, NUTS1 and NUTS2 level on NUTS3 level.

Figure 1.2: Approach to derive energy consumption patterns on NUTS 3 level



Source: TU Wien.

For instance, very detailed data on heating and cooling (H/C) consumption patterns are available on NUTS0 level, distinguishing between different heating systems, building categories etc. (see Figure 1.2 for details). Since there is information available on NUTS3 level with regard to the different building categories, we can apply this information to break down the building stock and related energy consumption patterns to NUTS3 level. Moreover, additional information available on NUTS1 and NUTS2 level to identify correlations between drivers which can then be applied on NUTS3 are taken into account.

For a proper development of such regional conversion matrices it is relevant to further distinguish the energy consumption by end uses, i.e. space heating/cooling, domestic hot water, electric appliances and transport. This distinction is crucial because these different end-uses show substantial differences in their regional characterisation: Heating/cooling energy typically cannot be transported over long distances. This holds in particular for district heating, but also for the renewable heating energy carriers solar heat (used by local solar thermal collectors) and ambient heat (used by heat pumps). On the contrary, electricity and all chemical fuels can be transported also over longer distances.

1.2.1 Structural data to derive regional disaggregation

The change of consumption patterns over the past 10 years is derived by two main types of data sources.

(1) Various aspects of the regional conversion matrices (see below) include also dynamic aspects. E.g. population development on NUTS3 level is available for different years and so is economic development. Thus, the regional conversion matrices are developed for the base year (2012) and in addition for the year 2002. As far as applicable, we aim for using 2012 as base year or the latest statistics available.
(2) Data for the energy consumption by end-use on NUTS0 is available also for 2012 (and partly also on NUTS1 and NUTS2 level for the year 2012 – for data sources see table below).

From combining both changing components (i.e. change of regional conversion matrices and change of energy consumption on higher regional level as NUTS3) we derive the change of consumption patterns on NUTS3 level.

Regional conversion matrices to break down energy consumption data on NUTS0, NUTS1 and NUTS2 level to NUTS3 level inter alia take into account following factors[4]:

- Population (Eurostat) (2002-2012)
- Floor area residential buildings

[4] The consistent dataset on energy consumption patterns in European regions and cities for 2012 will be contrasted with the consumption patterns in the year 2002. We will thus report on observed changes. However, a detailed analysis of drivers of these changes goes beyond what appears feasible in this project. E.g. the inclusion of relative price changes is complex, hence various aspects would have to be considered here. Nevertheless, these issues will be discussed in the scope of the case studies as far as possible.

- Shrinking vs. growing regions → conclusions regarding construction periods and heating system mix of buildings

- Economic activities (Eurostat) (2002-2012), used as a proxy for the
- floor area of non-residential buildings
- Structural business statistics by NACE Rev. 2

- Share of settlement type within the considered region (evaluation of CORINE land cover data)
- Share of single-family households/multi-family households
- Share of (some) energy carriers (e.g. Mapping/HC regarding energy carrier split between urban and rural region)

- Information on gas grid 2012

- Final energy consumption of natural gas by sector and length of gas distribution of network on NUTS0 level

- Information on renewable district heating systems (2012)
- Locations and plant size of renewable district heating and combined heat and power (CHP) plants based on renewable energies assessed within the BioSustain project ("Sustainable and optimal use of biomass for energy in the EU beyond 2020 – An Impact Assessment")

- Basic Detailed energy balances on NUTS2 NUTS0 level (2002-2012)
- Final energy consumption data is provided by Eurostat on NUTS 2 level (2002-2012)
- Some MS are missing and some included fields are empty in the according dataset. Additional NUTS 2 data is available by MS specific statistical offices e.g. Germany.

1.2.2 Share of renewable energy consumption

The analysis provides not only the a distinction of spatial energy consumption in different end-uses such as space heating, hot water, appliances and economic sectors. In order to derive the share renewable energies, a spatial analysis of energy supply is performed. However, a regional distribution of supply is only feasible for locally used energy sources. Thus, for electricity and transport fuels it is not possible to assign a certain local share of renewable energy usage.

Regarding renewable energy source for district heating, the spatial analysis is based on national data, spatial data from the *Heat Roadmap Europe*[5] project as well as the *Biostain-project*. The later provides geo coordinates and plant size of heat only heating and combined heat and power (CHP) plants based on renewable energies are used. In addition, the utilized renewable potential insight of task 2 are considered.

[5] http://www.heatroadmap.eu/

1.2.3 Final energy consumption for space heating, hot water and cooling

The second approach builds on a bottom-up calculation of energy consumption, based on technology and building stock data, leading to energy consumption of space heating and cooling, hot water preparation and electric appliances.

Key modelling approach

This simulation approach builds on detailed data (and high experience to analyse energy consumption patterns with bottom-up approaches) on NUTS0 level. Where data for bottom-up drivers are available on NUTS3 level (i.e. share of different building categories, building floor area, number of (total/occupied) dwellings, number of dwellings per construction period) this information are used in the calculation of energy consumption in the corresponding NUTS3 region.

For the bottom-up simulation of the energy end uses heating, hot water and cooling we used the building stock model Invert/EE-Lab which has been applied extensively on the European scale to analyse building related energy consumption patterns, related RES potentials and scenarios[6].

The basic idea of the model is to describe the residential and non-residential building stock and the heating, cooling and hot water systems on highly disaggregated level, calculate related energy needs and delivered energy and determine reinvestment cycles and new investment of building components. The model Invert/EE-Lab up to now has been applied in all countries of EU-28 (+ CH, IS, NO). A representation of the implemented data of the building stock is given at www.entranze.eu.

The following figure shows the structure and concept of the model Invert/EE-Lab. In typical model applications, the tool is used for developing scenarios for the development of energy consumption in the building stock for coming years and decades. The basic elements of these scenarios are (1) a highly disaggregated description of the building stock, heating, cooling and hot water systems and (2) a calculation of energy needs and delivered energy for each of these building segments. For the second step, a calibration of bottom-up calculated consump-

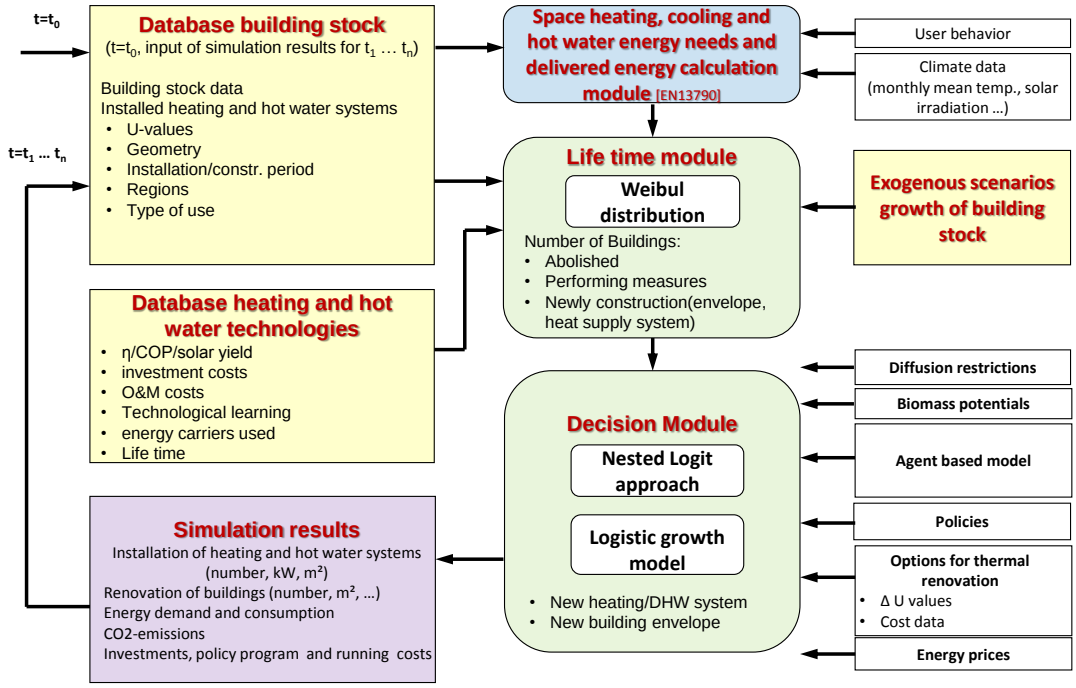
[6] See e.g. Mapping_HC: Mapping and analysis of the current and future (2020-2030) heating/cooling fuel deployment (fossil and renewables), (EC service contract ENER/C2/2014-641/SI2.697512), 2016; the consortium is involved in the project and has full access to the data;
Eichhammer, W., Braungardt, 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.
ENTRANZE: Enforcing the transition to nearly zero energy buildings, IEE-Project; completed 2014
Zebra2020 (Nearly Zero-Energy Building Strategy 2020), ongoing IEE project, www.zebra2020.eu
progRESsHEAT (Fostering the use of renewable energy for heating and cooling), ongoing H2020 project, www.progressheat.eu
RES-H-Policy – Policy development for improving RES-H/C penetration in European Member States, IEE project completed 2011, (Bürger et al., 2011)

tion with actually measured consumption has been carried out in several projects on national level (NUTS0).

These elements are used in this project to determine energy consumption on NUTS3 level for the base year and the historic development based on bottom-up simulations. Thus, the main relevant components are represented as the boxes (1) database building stock, (2) data base heating and hot water technologies and (3) space heating, cooling and hot water energy needs and delivered energy calculation in the figure below.

The basic structure and concept is shown in Figure 1.3.

Figure 1.3: Overview structure of Simulation-Tool Invert/EE-Lab



Source: TU Wien.

Disaggregated modelling of building stock

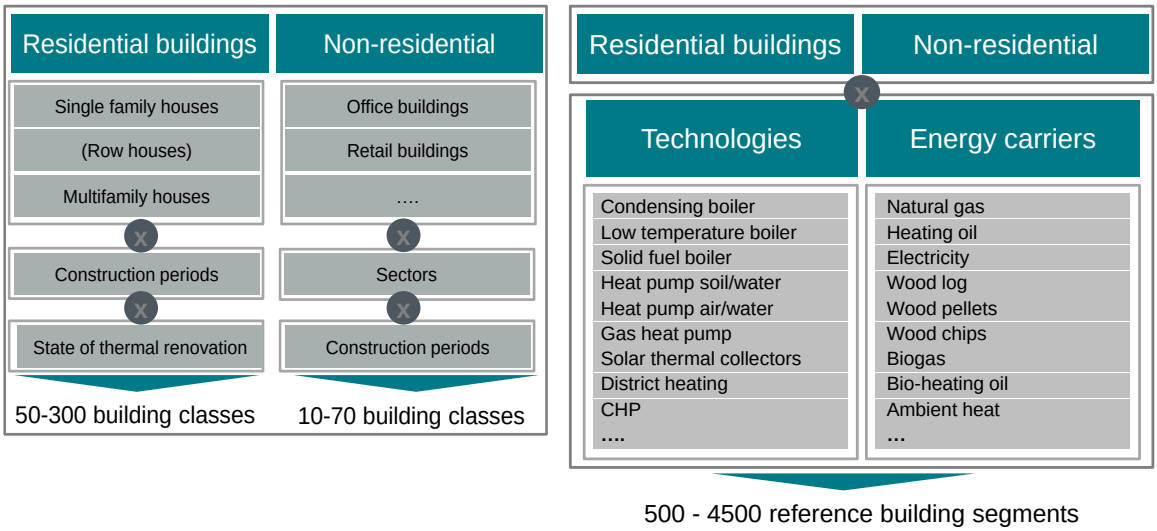
The building stock data in the model Invert/EE-Lab up to now has been set-up and calibrated for all countries of *EU-28 (+ CH, IS, NO).* A representation of the implemented data of the building stock is given e.g. at www.entranze.eu.

Invert/EE-Lab covers *residential and non-residential buildings.* Industrial buildings are excluded (as far as they are not included in the official statistics of office or other non-residential buildings).

The following figure shows the disaggregated modelling of the building stock within each country. The level of detail, data reliability and accuracy, the number of construction periods etc. depends on the data availability and structure of national statistics. We take into account data from Eurostat, national building statistics, national statistics on various economic sectors

for non-residential buildings, BPIE data hub, Odyssee, which are finally summarized in the ENTRANZE database (www.entranze.eu).

Figure 1.4: Disaggregated modelling of the building stock within each country (NUTS0 level) in the database of the model Invert/EE-Lab



Where relevant, climatic zones are taken into account within a country. Source: TU Wien.

Data on the building stock at NUTS3 level are used to break down the results of the NUTS0 level to the NUTS3 level. The detailed data sources for the building stock data on NUTS3 level are listed and described in the sections below.

Regarding the share of renewable energy carriers, we used the information on the share of energy carriers per building type (buildings with up to two dwellings and buildings with more than two dwellings and three service sector aggregates: (a) public services, health care, education and science, (b) accommodation, restaurants, stores and stores and (c) remaining services and urban/rural regions and correlate the utilization of energy carriers with their potential in each NUTS 3 region.

Final energy consumption for space heating and domestic hot water

This section describes the applied methodological approach to derive the dataset for space heating domestic hot water and air conditioning production on a NUTS3 level.

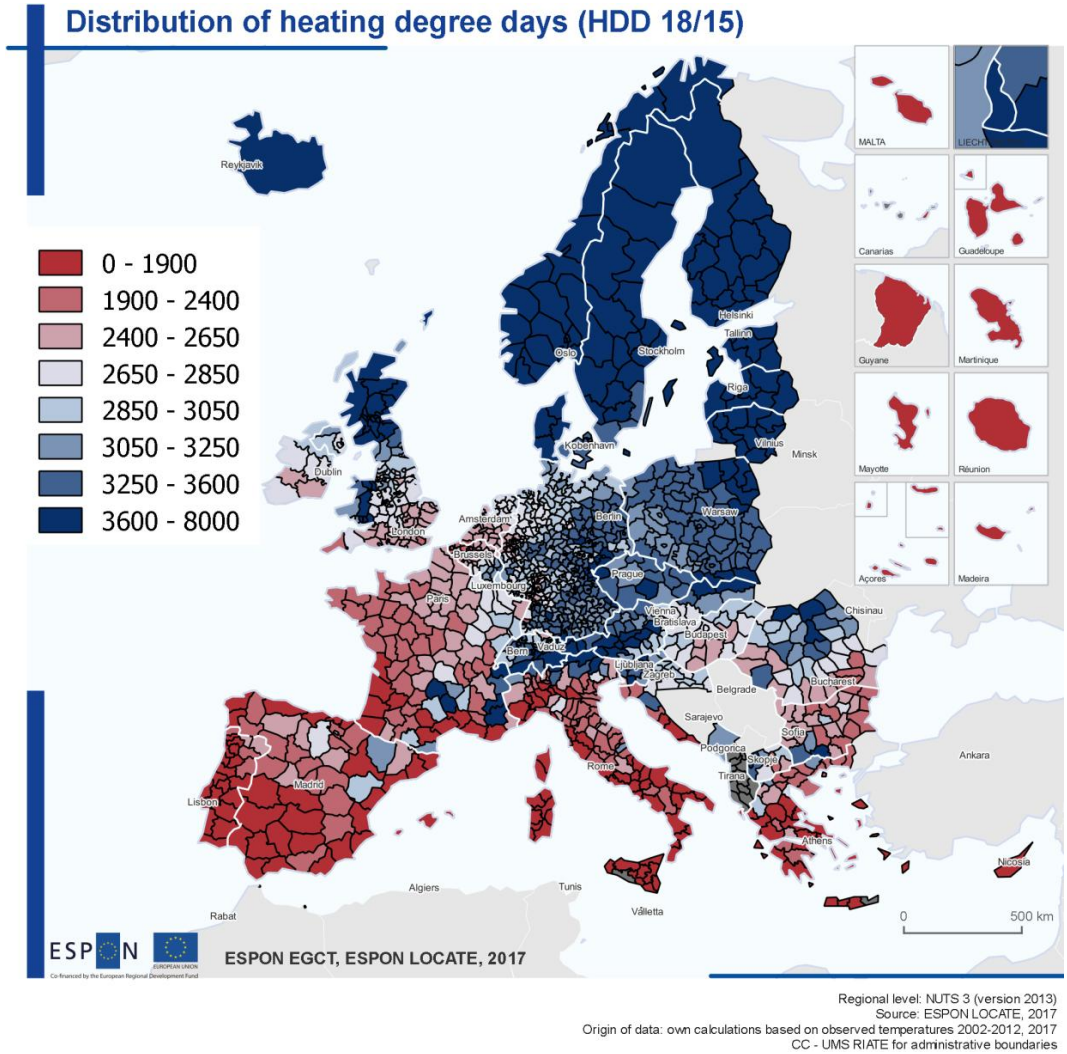
As already said above, we build for this task strongly on energy consumption data on NUTS 0 level derived in the European project “Mapping_HC: Mapping and analysis of the current and future (2020-2030) heating/cooling fuel deployment (fossil and renewables)” (EC service contract ENER/C2/2014-641/SI2.697512, 2016). Within this project, energy consumption per energy carriers for space heating, domestic hot water production and air conditioning for different building types and construction periods, consistent with the national energy balances were derived. In the current project, we develop indicators, which we then use to distribute the energy consumption on the national level (NUTS 0) to the NUTS 3.

Heating and cooling degree days

Two of the most influential parameters for the area-specific cooling and heating consumption are the heating and cooling degree days. Eurostat (EUROSTAT, 2016b) provides data for the annual degree days on the NUTS 2 level. To go beyond this regional level, we used observed daily temperatures on a 25x25 km grid for the period 2002-2012 to calculate the average heating (18/15) and cooling (18.5/18.5) degree days. For Iceland, which is not included in the used dataset, we draw on results from climate models, the MPI-REMO and the CNRM-RM5.1 for the period 2001-2010.

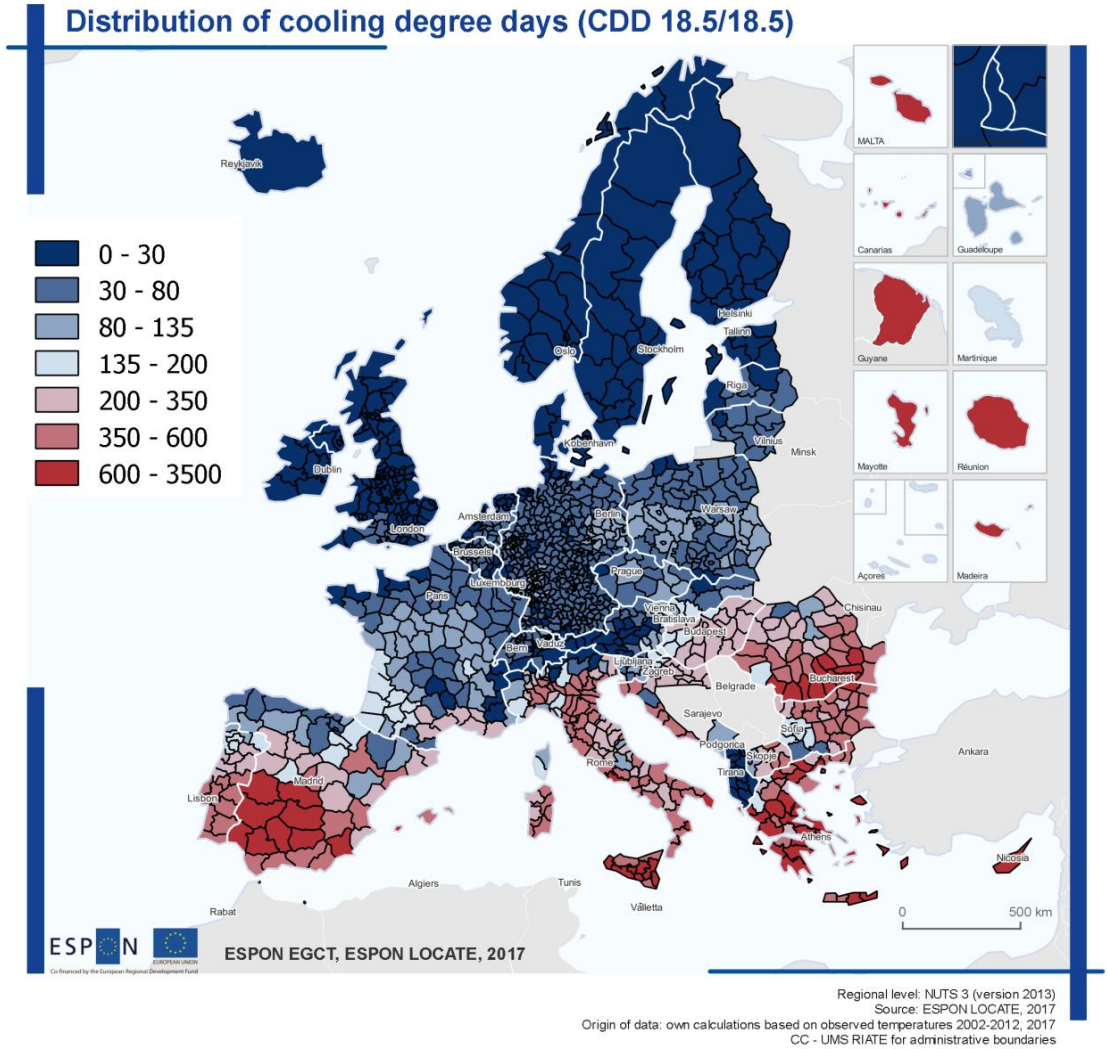
The resulting heating and cooling degree days per NUTS 3 region are shown in the Map 1.31 and Map 1.32.

Map 1.31: Map of heating degree days on the level of NUTS3 regions shown for NUTS3 regions



The blue colour code stands for cold regions and the red colour code represents warm regions. The intensity of the colour indicates the heating degree days on average for the years 2002 to 2012, based on observed daily temperatures on a 25 km resolution. For Iceland we draw on results from regional climate models (MPI- M-REMO and CNRM-RM5.1) for the period 2001-2010.

Map 1.32: Map of cooling degree days on the level of NUTS3 regions shown for NUTS3 regions



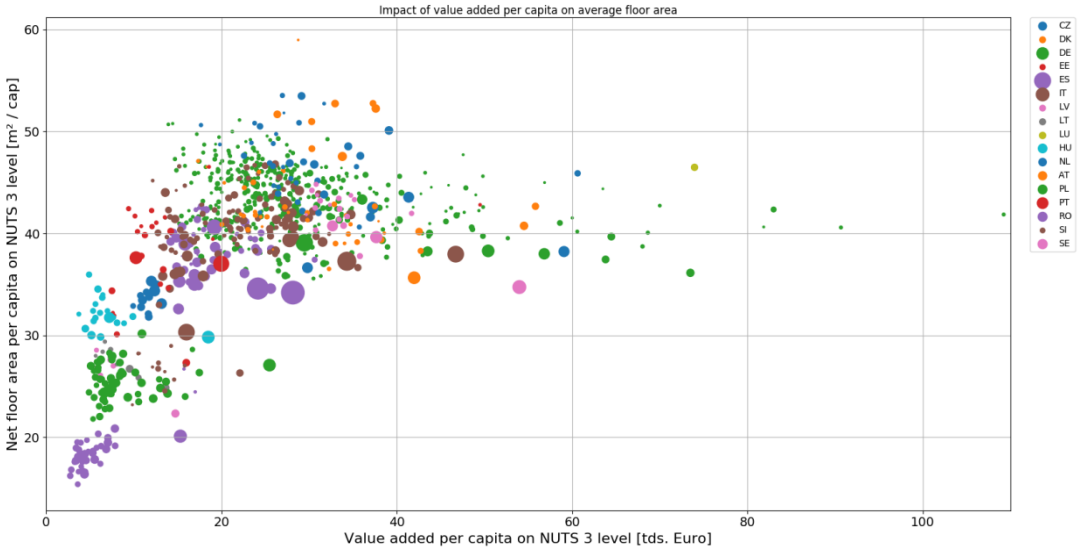
The blue colour code stands for cold regions and the red colour code represents warm regions. The intensity of the colour indicates the heating degree days on average for the years 2002 to 2012, based on observed daily temperatures on a 25 km resolution. For Iceland we draw on results from regional climate models (MPI- M-REMO and CNRM-RM5.1) for the period 2001-2010.

Floor area of apartments and occupation density of dwellings

Another important driver for energy consumption is the heated and air-conditioned floor area. The Population and Housing census 2011 (EUROSTAT, 2016a) provides data for the average size of occupied apartments on the NUTS 3 level for 19 European countries. We then analysed this data for strong correlations with other parameters.

Our analysis revealed that average floor area of apartments per capita increase with the income levels. Figure 1.5 shows the correlation of economic activities, expressed in value added of all economic sectors per capita, with the average per-capita size of apartments in NUTS 3 level. Up to an average per-capita floor area of about 40 m²/cap this correlation is evident. However, once this level has been reached, the effect levels off and not further increase in the per-capita floor area can be observed.

Figure 1.5: Correlation of economic activities and average net floor area per capita



Calculation energy consumption for space heating, domestic hot water production and air-conditioning on the level NUTS 3 regions

The energy consumption on country level (NUTS 0) is based in the outcomes of the recently completed project EU project *Mapping and analysis of the current and future heating/cooling fuel deployment* (Ragwitz, Fleiter, Steinbach et al. 2016)[7]. The dataset provides energy consumption per energy carriers and end-use (space heating, hot water, space cooling for different building types, economic sectors and construction periods. For residential buildings the dataset also differentiates the energy consumption between urban and rural areas.

Energy consumption for space heating and cooling

In order to break-down the results to the NUTS3 level, we used the regional indicators. For residential buildings the following parameters are used:

- Useful floor area per dwelling (A),
- Population (POP)
- Number of dwellings (DW)
- Number of dwellings per building type
- Number of dwellings per construction period (all provided by the Population and Housing Census 2011)
- Heating and cooling degree days (Map 1.31 and Map 1.32, average 2002-2012)
- Specific final energy consumption per building type based on Invert/EE-Lab model results

For non-residential buildings the considered parameters are:

- Population (POP)
- Total value added of service sector

[7] https://ec.europa.eu/energy/en/studies/mapping-and-analyses-current-and-future-2020-2030-heating cooling-fuel-deployment

- Sectoral value added (VA): (a) Accommodation, restaurants, stores and warehouses, (b) other private services and (c) public buildings, research and education, art, culture and health sector
- Share of number of dwellings per construction period of apartment buildings
- Heating and cooling degree days (Map 1.31 and Map 1.32, average 2002-2012)
- Specific final energy consumption per building type based on Invert/EE-Lab model results

The energy consumption for space heating of residential buildings ($Q_{sh,res}$) is defined by equation (Map 1.21). If the floor area of dwellings is not given (13 countries), we used the number of dwellings as approximation. For Bulgaria and Greece, for which also the share of dwellings per construction period is not available, we used a correction factor based on the share rural areas within each NUTS 3 region (see above).

$$Q_{sh,res,NUTS3} = \left(0.7 \cdot \left(\frac{A_{NUTS3}}{A_{Country}} \right) + \frac{0.15}{2} \cdot \left(\frac{DW_{total,NUTS3}}{DW_{total,Country}} + \frac{DW_{occupied,NUTS3}}{DW_{occupied,Country}} \right) + 0.15 \cdot \frac{POP_{NUTS3}}{POP_{Country}} \right)^{0.5 \cdot \frac{HDD_{NUTS3}}{HDD_{Country}}} \cdot \frac{\sum_{cp}^{Constr.period} s_{cp,NUTS3} \sum_{bt}^{Build.types} s_{bt,NUTS3} \cdot q_{sh,cp,bt}}{\sum_{cp}^{Constr.period} s_{cp,NUTS0} \sum_{bt}^{Build.types} s_{bt,NUTS0} \cdot q_{sh,cp,bt}} \cdot Q_{sh,res,NUTS0}$$

$Q_{sh,res,NUTS3}$ ... Energy for space heating on NUTS 3 level

$Q_{sh,res,NUT0}$ ... Energy for space heating on NUTS 0 level

HDD ... Heating degree days

s_{cp} ... Share of dwellings per construction period

(2002 values: it is assumed the relative shares of buildings constructed before 2000 have not changed between 2002 and 2012)

s_{bt} ... Share of dwellings per building type

$q_{sh,cp,bt}$ ... Floor area-specific final energy demand per construction period and building type

A ... Useful floor area of residential buildings

(2002 values: it is assumed that the specific size per DW is equal to the 2012 values)

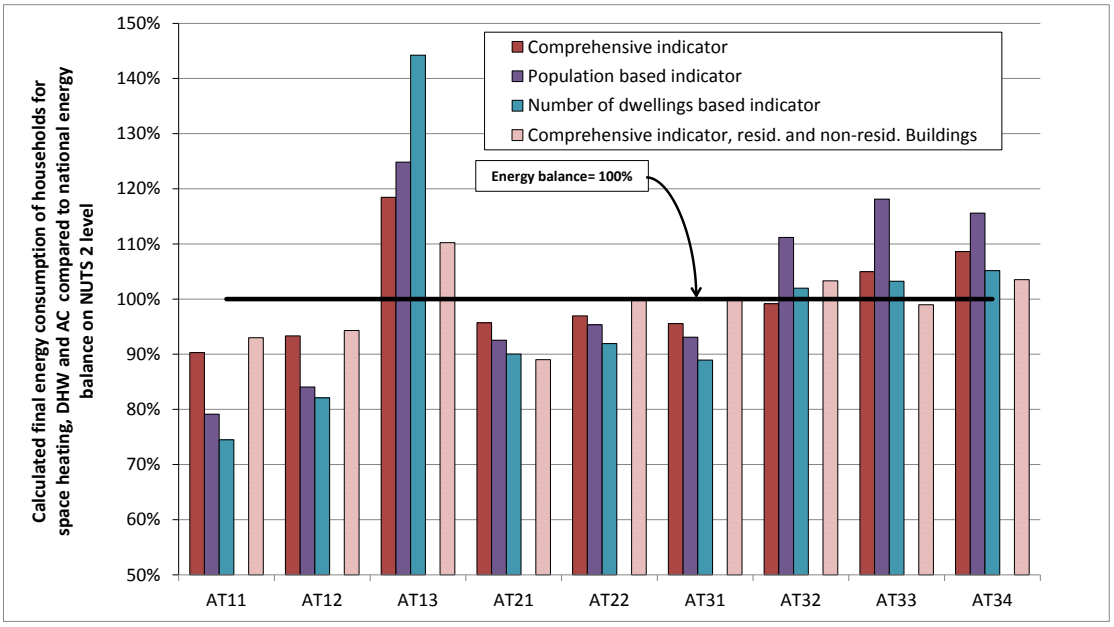
DW ... Number of dwellings

POP... Population

Validation of modelling approach

A comparison of the resulting energy consumption on the level of NUTS2 regions for Austria against the energy consumption according to the national energy balance for 2012 is shown in Figure 1.6. With the exception of the NUTS2 region AT13 (Vienna) the energy needs provided by the national energy balance are met within a range of about +/- 10%. Furthermore it can be seen that the indicator performs better than indicators which only build on the number of dwellings or inhabitants per region.

Figure 1.6: Comparison of the energy consumption on NUTS2 level using the comprehensive indicator described above and two simpler indicators which build only on population or number of dwellings for the Austrian NUTS2 regions.



We used the same formula to calculate the energy consumption for cooling, yet replaced the heating degree days by cooling degree days and considered the area specific cooling consumption as derived by the Invert/EE-Lab model (2).

$$Q_{AC,res,NUTS3} = \left(0.7 \cdot \left(\frac{A_{NUTS3}}{A_{Country}} \right) + \frac{0.15}{2} \cdot \left(\frac{DW_{total,NUTS3}}{DW_{total,Country}} + \frac{DW_{occupied,NUTS3}}{DW_{occupied,Country}} \right) + 0.15 \cdot \frac{POP_{NUTS3}}{POP_{Country}} \right)^{0.5 \cdot \frac{CDD_{NUTS3}}{CDD_{Country}}} \cdot \frac{\sum_{cp}^{Constr.period} s_{cp,NUTS3} \sum_{bt}^{Build.types} s_{bt,NUTS3} \cdot q_{AC,cp,bt}}{\sum_{cp}^{Constr.period} s_{cp,NUTS0} \sum_{bt}^{Build.types} s_{bt,NUTS0} \cdot q_{AC,cp,bt}} \cdot Q_{AC,res,NUTS0}$$

$Q_{AC,res}$ ... Energy for air conditioning

(2) CDD ... Cooling degree days

For non-residential buildings the indicators floor area is replaced by the (sectoral) value added of the service sector (3).

$$Q_{sh/AC,private/public\ services,NUTS3} = \left(\frac{2}{3} \cdot \frac{VA_{sector,NUTS3}}{VA_{sector,Country}} + \frac{1}{6} \cdot \frac{VA_{services,NUTS3}}{VA_{services,Country}} + \frac{1}{6} \cdot \frac{POP_{NUTS3}}{POP_{Country}} \right)^{0.5 \cdot \frac{HDD/CDD_{NUTS3}}{HDD/CDD_{Country}}} \cdot \frac{\sum_{cp}^{Constr.period} s_{cp,NUTS3} \sum_{ss}^{Service\ sectors} s_{bt,NUTS3} \cdot q_{AC,cp,ss}}{\sum_{cp}^{Constr.period} s_{cp,NUTS0} \sum_{ss}^{Service\ sectors} s_{bt,NUTS0} \cdot q_{AC,cp,ss}} \cdot Q_{sh/AC,private/public\ services,NUTS0}$$

(3) VA ... Value added

Energy consumption for domestic hot water production

For residential buildings (4), the distribution of energy consumption for domestic hot water production builds on the number of dwellings (DW) and population (POP) while for buildings of the service sector (5) the value added is used.

(4) $$Q_{DHW,res,NUTS3} = \left(\frac{0.5}{2} \cdot \left(\frac{DW_{total,NUTS3}}{DW_{total,Country}} + \frac{DW_{occupied,NUTS3}}{DW_{occupied,Country}} \right) + 0.5 \cdot \frac{POP_{NUTS3}}{POP_{Country}} \right) \cdot Q_{DWH,res,NUTS0}$$

(5) $$Q_{DHW/AC,private/public\ services,NUTS3} = \left(\frac{2}{3} \cdot \frac{VA_{sector,NUTS3}}{VA_{sector,Country}} + \frac{1}{6} \cdot \frac{VA_{services,NUTS3}}{VA_{services,Country}} + \frac{1}{6} \cdot \frac{POP_{NUTS3}}{POP_{Country}} \right) \cdot Q_{DWH/AC,private/public\ services,NUTS0}$$

Share of renewable energy carriers

To calculate the share of renewable energy carriers for space heating, domestic hot water and air conditioning, we calculated in the first step the share of energy carriers assuming that the energy carrier distribution for different building types (small and large residential buildings and buildings of the different service sectors) and urban/rural character of the region is equally distributed for all regions within countries. In a second step, the utilization of natural gas, biomass and district heating has been correlated with the availability of these energy carriers. 20% of the utilization per building type and urban/rural character of the NUTS3 region is considered to be uniformly distributed, the remaining share has then be correlated with the estimated potential using a elasticity of 70%.

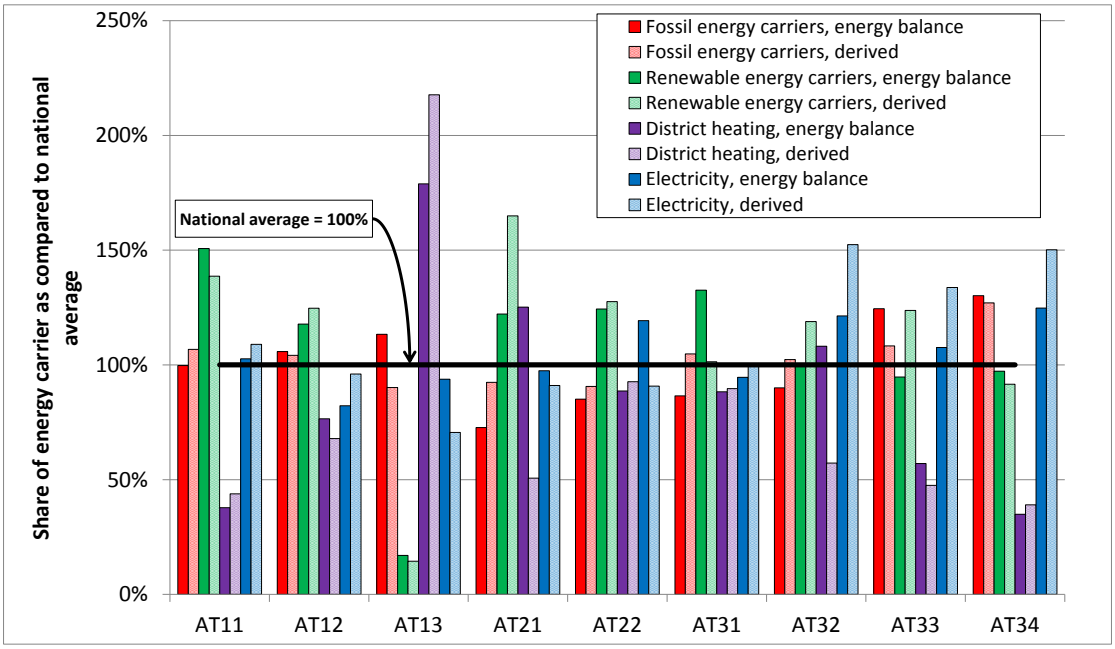
The shares of energy carriers per NUTS3 regions are then solved under the precondition that the energy consumption per energy carrier on the NUTS3 level needs to meet the consumption on the NUTS0 level.

According to the definition of Eurostat we define the renewable share of the heating and cooling ($RES_{H/C}$) sector excluding electricity (because the latter is separately accounted for in the renewable electricity share):

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

For district heating, share of renewable energy carriers is defined on the NUTS0 level based on the energy balance of 2013. Since there are no data for the detailed energy input and output of the transformation sector of the time period before 2010 available (at Eurostat) for most countries, we keep the renewable energy share of district heating constant and use the share of 2013 also for 2002.

Figure 1.7: Regional utilization of energy carriers as compared to the national average for the Austrian NUTS2 regions. The striped bars indicate the regional deviation from the national average derived by our indicators.



1.2.4 Final energy consumption for appliances and lighting

Modelling approach

Within this study we apply the energy consumption model FORECAST (FORecasting Energy Consumption Analysis and Simulation Tool) that aims to analyse final energy consumption on an annual basis based on a bottom-up methodology. The model considers the particularities of each consumption side sector, such as technology structure and data availability[8]. In a subsequent step the model results, the granularity of FORECAST results is used to generate a spatial resolution of final energy consumption by applying a regionalisation approach implemented in FORECAST-Regional model. This regionalisation approach is implemented as a two-step-process: the national final energy consumption is calculated based on FORECAST and a regional allocation is estimated by applying sectoral distribution keys via FORECAST-Regional. FORECAST-Regional also uses a database with regional data, which represents the numerical framework for the spatial resolution.

Regional Database

The regional database contains data for all parameters needed for the spatial resolution. The selection of data is oriented towards the typical drivers that are used for the analysis in bottom-up energy consumption models. To do so, a differentiation is made by cross-sectoral drivers such as population, gross domestic product (GDP) or climate conditions and sector-

[8] http://www.forecast-model.eu/forecast-en/index.php).

specific drivers such as gross value added (GVA), employees, disposable income, etc. The data collection is primarily based on public sources. The data are provided in different levels of granularity for districts (NUTS 3), municipalities (LAU 2) or postal code areas. Hence, there are particular challenges to ensure consistency among the different sources.

Definition of sectoral distribution keys

Final energy consumption on national level is broken down by region using sectoral distribution keys, which are derived from consumption theory. The objective is to transform the heterogeneous composition of national energy consumption into regional structures. Within FORECAST-Regional, the following parameters are used for the sectoral distribution keys:

(1) Household sector (without heating): specific electricity and gas consumption per size of household, population, households by number of inhabitants, access to gas grid
(2) Tertiary sector (without heating): specific electricity consumption per process/subsector, gross value added by subsector
(3) Agricultural and forestry sector: specific electricity consumption per gross value added, gross value added, access to gas grid, access to district heating grid

1.2.5 Final energy consumption transport energy

In order to derive regional consumption patterns of the transport sector, different methodologies are applied for road, rail and air transport

Passenger and freight road transport

Passenger and freight road transport includes all diesel and gasoline driven vehicles on roads as well as special off-road vehicles. Energy consumption of road traffic could be best monitored by a bottom-up approach with measuring the fuel consumption at each petrol station within a NUST-3-Zone. This consumption-based approach would be the most sophisticated way to calculate and monitor the energy consumption on NUTS-3 level. Unfortunately, fuel consumptions for single petrol stations are not available within public statistics. A drawback of such an approach is that it does not differentiated between fuelling tourism due to different fuel taxation and real fuel consumption related to the traffic volume.

Hence, another microscopic approach is the traffic volume based energy consumption It requires traffic data measured in vehicle kilometres for each NUTS-3 region in order to calculate the energy consumption on the roads within the borders of each zone. As the traffic volume is also not available on this geographic scale, macroscopic top down approaches need to be applied for an estimation on spatial level. The available data on national level are limited to the energy consumption of different energy sources for transportation (gasoline, diesel).

According to transport modelling theories, the significant influences on freight transport are GDP and for passengers transport the population as well as the number of jobs (Ortúzar/Willumsen 2001 and Schade 2005). Since both indicators are available on NUTS-3-level, they are used to derive regional energy consumption patterns of road transport. As gasoline and diesel consumption is monitored separately an isolated calculation of both fuel types is possi-

ble. Commercial and duty vehicles are driven by diesel engines only, hence gasoline is purely used by passenger roads transport. According to mobility surveys about 20% of the traffic volume is related to the trip purpose “work” (MOP 2010). This leads to the estimation, that 20% of the transport volume and hence gasoline consumption is related to the number of jobs (and GDP) and 80% to the population. As a result, gasoline consumption within a specific NUTS-3 region is calculated as follows:

$c_{gasoline,i} = C_{gasoline,NUTS\,0} * (0.2 * s_{GDP,i} + 0.8 * s_{POP,i})$

where:

i *NUTS-3-zone*

c *consumption*

s *share (NUTS-3-zone/national)*

POP *population*

Unlike gasoline, diesel is used for both, private and commercial transports. According to the estimation for gasoline consumption, also about 20% of the private traffic volume and hence the diesel consumption is related to the trip purpose “work” (MOP 2010). Additionally, the whole freight traffic depends on the economic development and therefore, it is strongly related to the development of GDP. Compared to the stock of private cars, the number of heavy and light duty vehicles is rather small (in Germany 2.5 Million duty vehicles compared to 40 Million private cars – KBA 2015a and KBA 2015b). While the stock of duty vehicles in all European countries is only about 6% of the one of private cars, the annual mileage is 8 to 10 times higher and the fuel consumption per vehicle is about 4 to 6 times higher (KBA 2014 and Hülsmann et al. 2014). The combination of these insights leads to the following dependence of fuel consumption and GDP/population: The influence of the GDP on diesel consumption is weighted by 0.6 and the influence of the population by 0.4:

$c_{diesel,i} = C_{diesel,NUTS\,0} * (0.6 * s_{GDP,i} + 0.4 * s_{POP,i})$

where:

i *NUTS-3-zone*

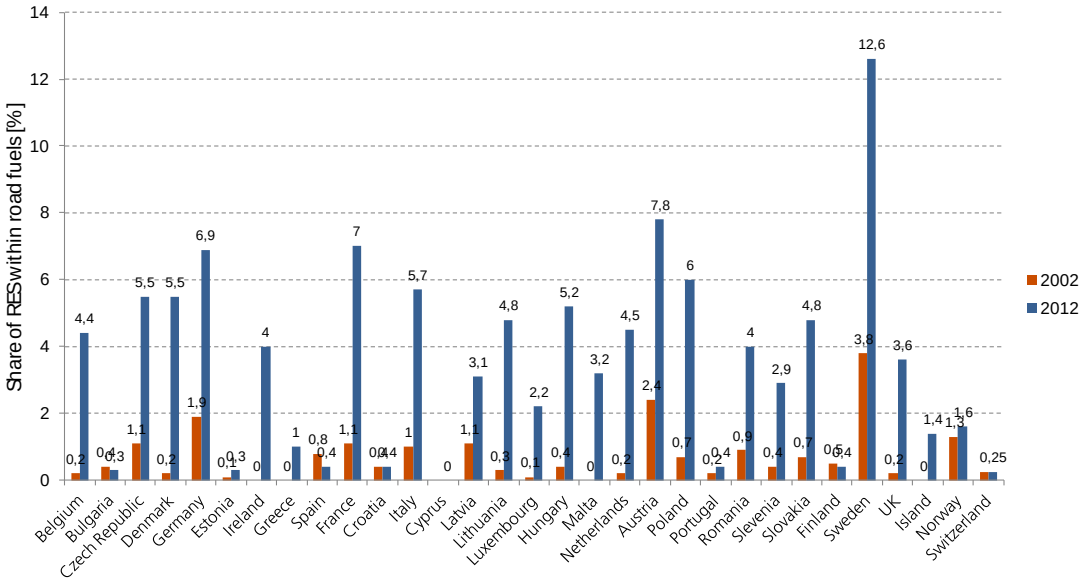
c *consumption*

s *share (NUTS-3-zone/national)*

POP *population*

The share of renewable energies within road fuel is difficult to estimate on NUTS-3-level. As there is no dedicated relation between GDP or population and consumption of alternative fuels, the share of RES used in the transport sector can only be calculated on national level (NUTS-0). It is remarkable though, that the RES share has been tripled in most countries in the period 2002 to 2012. Figure 1.8 shows that RES share in road fuels within Europe raised from 0.7% in 2002 up to 3.5% in 2012 (EUROSTAT).

Figure 1.8: RES-share in NUTS-0-Zones 2002 and 2012



Source: Eurostat.

Passenger and freight rail transport

Unlike the energy consumption of road transport which can be assigned to fuel stations, electricity consumption for rail transport is offered by an electric network. Thus, a bottom up approach as described for road transport is not possible. The energy consumption for rail transport is available in statistics on NUTS-0-level. In order to distribute these values on NUTS-3-level by GDP and population, energy consumption is distinguished in freight and passenger transport. While passenger transport volume is measured in passenger-kilometres, freight transport is monitored in tones-kilometres (EUROSTAT and UIC 2011). A comparison of both physical values is difficult. Energy consumption is driven by the total weight of the train, the average speed of the train and the number of stops within a single trip from origination to destination. Passenger trains are lighter and faster as freight trains (UIC 2011), but, especially regional trains have to stop more often due to a dense station network. These network specific factors cannot be considered in detail as there is a lack of data on NUT-3-level.

Multiplying passenger kilometres by an average weight, makes passenger and freight transport comparable. Together with statistics of the International Union of Railways (UIC 2011) offering data of train movements by freight and passenger trains, an overall analysis leaded to the result that a share of about 50% of rail energy consumption is caused by freight. Hence, for the distribution of rail energy consumption on NUTS-3-zones, both the shares of GDP (causes freight transport) and population (causes passenger transport) can be weighted equally:

$$c_{electricty\ rail,i} = C_{electricity\ rail,NUTS\ 0} * (0.5 * s_{GDP,i} + 0.5 * s_{POP,i})$$

where:

i *NUTS-3-zone*

c *consumption*

s *share (NUTS-3-zone/national)*

POP *population*

The diesel consumption of rail transport is derived by deploying rail network data. Statistics are available on the length of electrified and non-electrified networks. However, as energy consumption is not related to network length but to transport volume, further assumptions need be made. The International Union of Railways offers country specific values for electrification based on train movements. The data reveal are large variations among the European Member States. For instance, diesel engines operate only 1% of the transport volume in Austria, while in Latvia diesel locomotives drive more than 90% of the train-kilometres (UIC 2011). Since there are data gaps for certain countries, the average share of the transport volume driven with diesel engines was used for those countries. Based on these values, diesel consumption of the rail sector is calculated as follows:

$$c_{diesel\ rail,i} = \frac{c_{electricity\ rail,i}}{1 - s_{diesel,i}} * s_{diesel,i}$$

where:

i *NUTS-3-zone*

c *consumption*

s *share of transport volume driven with diesel engines*

Air transport

The most accurate approach to estimate kerosene consumption on a NUTS-3-level would be the use consumption data of single airports. Since this data are not available in public statistics, an alternative methodology is developed.

Statistics for kerosene consumption are only available on NUTS-0-Level. The local kerosene consumption strongly depends on the number of aircraft movements and hence on the number of passengers. The four biggest airports of Europe are London (LHR), Paris (CDG), Frankfurt am Main (FRA) and Amsterdam (AMS) accounting for more than 20% of all air travellers in Europe (websites of the airports 2017). As there is a concentration of the passengers on a manageable number of airports, the data collection within the project was concentrated on the airports which contain 80% of all passenger movements with destinations within Europe and to the rest of the World. Each airport can be clearly dedicated to a single NUTS-3-Zone and hence the national kerosene consumption can be split up to these NUTS-3-Zones be multiplying the total kerosene consumption by the share of passengers by airport. The methodology leads to a punctual distribution of the kerosene consumption. The kerosene consumption per NUTS-3-region is calculated as follows:

$$c_{kerosene,i} = C_{kerosene,EU28} * s_{PAX,i}$$

where:

i *NUTS-3-zone* *s* *share (airport/national)*

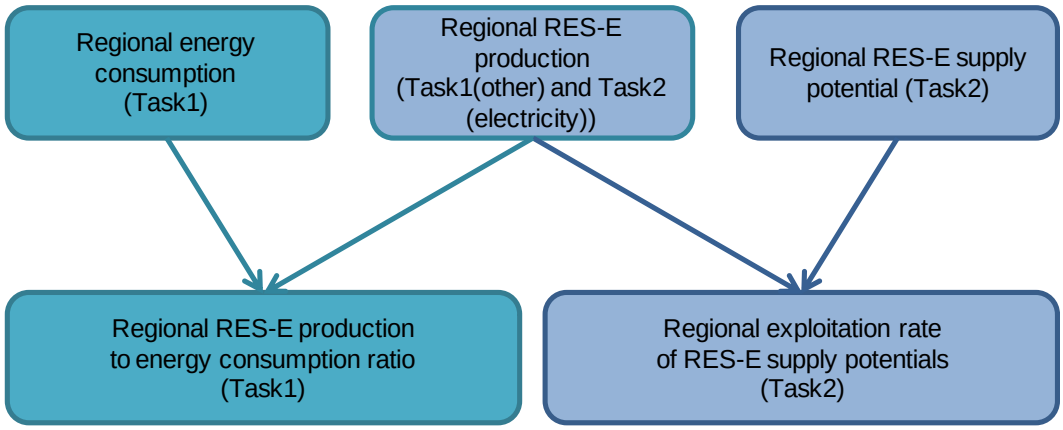
c *consumption* *PAX* *# passenger*

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

The objective of this chapter is the provision of an overview on the regional potential for generating and distributing renewable energy across Europe, broken down into wind power, solar power (thermal, photovoltaic and concentrated), hydroelectric power, tidal power, geothermal energy, biomass and the renewable part of waste.

As shown in Figure 2.1 the derived overview on supply potentials will then be matched with the regional production and consumption of renewable energy (chapter 1), identifying the degree of exploitation of supply potentials.

Figure 2.1: Integration of results from task 1 and task 2



Source: Fraunhofer ISI.

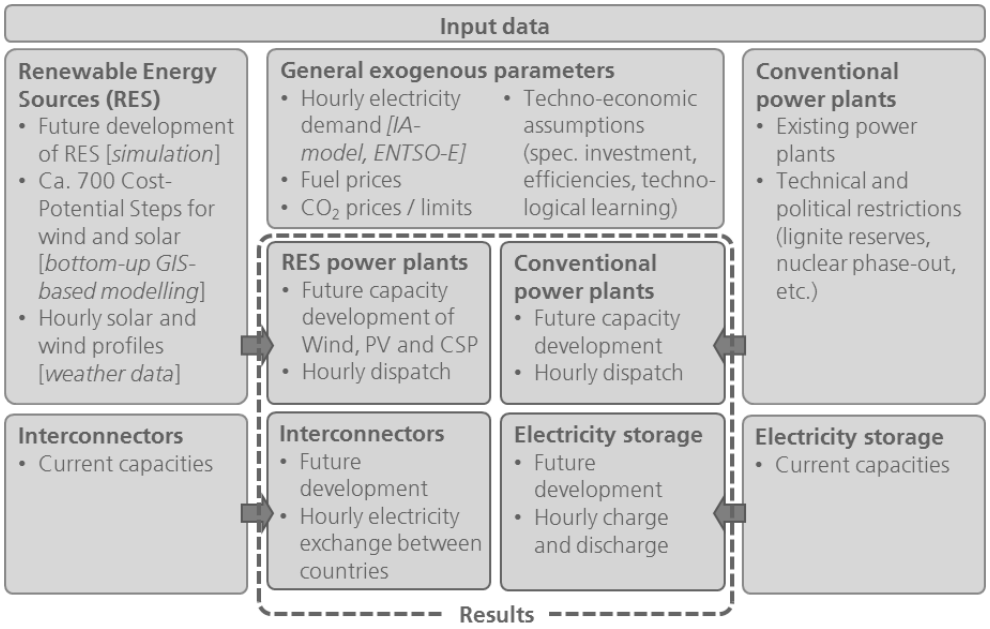
As a final step within this task we will then reveal required measures for mobilising the identified potentials for renewables across Europe.

2.1 Methodology

Concerning the GIS-based works for wind and PV the analyses is based on a European wide 10 x 10 km grid which can be aggregated to different NUTS levels. Figure 2.2 is presenting the general structure of the detailed potential model.

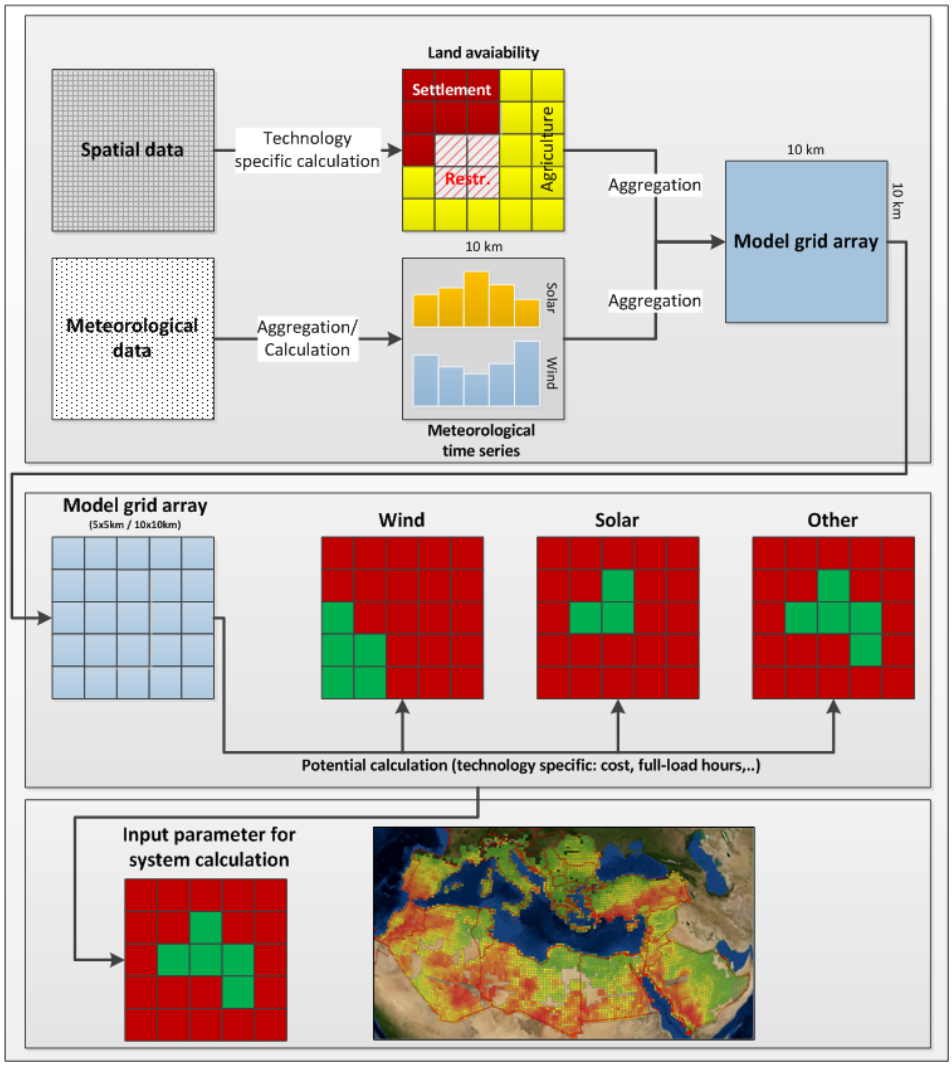
The renewable energy potential had been calculated within the Enertile model. Enertile is a detailed model for calculating and optimizing electricity systems in Europe and MENA. It is possible to calculate pathways of development and deployment of RES and conventional power plants. Within the proposed project mainly the renewable energy potential component will be used.

Figure 2.2: The Enertile model



Source: Fraunhofer ISI.

Figure 2.3: General structure of the potential model



Source: Fraunhofer ISI.

Figure 2.3 shows the general structure of the potential model with the core components.

The detailed analysis had been performed for the main technologies wind and solar power. The other technologies will be modelled with a different approach.

The overview on supply potentials for the distinct renewable energy sources involves GIS-based analysis, combined with other ways of modelling as well as desk research and processing of relevant data sources.

To achieve a reliable picture of detailed 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. For both steps data with comparable standard is used to receive an overall picture as consistent as possible. As a result, the technical and economic potential is derived. While the technical potential for RES-E-electricity production shows the overall potential, the economic potential shows the economically feasible potential, in terms of competitive levelized costs of electricity (LCOE). The economic potential of RES production that is used directly (e.g. for heating purposes) will be derived by the INVERT model and the results are described in task 1.

2.2 Regional renewable energy potentials and exploitation rates

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.

2.2.1 Wind power

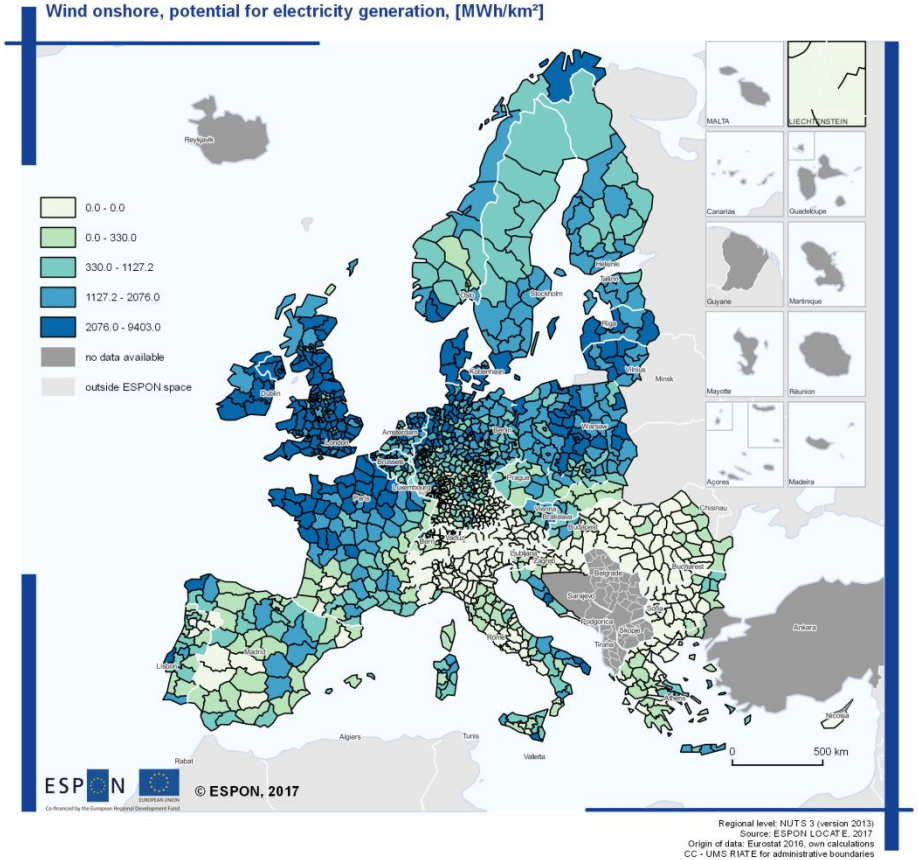
Wind energy developed to an affordable renewable electricity source over the past decades. Nevertheless, the cost of electricity from wind farms depends strongly on local conditions and wind speeds. The following chapter will be firstly give an overview on the general wind power potential and then present the installed capacity in 2012, the change in installed capacities between 2002 and 2012 and the corresponding exploitation rates.

Wind Power Potential Onshore

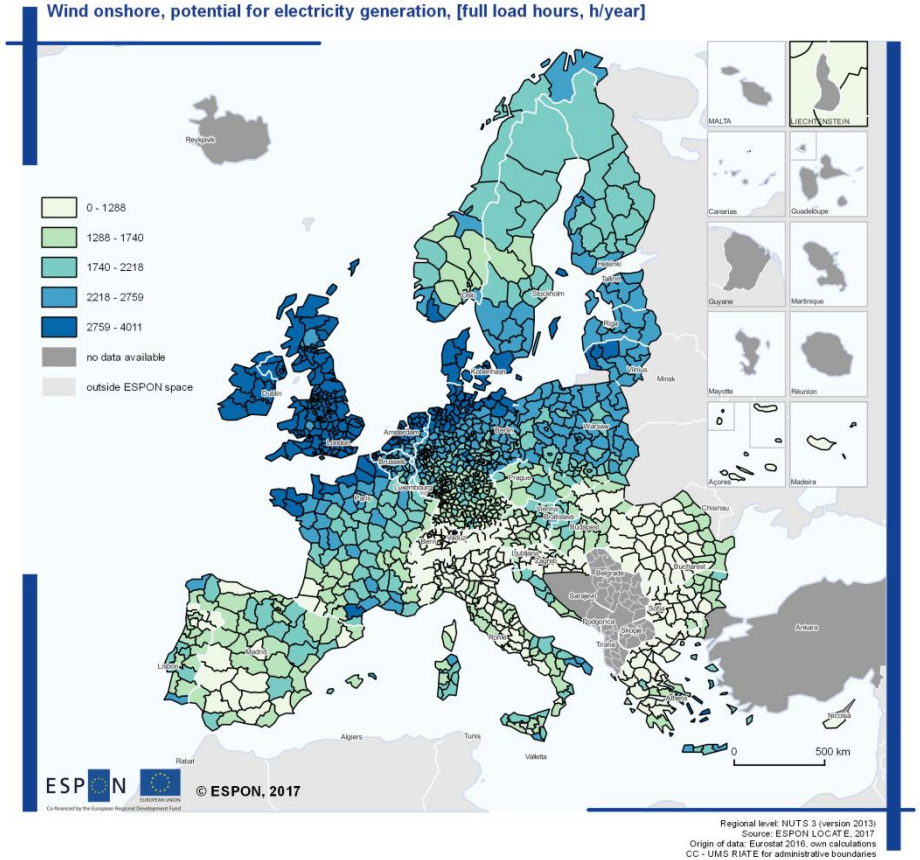
Map 2.1 and Map 2.2 show the wind power potential in Europe. The potential for wind energy depends strongly on average wind speeds and land availability for wind power installations. To account for economic restrictions, areas with low wind energy harvest (less than 1,800 full load hours are excluded from the potential). Nevertheless, the potential is displayed in poten-

tial electricity harvest per area, and does not show the investment necessary to exploit the potential. Data for the Alps and the Balkan region is generally available, as far as possible, this data has been included. Liechtenstein is not covered by a special potential calculation but has very limited wind energy potential as the neighbouring regions due to geographical characteristics.

Map 2.1: Wind onshore energy potential, MWh per km²



Map 2.2: Wind onshore energy potential, electricity production potential in full load hours per year



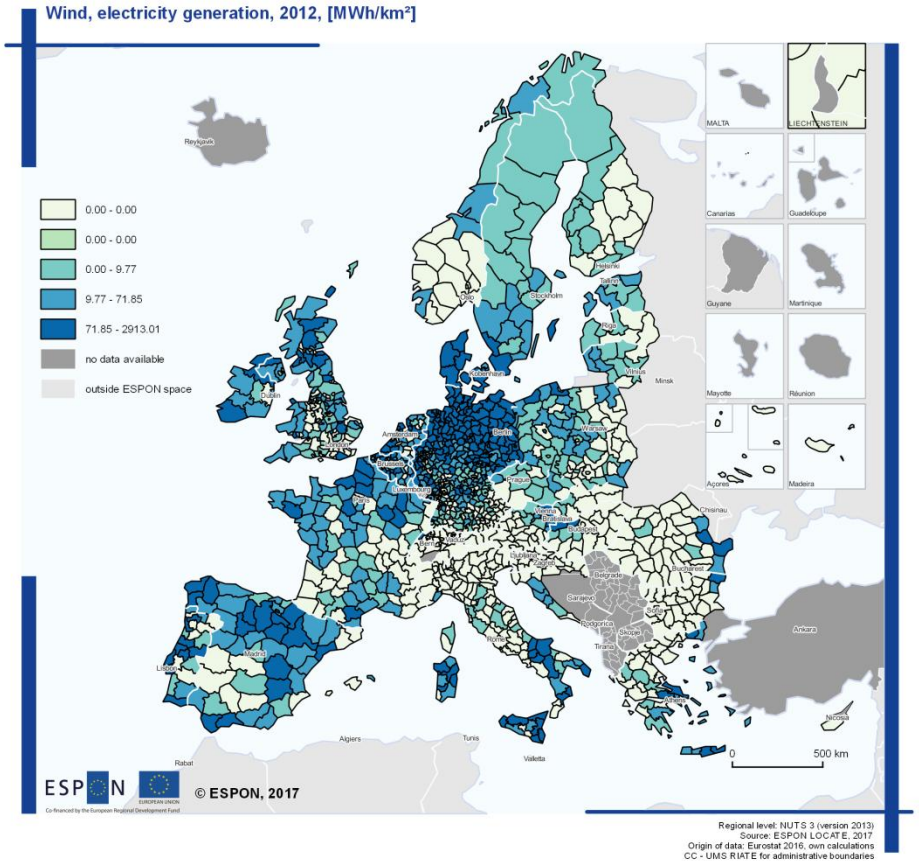
Wind Onshore Power Exploitation

The installed wind power capacity increased strongly between 2002 and 2012 (see Map 2.5 for the installed capacities in 2012 and Map 2.6 for the change between 2002 and 2012). 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[9]. The database contains wind power installations including locations, date of commissioning and actual state of operation (mainly for the year 2016). The data was filtered by commissioning date to assess values of installed capacity for the years 2002 and 2012. The commissioning date together with hub height and plant type was also used to estimate the state of operation for older wind power plants in 2002 and 2012.

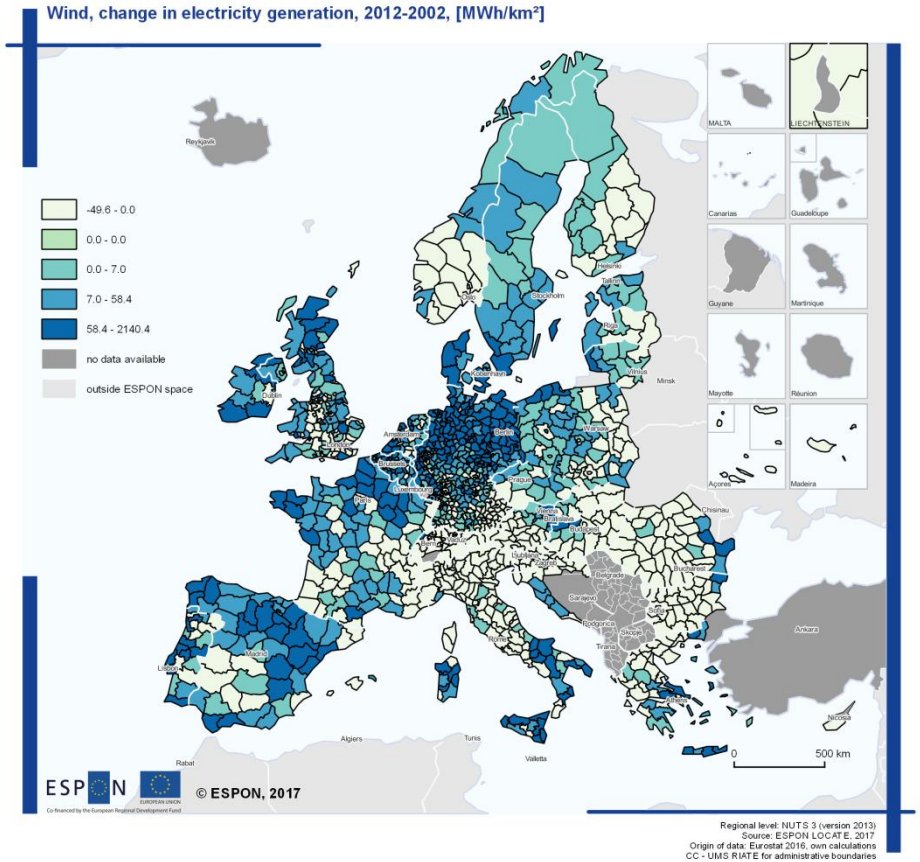
For the breakdown of country specific electricity generation from wind (based on Eurostat data), the regional generation is assessed using the derived installed capacity and the expected full load hours calculated in potential analysis corrected with country specific values. Map 2.5 and Map 2.6 show the resulting exploitation rates for 2012 and change between 2002 and 2012.

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

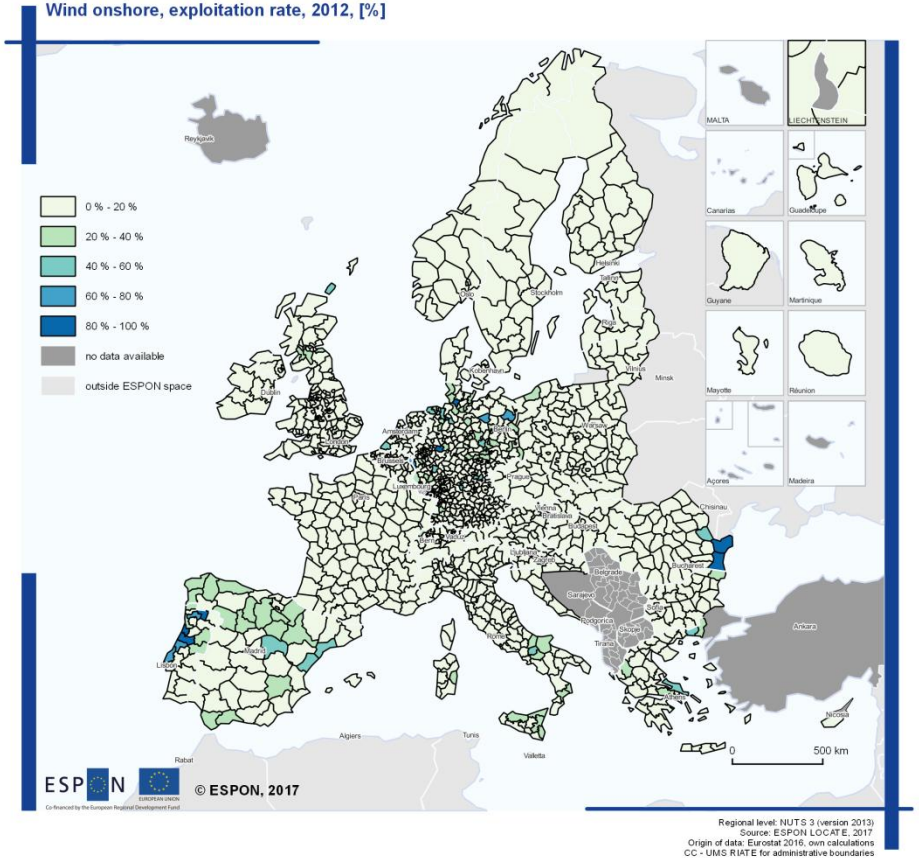
Map 2.3: Wind onshore, installed capacity in 2012, MW/km²



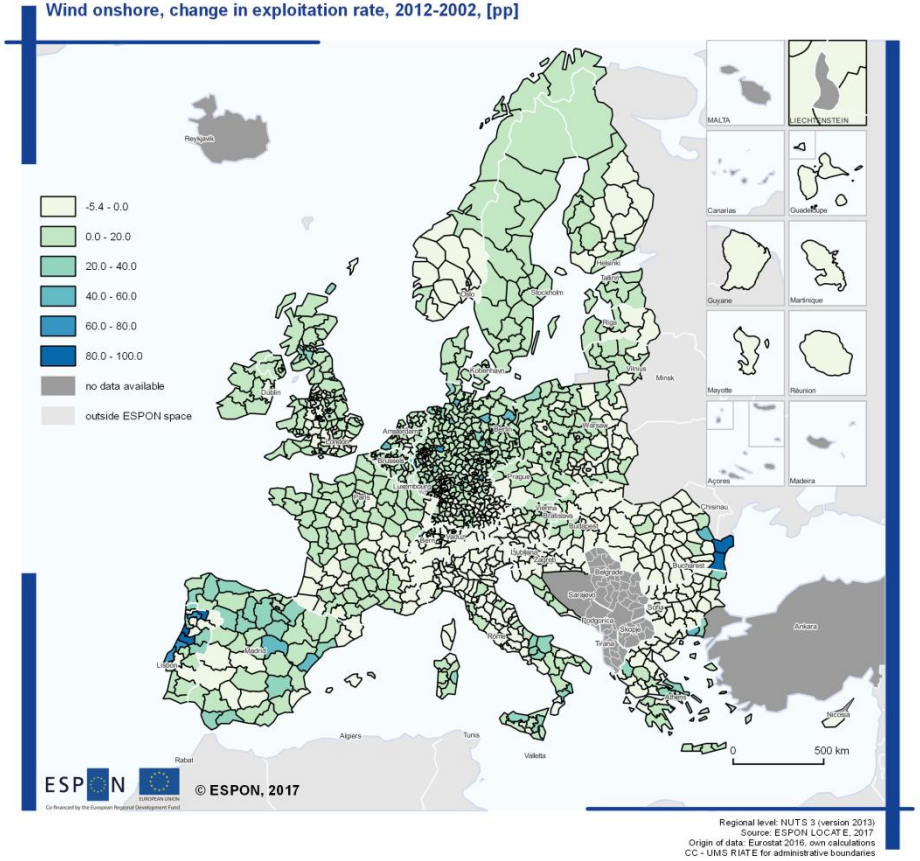
Map 2.4: Wind onshore, change in installed capacity in 2012-2002, MW/km²



Map 2.5: Wind onshore exploitation rate 2012



Map 2.6: Change in wind onshore exploitation rate 2012-2002



2.2.2 Solar energy

Solar energy developed even faster than wind energy between in 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. As for Wind the cost of electricity from solar installations also depend strongly on local conditions.

Solar Power Potential

Map 2.7 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 FLH 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 2.8 shows the expected full load hours. Areas with high full load hours, showing a high electricity harvest per installed capacity can lead to low potential due to restricted potentials to install PV installations (e.g. parts of Spain). Areas with relatively low electricity harvest can have significant solar energy potentials when there are low restrictions on solar installations (e.g. some parts of Norway and central Europe).

Map 2.9 and Map 2.10 show the installed capacity in 2012 and the change towards 2002, respectively. Data on installed capacity on NUTS 3 level are not available for all countries. The main data source is the *Open power database*[10] which contains regional installation data from Germany, Denmark, France and Poland. Furthermore, installed capacity on NUTS 3 are available for Italy[11] and UK[12]. For the other countries, data are only available on NUTS 1 and for Spain[13] on NUTS 2 level. In order to derive NUTS 3 data for all countries, the data of the six countries with available regional data are used and the correlation between installed capacity, share of installed capacity and Nuts3 data in dependence of available area, population, GDP, number of dwellings and potential full load hours are assessed.

Solar Power Exploitation

While in 2002 installed capacity for solar power was low compared to 2012 (see Map 2.11 for the exploitation in the year 2012) values and today. Countries with technology specific policies to promote solar power installations reached a considerable increase in capacity (e.g. Spain, Greece, Italy, Belgium, Germany and others). These effects also determine the development of solar power exploitation rate between 2002 and 2012, which is shown in Map 2.12.

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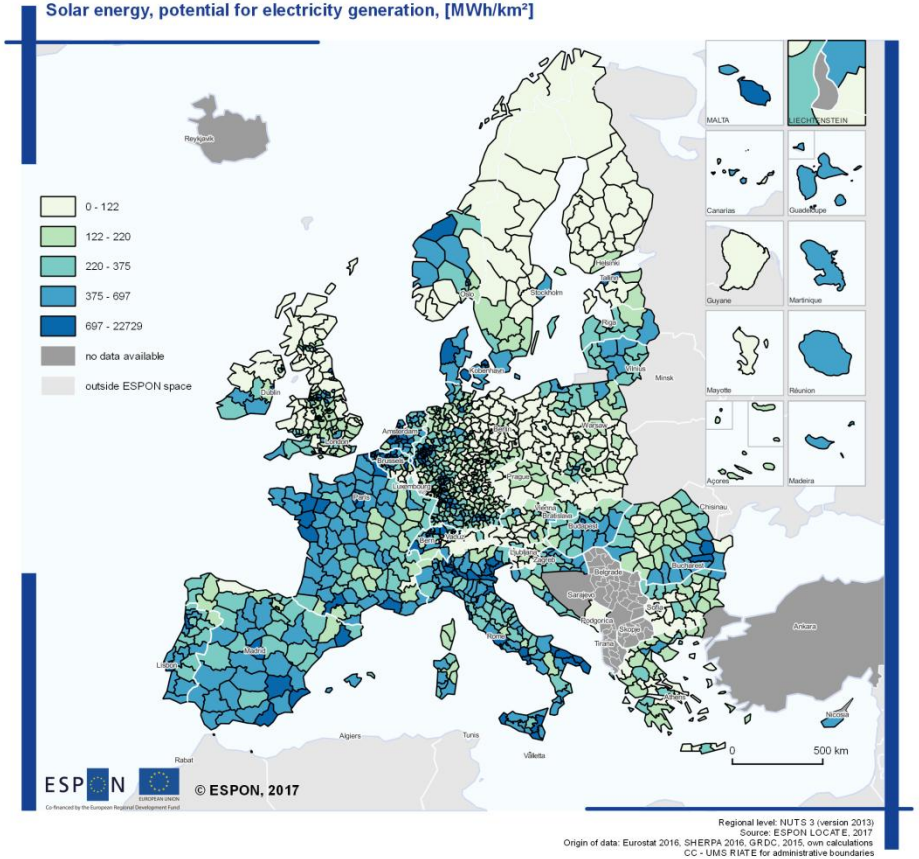
[10] http://data.open-power-system-data.org

[11] http://www.gse.it/it/Statistiche/RapportiStatistici/Pagine/default.aspx

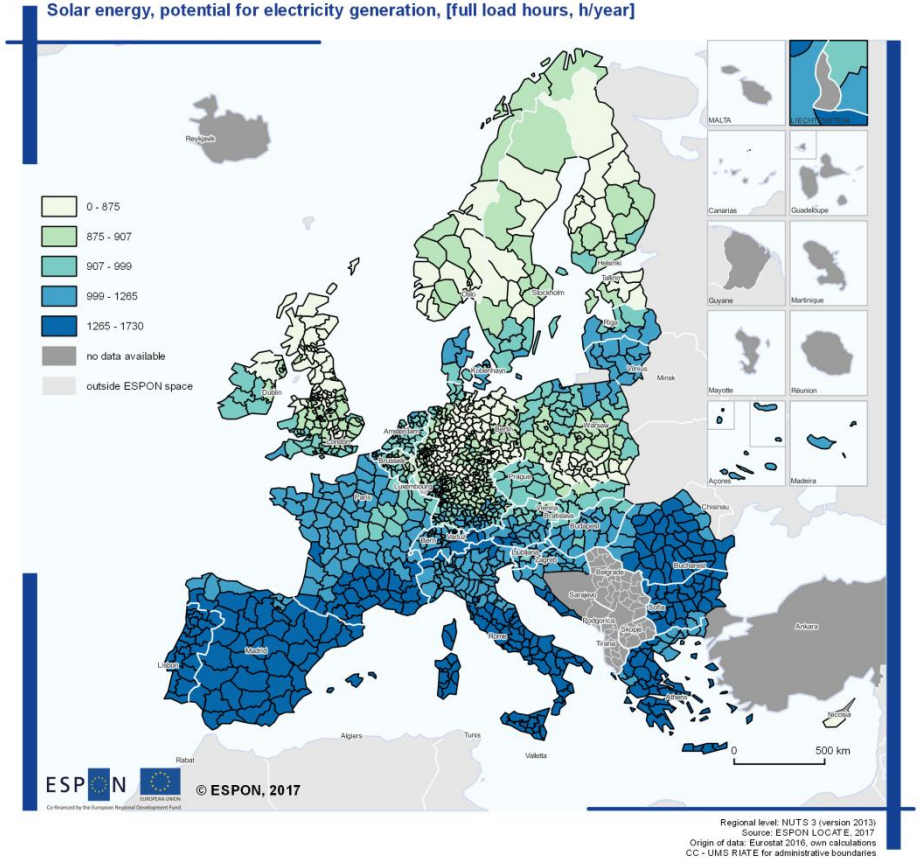
[12] https://www.gov.uk/government/statistics/regional-renewable-statistics

[13] http://www.ree.es/es/estadisticas-del-sistema-electrico-espanol/series-estadisticas/series-estadisticas-por-comunidades-autonomas

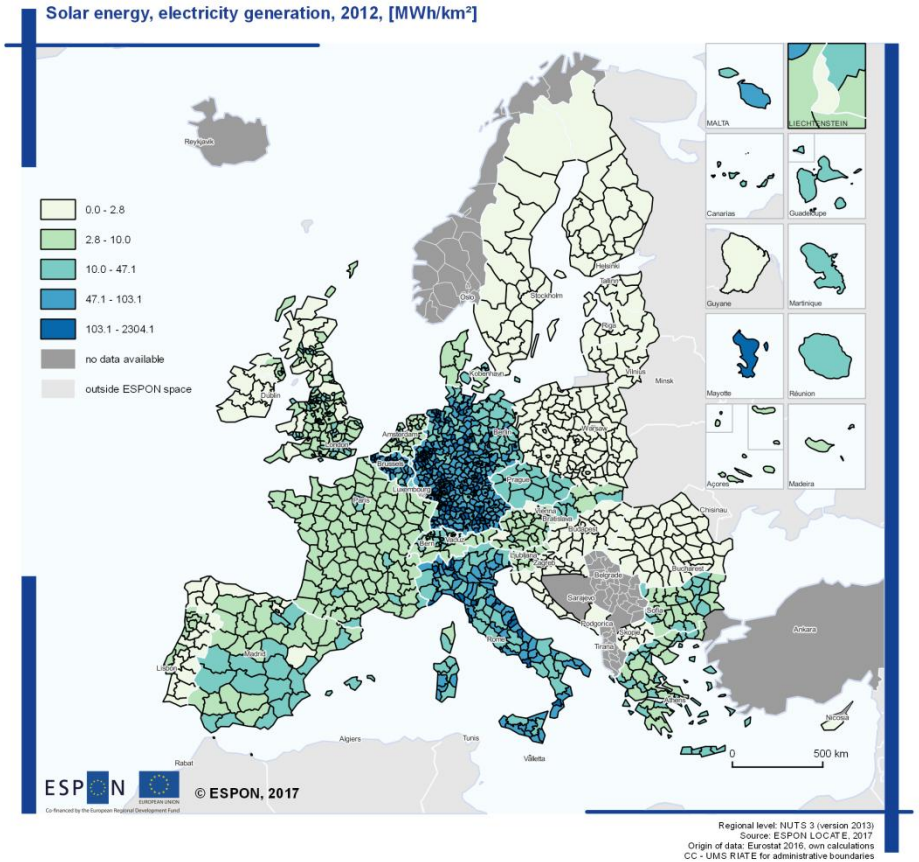
Map 2.7: Solar energy potential, MWh/km^2



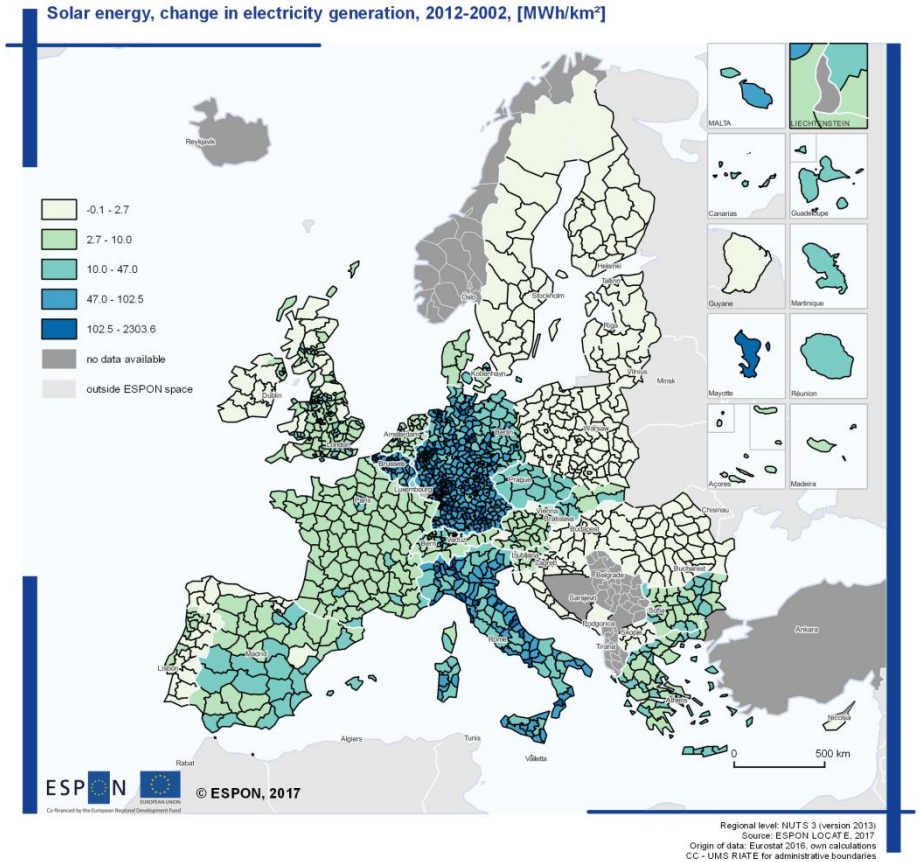
Map 2.8: Solar energy potential, electricity production potential, full load hours per year



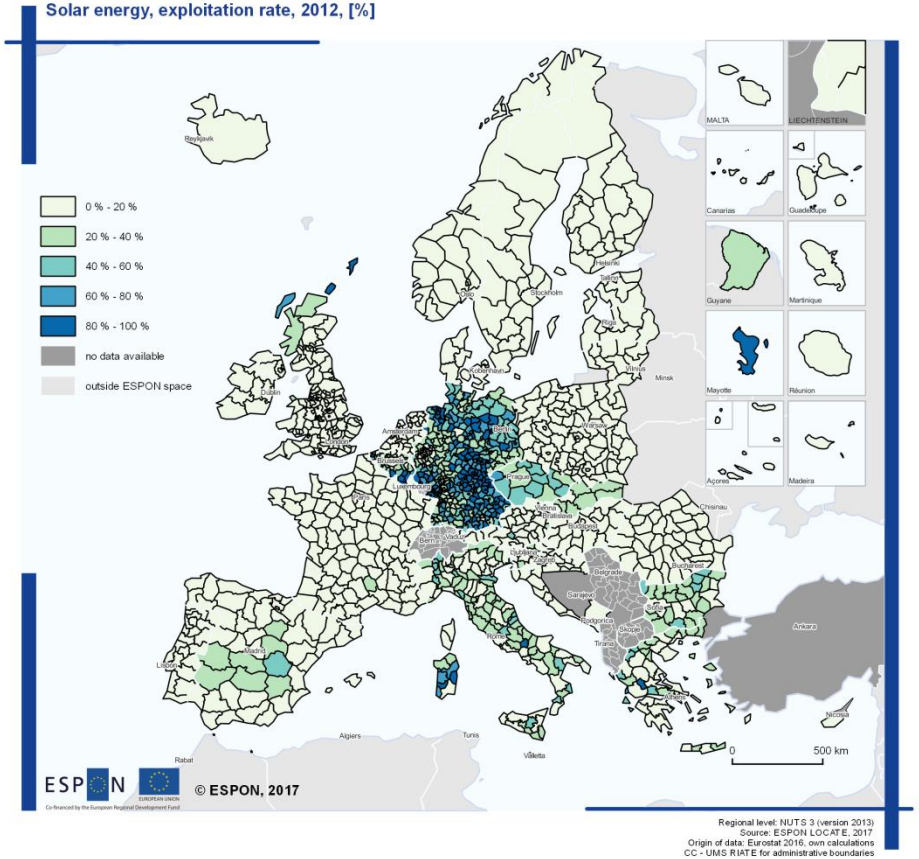
Map 2.9: Solar Energy, installed capacity in 2012, MW/km²



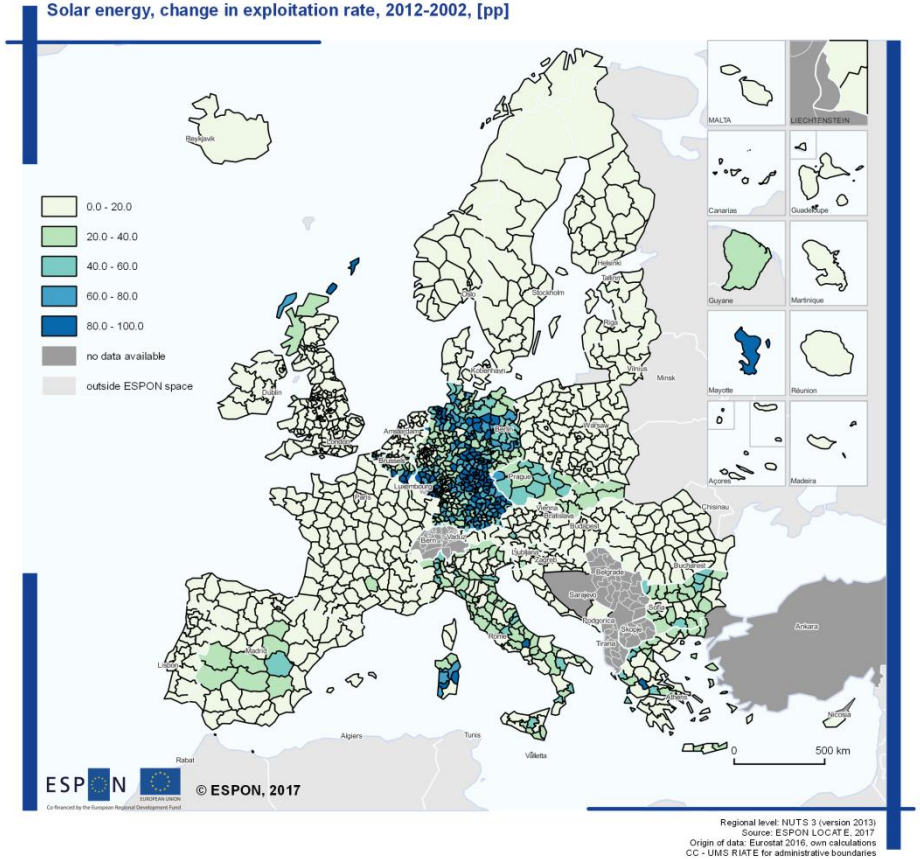
Map 2.10: Solar Energy, change in installed capacity in 2012-2002, MW/km²



Map 2.11: Solar exploitation rate 2012



Map 2.12: Change in solar exploitation rate 2012-2002



2.2.3 Hydropower

In the study hydro power will be assessed using existing data and study results on contrary to the main renewable energy potential of solar wind power which had been calculated in the enertile model. Still the distribution of hydro power potential on NUTS 3 level remains challenging. In the study the SHERPA[14] report had been used to determine the overall (small) hydro potential for large hydro the EUROLECTRIC study results had been used. As the studies only show the total potential on NUTS 0 level a methodology had been developed to distribute the potential on NUTS 3 levels. For the distribution of the potential long-term mean monthly discharges of flow rate station had been used. Depending on the basins they are representing the overall potential had been distributed on the different streams. The streams had been divided in large and small rivers/streams to distribute the small and large hydro potential accordingly. Using this approach it is possible the also 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 be firstly give an overview on the large hydro power potential and then present the perspectives on small hydro power.

Large Hydro Power Potential

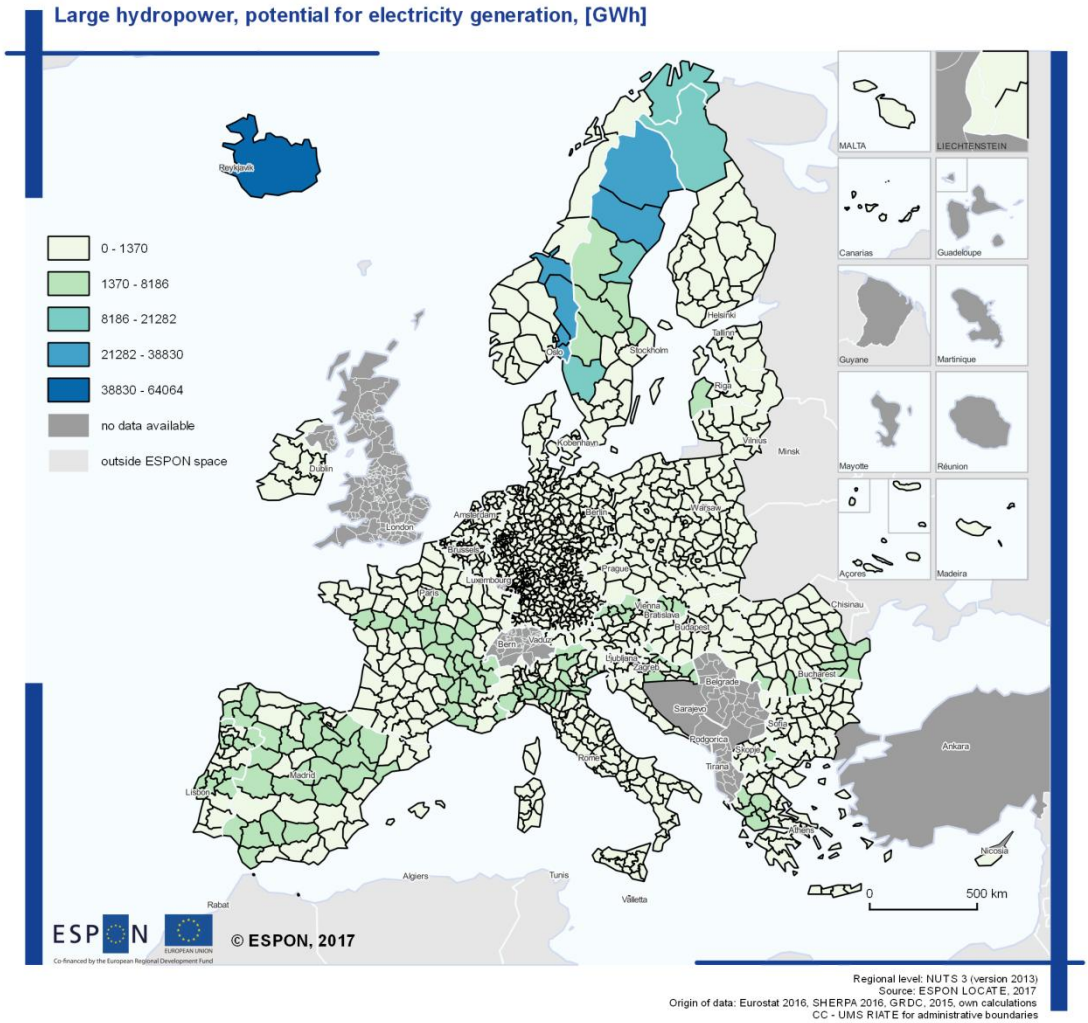
Hydro power potential estimations often differ from each other. The estimated potential in some cases is twice as big as in other studies. In the following analysis a the EUROLECTRIC[15] data has been used and referenced with Eurostat data. It showed relative similar values compared to some reference countries.

Map 2.11. 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.

[14] 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].

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

Map 2.13: Technical potential for large hydropower, GWh



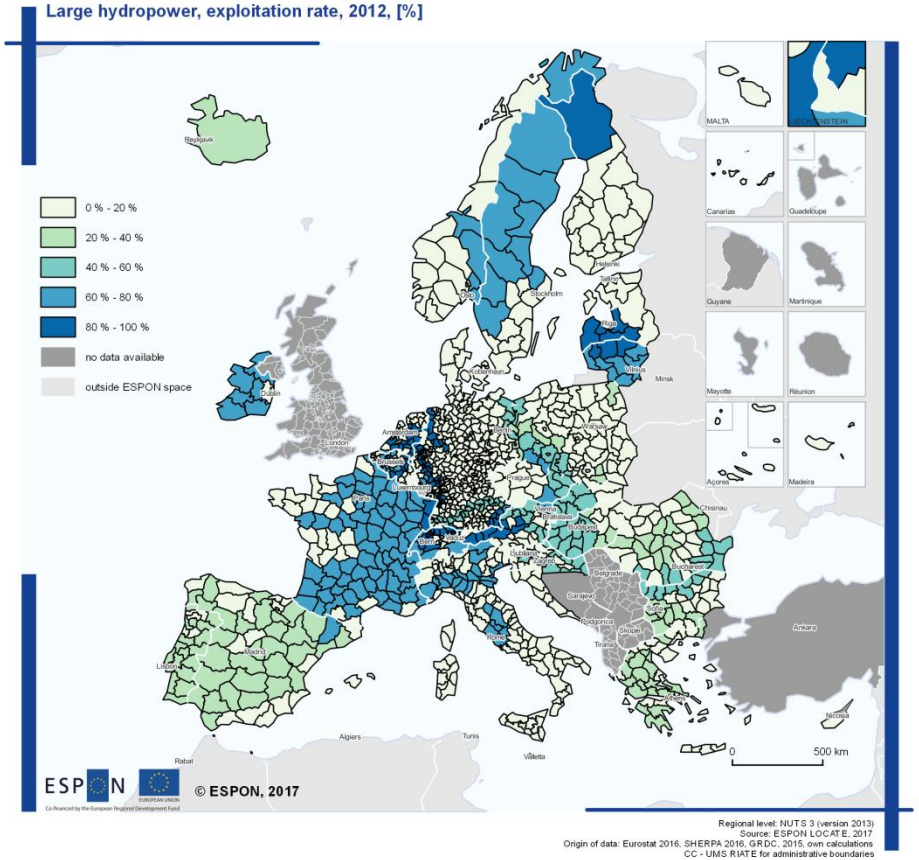
Source: Own calculations; SHERPA 2008; GRDC 2015; Eurolectric 2010; Eurostat 2017.

Large Hydro Power Exploitation

The large hydro potential exploitation is already very high in several countries. In Germany it even reaches over 90% in 2002. Exploitation rates of 53 till 70% are reached in France, Italy, Austria, Norway, Czech Republic and Slovakia. However, in some studies the small hydro potential is still considered to be widely untapped. Therefore, in some cases the potential showed in the map above might increase. In example the SHERPA report shows an increase of 7.24 TWh in Germany if small hydro potential would be fully implemented, an increase of over 29%.

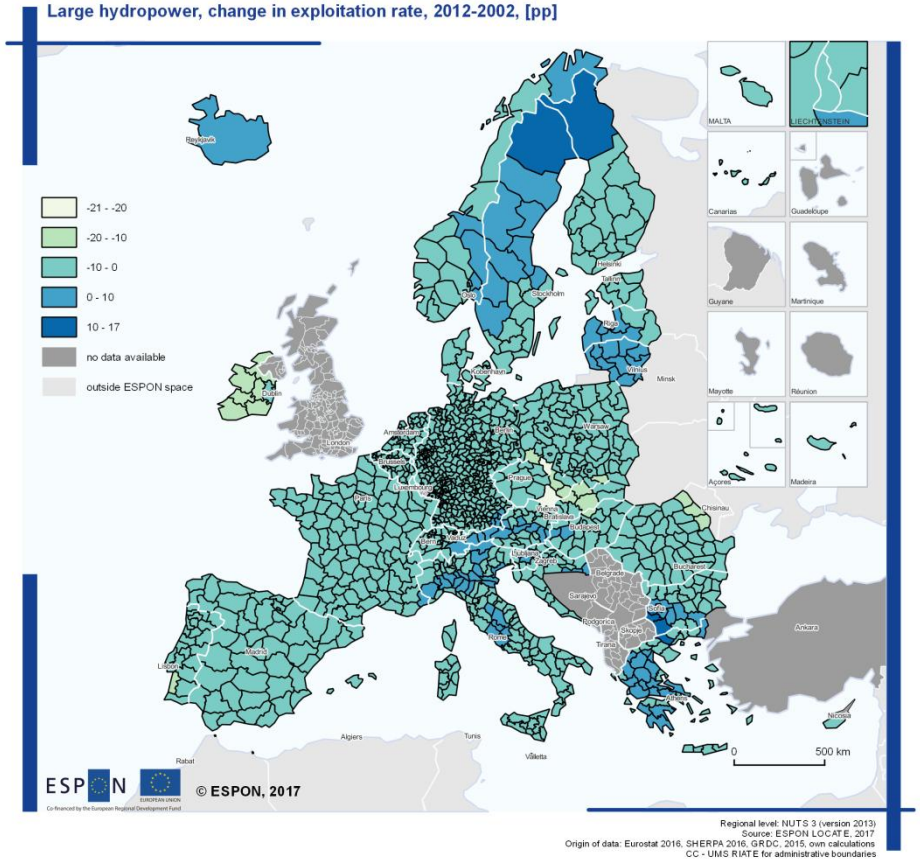
The exploitation had not significantly changed in 2012. In fact some of the countries have realized a smaller generation exploitation, i.e. Czech Republic, but the decrease was mainly driven by a lower generation then by reduced capacities. The capacity in the countries presented above has even increased from 113 GW in 2002 to 119 GW in 2012.

Map 2.14: Large hydro power exploitation rate 2012



Source: Own calculations; EURLECTRIC 2010; SHERPA 2008; GRDC 2015.

Map 2.15: Change in large hydro potential exploitation rate 2012-2002



Source: Own calculations; EURLECTRIC 2010; SHERPA 2008; GRDC 2015.

Small Hydro Power Potential

The following map is showing the technical potential for the small hydro power as it has been calculated in the SHERPA report and afterwards distributed on the NUTS 3 level with the approach described above. It should be mentioned that the potential calculation in the SHERPA report could not be recalculated. In some countries like Germany and Switzerland it appears also a little bit high. However, the SHERPA report is the best source for the small hydro potential and it is pointing clearly out some challenges of small hydro potential calculation.

The overall technical potential is estimated to reach around 86 TWh/year in the countries showed in Map 2.14. The largest national potential with 17 TWh/year is in Norway, followed by Germany with 9 TWh/year. In some NUTS 3 areas the stream data was inconsistent. Either streams had been missing a reference long-term discharge stations had no data saved in the database. The national potential had been then equally distributed over all other NUTS 3 areas.

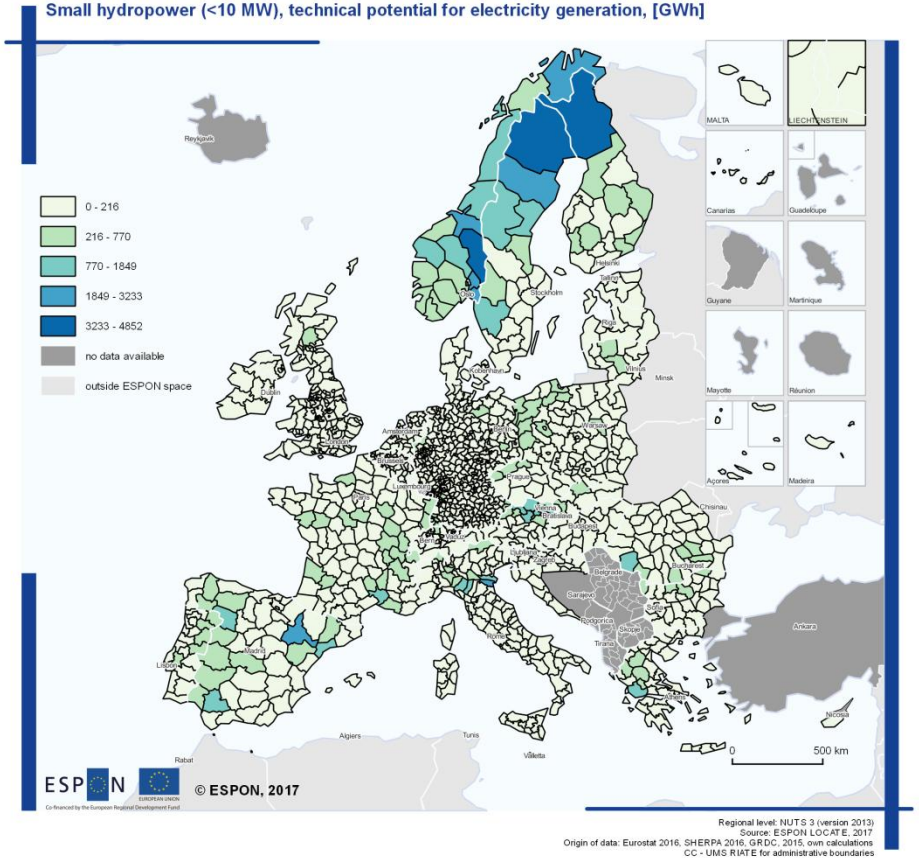
In terms of to potential per km^2 per country, the small hydro potential varies between 1 and up to 61.3 MWh/year and km^2. The latter value is a peak value[16] in Austria. The average value[17] in all NUTS 3 areas is 19 MWh/year/km^2. Based on the technical potential the economic small hydro potential is derived. The overall economic potential is shown in Map 2.15, and sums up to 78.9 TWh/year and an average value of 10 MWh/year/km^2 per NUTS 3 area.

Out of the technical potential the economic small hydro potential can be derived and is presented in the following map.

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

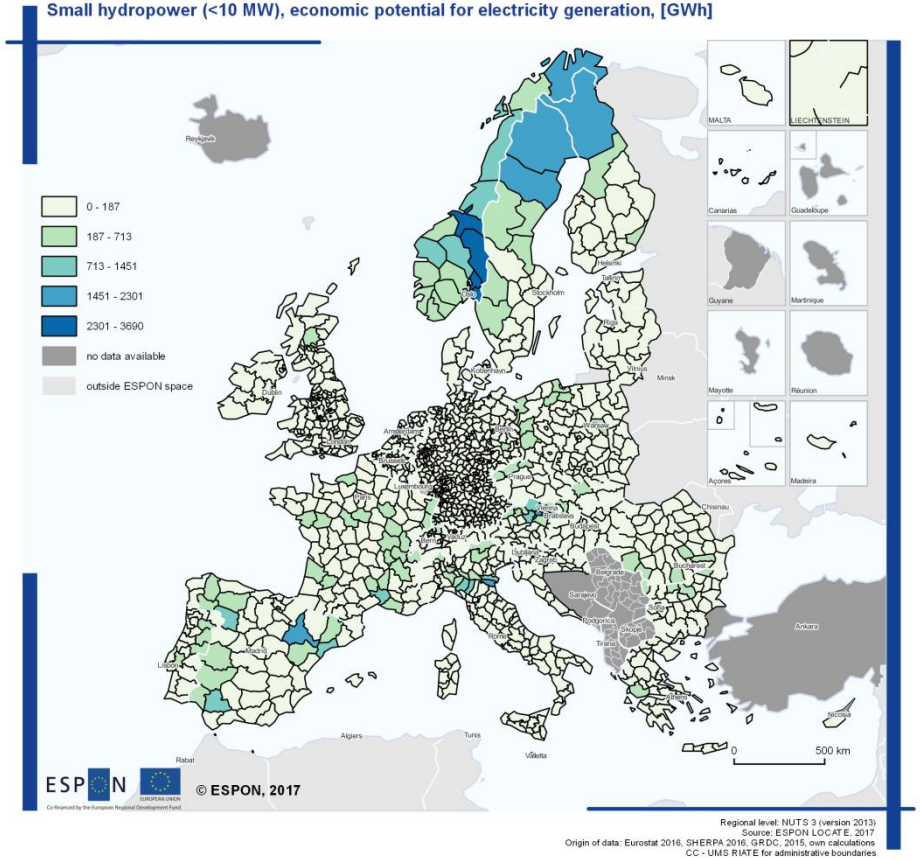
[17] Standard Deviation: 49,14 MWh/year/km^2

Map 2.16: Small Hydro Technical Potential (< 10 MW), GWh



Source: Own calculations; SHERPA 2008; GRDC 2015.

Map 2.17: Small Hydro Economic Potential (< 10 MW), GWh



Source: Own calculations; SHERPA 2008; GRDC 2015.

Small Hydro Power Exploitation

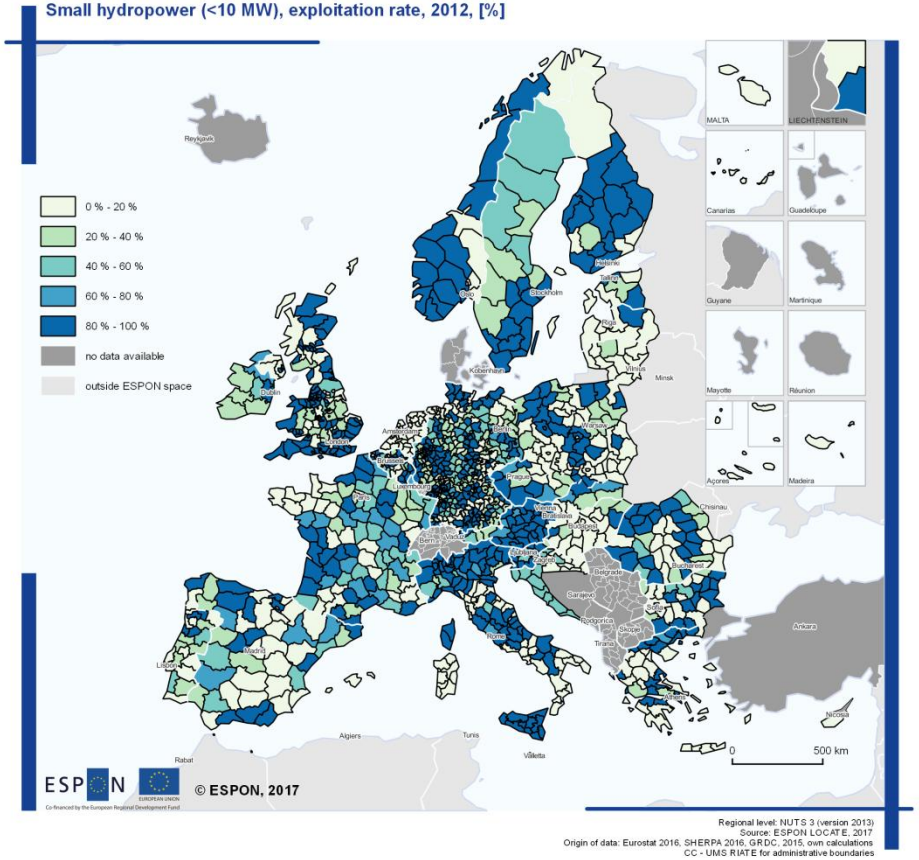
In the following, the exploitation rate in 2002 and 2012 of the small hydro potential will be presented. As the reference value the technical potential will be used. The reason for this decision is, that the economic potential calculation in the data used is not clearly described and therefore important input parameters remain unknown.

Map 2.18 shows the exploitation rate. The mean rate in 2002 reached around 32% in all NUTS 3 areas. With on overall generation of 48 TWh, considering the technical potential of 86 TWh, the small hydro potential remained untapped in 2002, reaching a value of nearly 55%.

The exploitation is not evenly distributed. The highest exploitation rates can be registered in France and the basins related to the Alps. A relative low exploitation can be found in middle and eastern Europe as well as in Spain. It should be considered that in regions with a lower density of technical potential the economic potential tends also to be lower. This could be one explanation to the lower exploitation in these areas.

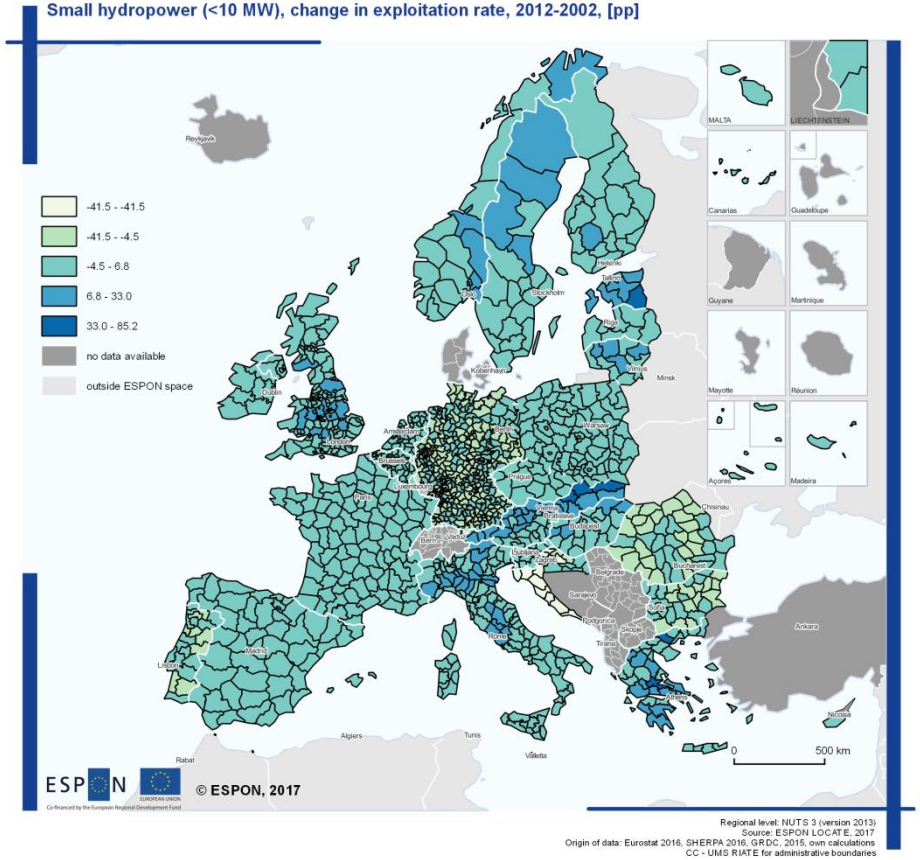
In 2012 the exploitation increased especially in Germany and also other regions with an initial lower potential exploitation and reached a rate of 36%, 4 percent points higher than in 2002. The total generation is summing up to 62 TWh which is representing around 72% of the technical potential. Considering only the EU28 the generation increased from 38 TWh to 43 TWh. However, the generation might not be simply translated in capacities. The overall installed capacity following Eurostat data increased in the EU28 during that period from 11.3 GW to 13.3 GW, an increase only by 17%. As a result the small hydro deployment is showing a moderate dynamic during the period of 2002 to 2012. Compared to a total of 192 GW wind onshore installed the generation share of small hydro remains limited.

Map 2.18: Small Hydro power exploitation rate 2012 (< 10 MW)



Source: Own calculations; SHERPA 2008; GRDC 2015.

Map 2.19: Change in small hydro power exploitation rate 2012-2002 (< 10 MW)



Source: Own calculations; SHERPA 2008; GRDC 2015.

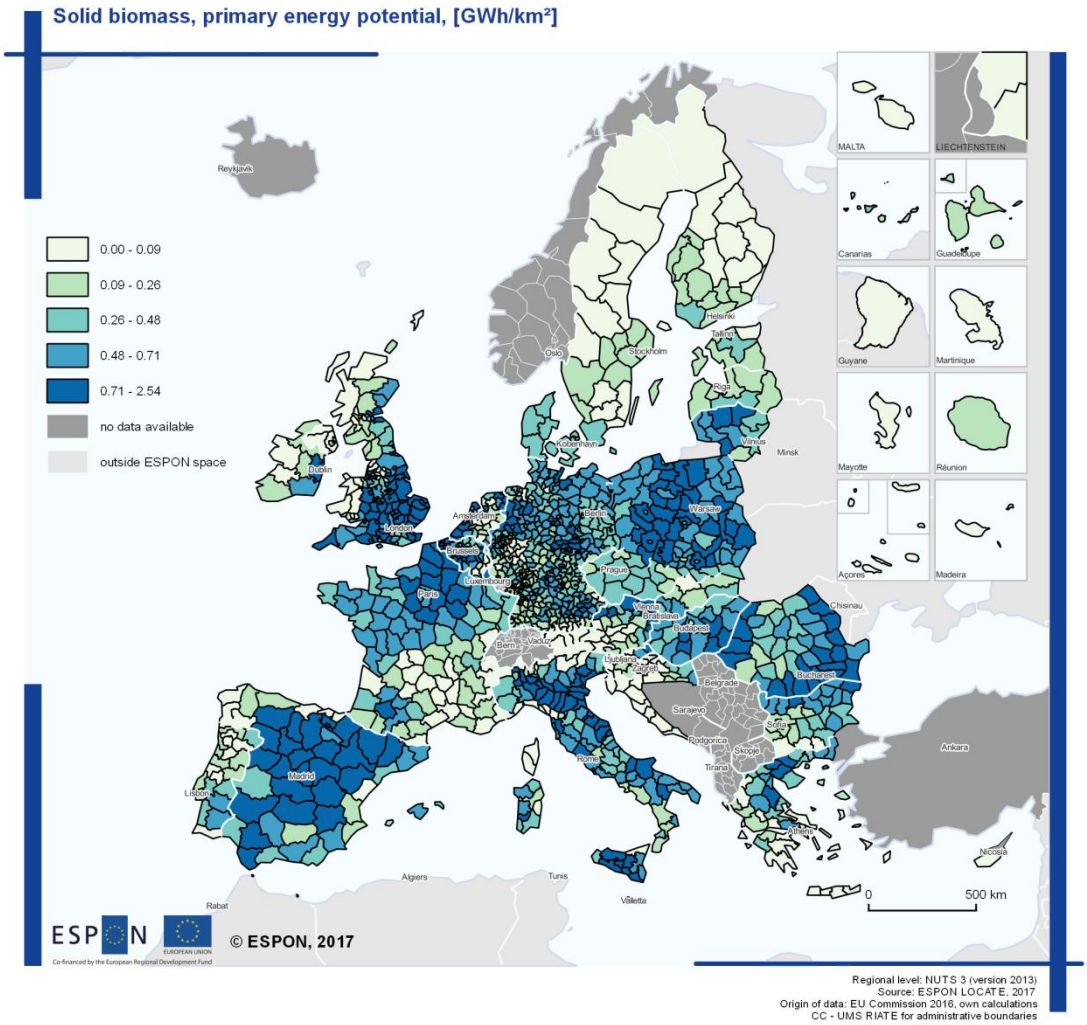
2.2.4 Biomass

This study makes use the existing classification of biomass feedstock used in TU Wien's Green-X model that are divided in three main types of biomass feedstock categories, consistent with the Biomass Energy Europe (BEE) project:

(1) Forest products and forests residues (see Map 2.20)
(2) Energy crops see (see Map 2.21)
(3) Organic wastes (see Map 2.22)

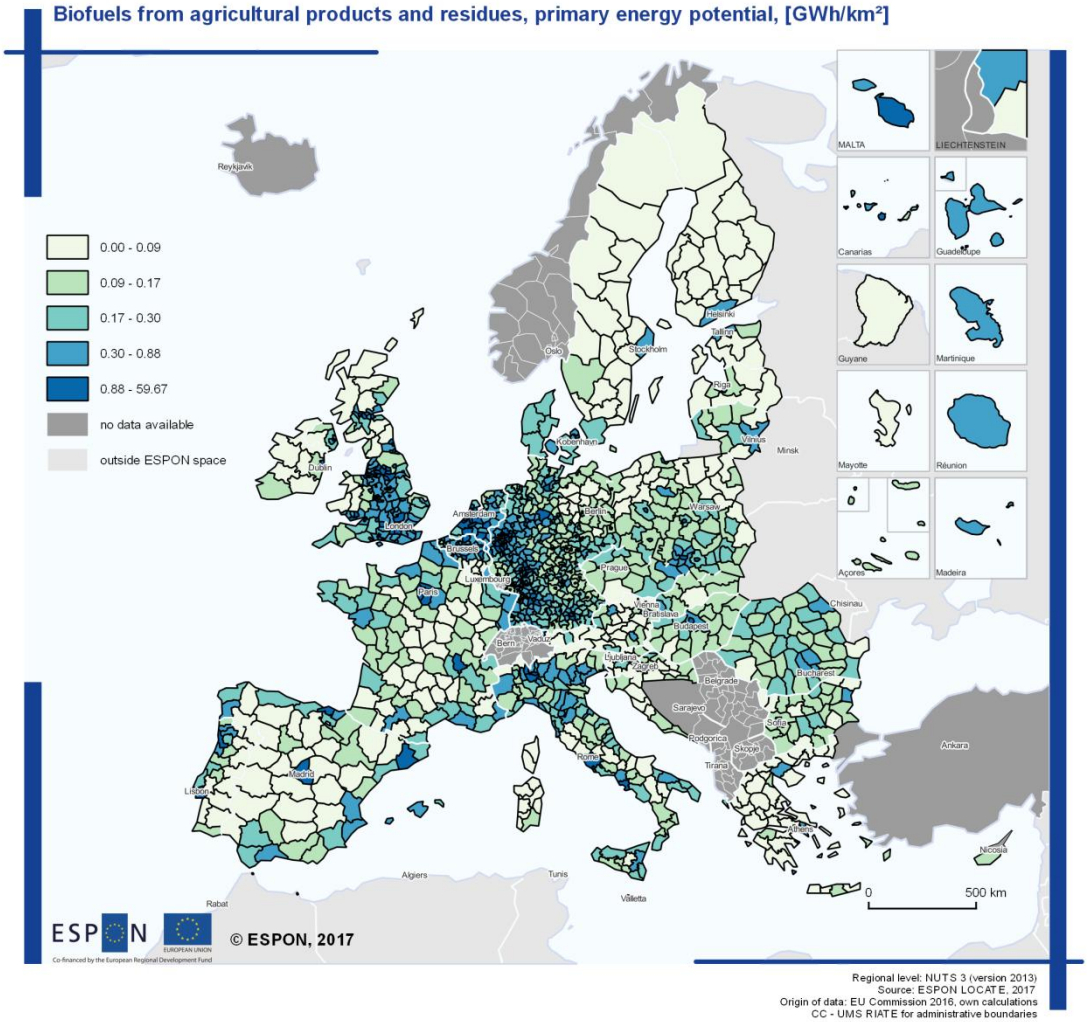
A key source for our envisaged assessment of biomass supply potentials is the BioSustain project ("Sustainable and optimal use of biomass for energy in the EU beyond 2020 – An Impact Assessment"), providing useful insights on current and expected future supply and consumption of biomass for energy purposes across the EU. It is a European study, done on behalf of the EC, DG ENER, targeted to ensure the sustainable production and use of bioenergy in the EU beyond 2020. Within that project an intensive review of biomass supply potentials and consumption pattern has been conducted by EU Member State, offering a sound basis for our follow-up analysis at regional level within this request. (EC, 2017)

Map 2.20: Primary potential of solid biomass in GWh/km²



Data on country-specific feedstock potentials available for bioenergy supply (i.e. by subtracting from the identified supply potentials the current and expected future use for material purposes and other growing bio-economy sectors) forms the basis for our assessment of regional bioenergy feedstock potentials. GIS-based modelling facilitates the estimation of the regional breakdown (at NUTS-3 level) of identified nationally available feedstock potentials. More precisely, a land use analysis for arable land and land used for forestry had been conducted.

Map 2.21: Primary potential of energy crops in GWh/km²



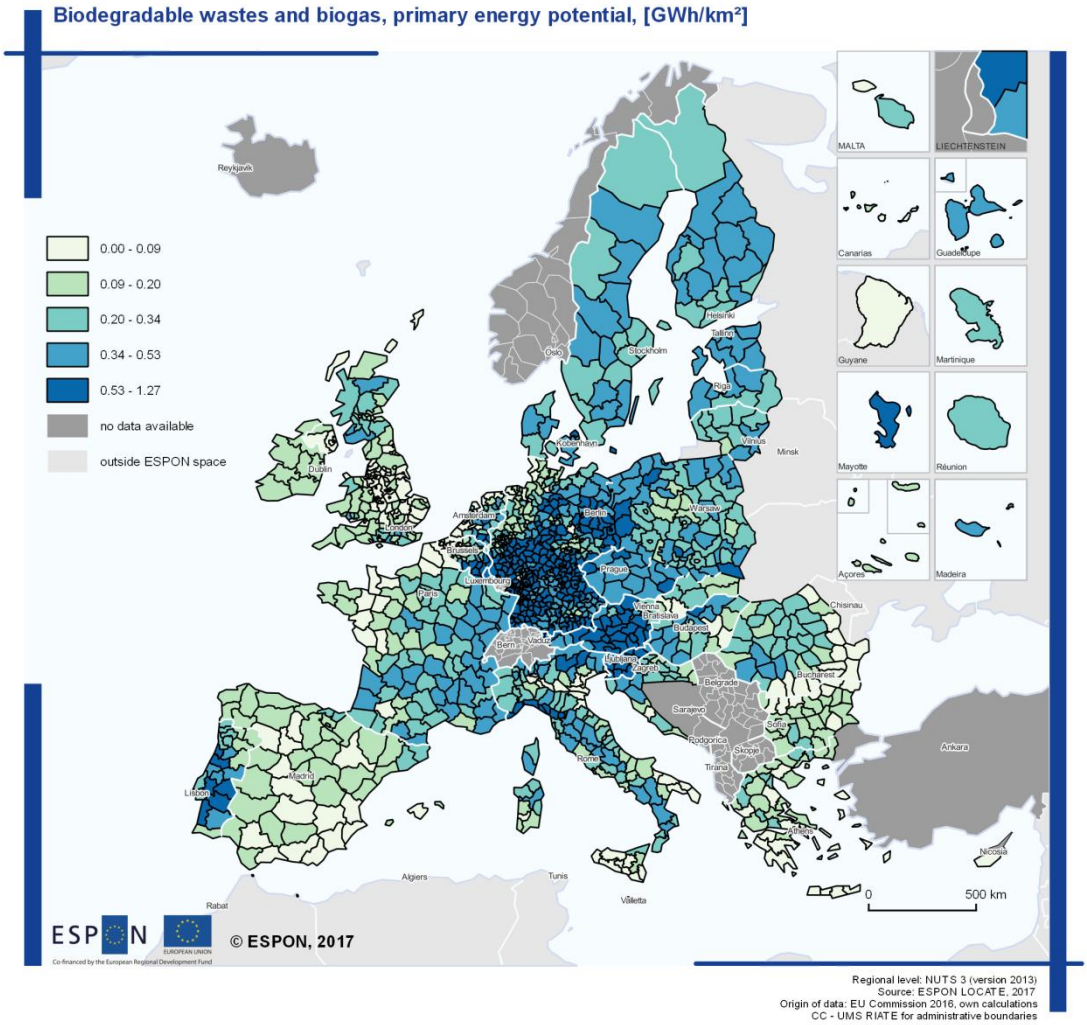
Biomass Energy Potential

Within the cited report (EC, 2017) a review of recent literature 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 was included. Please note further that from the overall bioenergy 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 2.20 to Map 2.22.

Biomass Exploitation

There are multiple reasons why there is no information included in this report on the exploitation of the primary energy potential of biomass. First and foremost there is a competition between the material- and energy-use of biomass on a local scale. This means that for an assessment regarding the local exploitation of biomass resources, not only the energetic demand but also the material use has to be situated. The data sources on the material use of biomass is very scarce. Secondly, there are many biomass based energy carriers which can be transported easily. As a result, it is an unrealistic assumption that the energy potential of biomass is directly used in the region where it was grown and harvested.

Map 2.22: Primary potential of biodegradable wastes and biogas in GWh/km²



2.2.5 Geothermal Energy

The potential of geothermal energy was assessed based on existing studies as geothermal energy potential depends very strongly on local conditions and the application of the grid approach used for PV and wind energy is not suitable for geothermal energy.

The existing literature about the potential for geothermal district heating in Europe covers selected European countries (e.g. 14 countries in Dumas and Bartosik, 2014). The main objective of a recently published work was to combine the information provided basically by two different reports and to extend this coverage to the whole European Union and relevant neighbouring countries with respect to geothermal energy (Danese, 2016).

Geothermal Energy Potential

In many cases, a temperature level of 60-100°C of geothermal sources is sufficient to supply district heating grids. However, as showed in Map 2.23, at a depth of 2,000 m the potential is discontinuous. It is easy to note that, even if there is potential in every European country, only a portion of its population live in areas that can be supplied by geothermal district heating (shown as blue colored areas in Map 2.24). The geothermal energy potential is expressed in energy units needed in the heating and cooling sector based on demand projections that could be substituted by geothermal district heating technology. The total potential in GWh and is calculated by multiplying the population's potential percentage to be covered by geothermal district heating at different depths and the forecasted heating and cooling demand in the year 2050 according to the EU Reference Scenario 2016 (Capros et al, 2016).

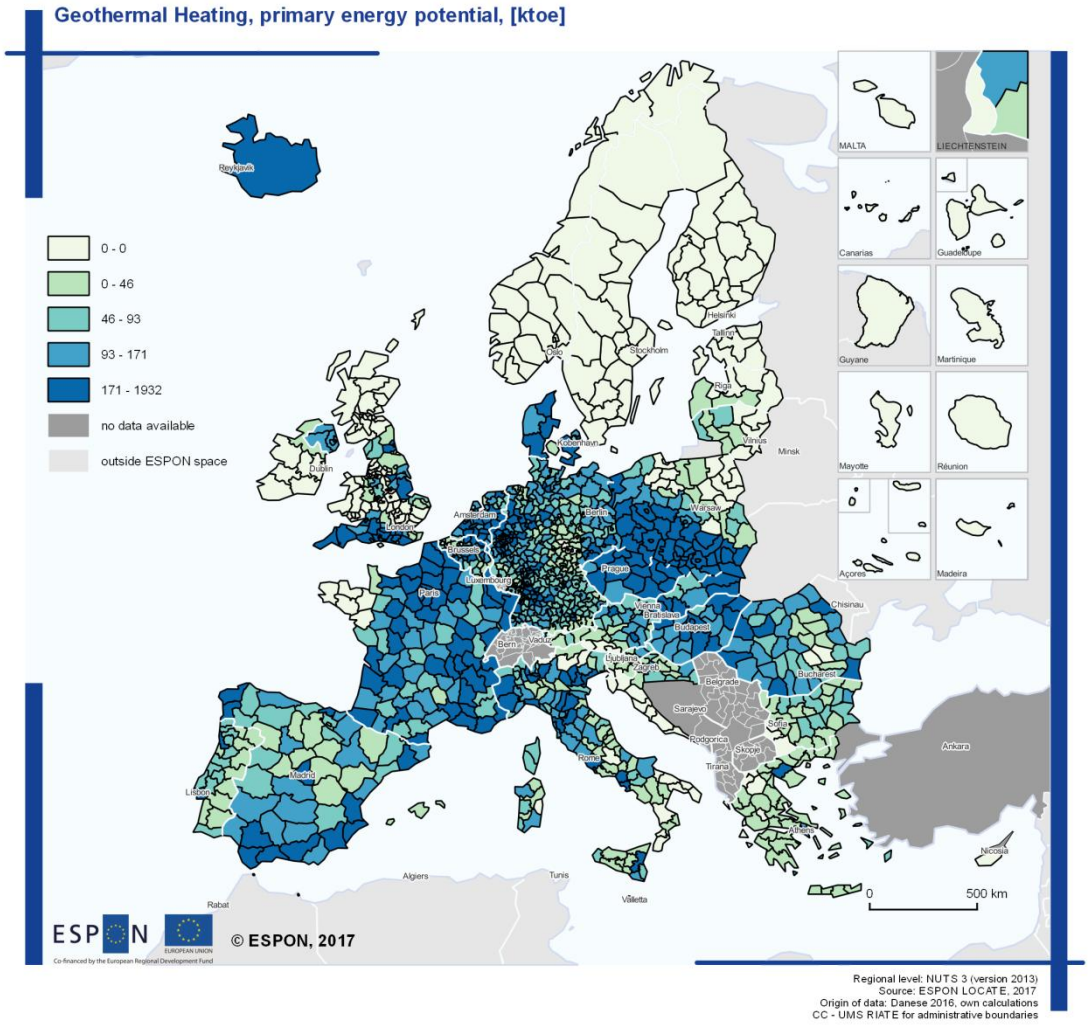
Map 2.23: Model temperature at 2,000 m depth

Source: GEOELEC Viewer.

Geothermal Energy Exploitation

An assessment of the exploitation of geothermal energy was not possible within the scope of the project. First, because overall only very few geothermal district heating plants have been installed in the EU up to now. And second, because due to the low penetration of the technology there is little reliant experience on the issue of competing exploitation or use.

Map 2.24: Total potential of geothermal district heating in ktoe$_{thermal}$



2.2.6 Tidal/Wave Energy

The tidal and wave energy is relative difficult to be implemented and distributed on the NUTS 3 level. Therefore, only a rough estimation can be given within this report as the focus is on the main technologies with the largest potential like wind, solar and large- and small hydro.

Tidal/Wave Energy Potential

The main tidal energy potential can be found in France and the UK. It is estimated to be 1 GW in France and 11.4 GW in UK[18]. However, the economic potential can be hardly estimated as most of the maritime technologies are not market ready respectively are considered to be in the pre-market phase. This is also shown by the low installed capacity.

[18] http://atlantisresourcesltd.com/marine-power/global-resources.html

Table 2.1: Installed Tidal Energy Capacity in Europe

Location	Installed Capacity in MW
CHANNEL ISLANDS	1
ENGLAND & WALES	4
FRANCE	26
NORTHERN IRELAND	1
SCOTLAND	2
TOTAL	34

Source: PLATTS 2012.

The amount of tidal energy capacity is only representing 0.002% of the total hydro power installed capacity of 15,005 MW. However, corresponding to the Platts database 12 MW of tidal energy capacities had been deployed between 2003 and 2012. This shows a recent dynamic in the development.

The technical wave energy technical potential is estimated in Europe to be around 286 GW[19]. Several pilots are deployed in the last decade

Tidal/Wave Energy Exploitation

In Europe there are only a few significant installations existing in the UK and one installation in Portugal with a capacity of around 2 MW launched in 2008. In the UK a 3 MW installation has been installed in Scotland. Hence, there is hardly any exploitation of tidal and wave energy potentials within Europe up to today.

2.3 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.

The EU's Renewable energy target for the year 2020 includes a national renewable energy action plan (NREAP) for each EU country. This means that each country had to put down which actions they intend to make to meet their own target. These plans are legally binding. With this Action Plan, the EU wants to meet the target of 20% renewable energy in Europe in 2020.[20]

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

[20] https://ec.europa.eu/energy/en/topics/renewable-energy

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

Financial state budget independent 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[21]

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.[22] Therefore, new renewable technologies are independent from price risks. This excludes producers from actively participating in the market and thus overcompensation is very possible.[23] 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.[24] Feed-in tariffs and feed-in premiums are called supply-push instruments.

On the other side, there are consumption-pull instruments such as quota systems. Thereby, the amount of electricity produced by renewables is fixed (for example by Tradable Green Certificates). It is therefore possible for renewable energy plant operators to sell certificates and it helps to enable a market between renewable producers and suppliers of energy and

[21] 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)

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

[23] 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)

[24] Ibid.

other market players.[25] Quota based systems such are energy saving obligations and white certificates systems are also effective market based instruments for supporting energy efficiency in the European Members States. Thereby, energy suppliers are obliged to conduct and certificate certain amount 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 of the proposal for the recast of the Renewable Energy Directive, the EC suggested a RES-H/C quota systems which would be limited only to RES-H/C systems.

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 (RE) producers and can lead to a reduction of support costs. This is possible because tender has several criteria such as the amount of energy generation, the capacity deployed and also a maximum price can be set. All these criteria make support costs more predictable. The disadvantage of such a scheme is that higher transaction costs arise due to the fact that there are more bureaucratic 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.[26]

Investment support exists in various forms as grants, soft loans, tax exemptions or reduction. It 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.[27] Investment grants are currently the major support mechanism for renewable heating and cooling (RES-H/C) technologies in the EU Member States.[28]

Tax exemptions are available indirectly due to all taxpayers and not by energy consumers. The Directive 2003/96/EC allows tax exemptions or reductions for biofuels and also for electricity produced by solar, wind, tidal, geothermal and hydraulic devices. These instruments

[25] Ibid.

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

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

[28] 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

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 with regard to support of RES-Heating and cooling 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 consumption which is mostly covered by renewable sources.

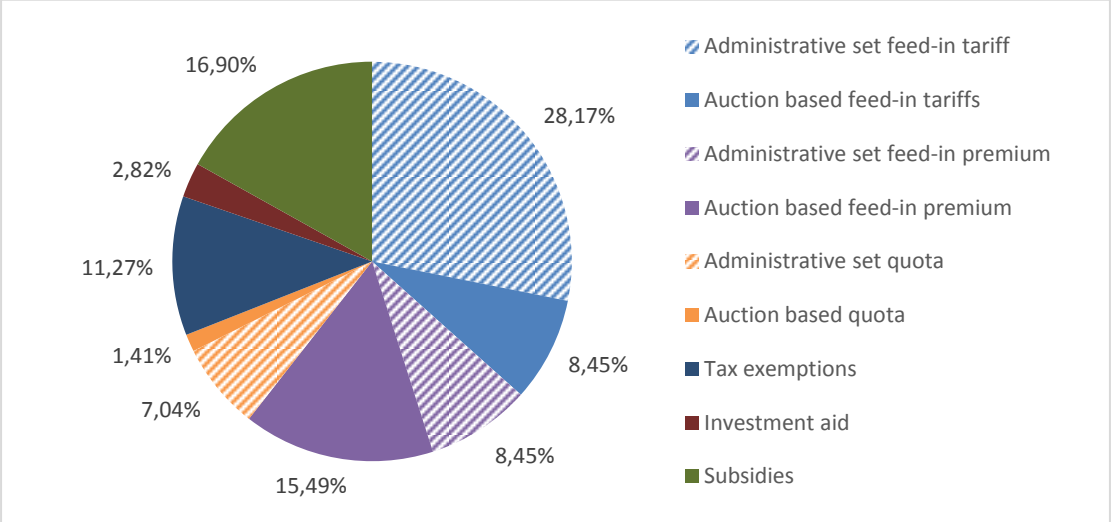
A few countries such as Germany have implemented direct a use obligation for RES-H/C requiring owners of new buildings or existing buildings in case of major renovation or heating system change to source a certain share of their heating consumption by RES. Actually, all Member States are required to implement such a regulation according to the current Renewable Directive. A complete ban of fossil fuels for new heating installation is another effective regulations 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 industrial consumers, there is effective price signal for households or services to change their heating systems to RES. Even though that 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.

Figure 2.4 depicts the shares of different policy instruments deployed for supporting RES-E in EU Member States and other European countries. 29

[29] Includes: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Czech Republic, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Former Yugoslav Republic of Macedonia (FYROM), Malta, Moldova, Montenegro, Netherlands, Norway, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Turkey, Ukraine, United Kingdom

Figure 2.4: Shares of support policies in EU 28 + Turkey, Ukraine, Serbia, Moldova, Albania, Montenegro, FYROM, Bosnia and Herzegovina, Iceland, Norway by August 2017.



Source: Own depiction based on http://www.res-legal.eu/search-by-country/RES-leagl (2017) (multiple responses allowed), http://www.res-legal.eu/search-by-country/*

A majority of the considered countries are using administrative set feed-in tariffs with over 28%. If auction based feed-in tariffs are also taken into account, even more than 36% are using feed-in tariffs as an instrument. Furthermore, 16% of the countries are using subsidies to support renewable energies. Feed-in premiums accounts for almost 16%. More than 11% of the examined countries are using tax exemptions to expand renewable energies. A minority of countries is using administrative set quota systems (about 1.4%) or investment aids (almost 3%).

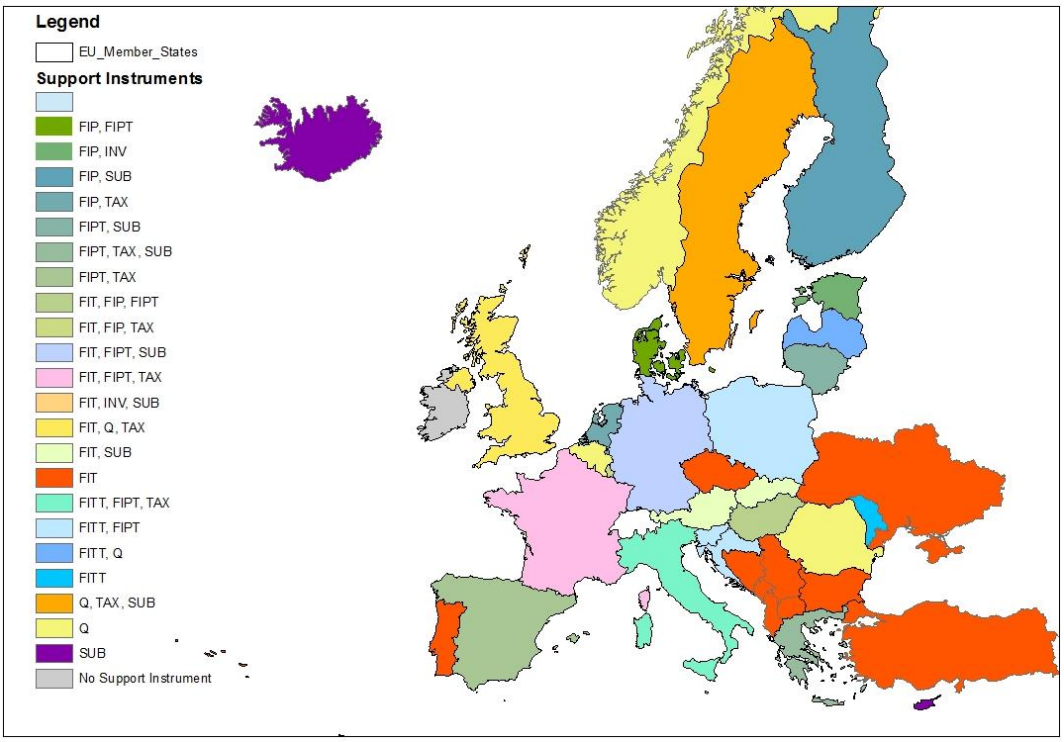
Figure 2.5 shows an overview of the different use of support instruments for each considered country. Twelve of the considered EU Member States already use tender schemes. It is also evident that Non-EU Member States have only one instrument in place to support renewable energies[30] whereas the majority of EU Member States have at least two main national policies in place. Only Ireland has no support scheme since the old feet in tariff scheme has expired.[31] A reason why especially the use of administrative set feed-in tariffs is fading out in the European Member States can be explained by the EU Commission release of the state aid guidelines restricting the further use of fixed feed-in tariffs: “In order to incentivise the market integration of electricity from renewable sources, it is important that beneficiaries sell their electricity directly in the market and are subject to market obligations.” [32]

[30] In this section only the electricity sector is considered

[31] http://www.res-legal.eu/search-by-country/ireland/

[32] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014XC0628(01) [Guidelines on State aid for environmental protection and energy 2014-2020]

Figure 2.5: Overview of the use of different instruments by European Countries



Source: Own depiction based on http://www.res-legal.eu/search-by-country/] (multiple responses allowed)

In summary, administrative set feed-in tariffs are declining in the EU Member States. Feed-in tariffs have proven to be a very effective support scheme to stimulate the uptake of RES-E as they lower the investment risks for plant operators.[33] On the other hand, feed-in tariffs are getting expensive when the amount of renewable energy plants is sharply rising. Furthermore, Winkler et al. state that price volatility is highest under feed-in tariffs and that negative prices occur mostly in feed-in tariffs schemes. Winkler et al. also reports that the merit order effect is not reduced by feed-in tariffs as all available energy is put into the market separate of the consumption situation.

Therefore the European Commission declares that from the first of January 2017 all new aid schemes and measures has to consider the following condition: “Aid is granted in a competitive bidding process on the basis of clear, transparent and non-discriminatory criteria”.[34]

As an example for the introduction of auctions in an existing market, the auction for ground-mounted PV plants in Germany is described in the following. The EEG 2012 granted a fixed feed-in tariff for ground-mounted PV plants.[35] This step was necessary to implement PV

[33] Impact of renewables on electricity markets – do support schemes matter? By Jenny Winkler, Alberto Gaio, Benjamin Pfluger, Mario Ragwitz; in: Energy Policy 93 (2016) pages 157-167

[34] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.187.01.0001.01.ENG

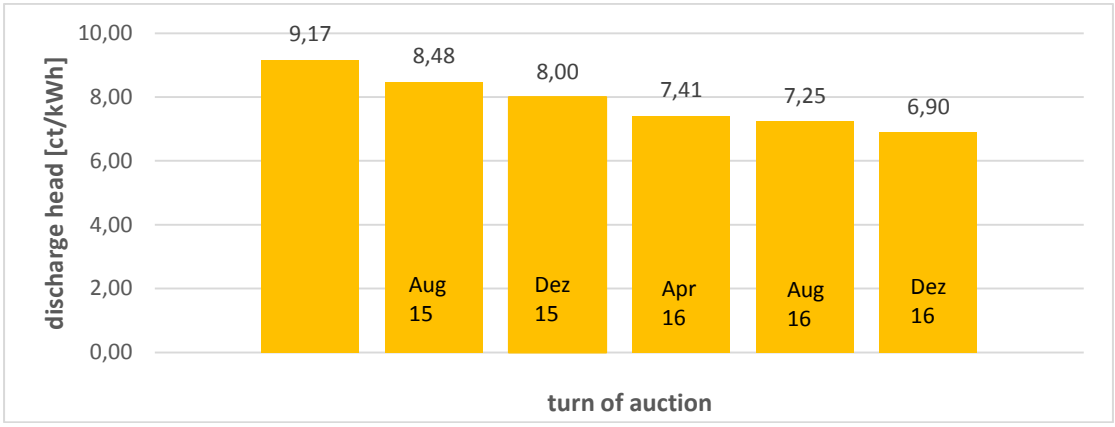
[35] https://www.diw.de/documents/publikationen/73/diw_01.c.437464.de/dp1363.pdf

plants in Germany and to create incentives for a further technology development. This development led to decreasing investment cost and therefore a different support instrument became necessary.[36] The EEG 2014 included the following innovations:

- Determination of the discharge head by tender
- Pilot stage 2015 for ground-mounted PV plants
- Decreasing funding rates for new plants
- Obligation for direct marketing[37]

The first turn of auction took place in April 2015. Since then six turns of auctions occurred.[38] The price development is shown in Figure 2.6.

Figure 2.6: Price development for funding rates for ground-mounted PV plants in Germany[39]



Between the first and the last auction, the price has fallen by over 35%.[40] In the first turn of auction, the price was set by pay-as-bid; this means each tenderer got his or her own surcharge. Afterwards the procedure was changed to uniform pricing so every tenderer got the same promotion (highest commandment). The last three turns of auction were again changed to pay-as-bid. For all turns of auction, it can be said that the surcharge value was always lower than the maximum price.[41]

[36] https://www.bmwi.de/Redaktion/DE/Dossier/erneuerbare-energien.html

[37] http://www.energiedialog.nrw.de/das-neue-eeg-2014-was-aendert-sich/

[38] http://www.erneuerbare-energien.de/EE/Navigation/DE/Recht-Politik/Photovoltaik-Freiflaeche/photovoltaik-freiflaeche.html

[39] http://www.erneuerbare-energien.de/EE/Navigation/DE/Recht-Politik/Photovoltaik-Freiflaeche/photovoltaik-freiflaeche.html

[40] https://www.bmwi-energiewende.de/EWD/Redaktion/Newsletter/2014/20/Meldung/die-wichtigsten-neuerungen-auf-einen-blick.html

[41] https://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/Berichte/bericht-pilotausschreibungen.pdf?__blob=publicationFile&v=5

After the turn of auction, the tenderers have 24 months to realise their project. If a project is not realised within these 24 months a penalty is set which is 5% of the investment sum. After the first round of auction, 96% of the projects were realised.[42]

Overall, it can be concluded that the use of feed-in tariffs is a good way to implement renewable technologies in a system with many fossil fuels. However, it is also evident that a system with many renewable energies has to consider different support instruments as costs and caps for renewable energies has to be limited. Furthermore, it is proven that most renewable energies (like photovoltaics, wind energy and biomass) are ready for the market and that support costs are sinking when renewables have to participate in the free market.

[42] https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2017/15052017_PV.html

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

3.1 Context

Regions[43] and cities can be important drivers of low-carbon development. Successful steering of development is depending on locational factors, regional economic conditions and structural factors (e.g. in terms of renewable energy potential, human resources, institutional setting, governance structures, legal and economic national framework and development, demographic development, etc.).

A major challenge is to combine governmental activities at national and regional levels in a coherent way, e.g. relating to legislation and regulations, policies and incentives, funding opportunities etc. in order to spur low-carbon-oriented investments from both, private and public sectors. 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)*

At the same time, private actors can contribute to regional awareness and may lead – through a sharpened image of that region – to further investment from enterprises and households. Over time, this will even lead to changes in habits and preferences of people and businesses.

Various EU-wide initiatives try to activate the regions' potential to support low-carbon development by a variety of approaches, e.g.

- The *Committee of the Regions (CoR)* – The EU's Assembly of Regional and Local Representatives (www.cor.europa.eu*).*
- The *Europe 2020 Monitoring Platform* of CoR (https://portal.cor.europa.eu/europe2020/Surveys/Pages/A-Resource-Efficient-Europe.aspx).
- The *Covenant of Mayors (CoM)* (www.covenantofmayors.eu*);*

[43] 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.

- The sub-national Global Climate Leadership Memorandum of Understanding *"Under 2 MOU"* (http://under2mou.org/).

In addition, the potential for more ambitious low-carbon development in regions has been acknowledged broadly by a number of *research projects.* Thus, more detailed information on various aspects of implementation and development of low-carbon regions is also available from research and case studies elaborated in the course of such projects. In order to make use of this valuable source of information, we added a meta-analysis of selected, thematically focused case studies to complement the findings of the (own) case studies elaborated in this project (see below).

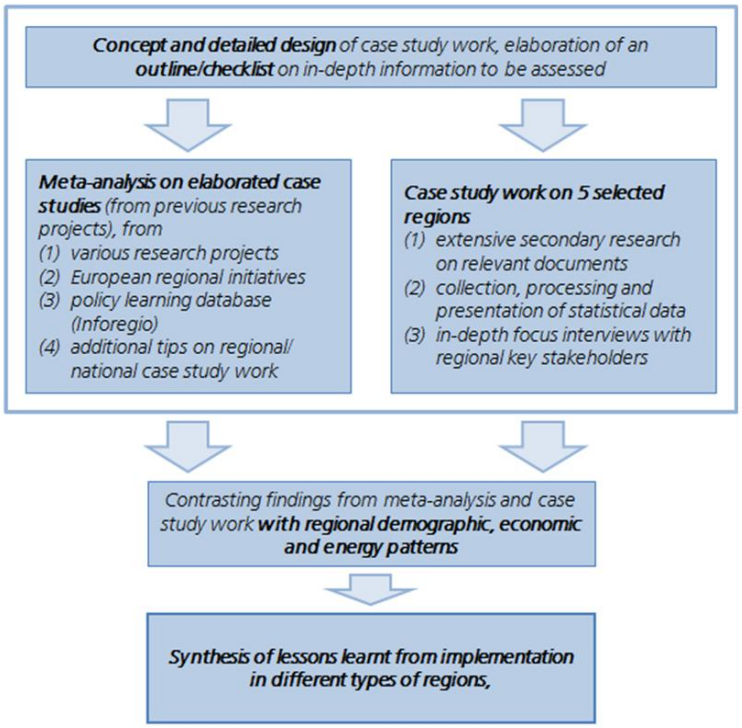
3.2 Specific approaches and methods

In order to provide a larger spectrum of case study information and considering the limited number of new case studies to be elaborated within the contract, the case study work is based on two tiers of analysis,

- case study work on five selected regions
- an additional analysis which is based on already published case study results of previous research projects (meta-analysis)

These two main sources of information will be evaluated in an integrated way, in order to make best use of available information.

Figure 3.1: Conceptual framework of task case study work



The case study work is also closely linked to the studies on policies and measures in terms of the identification of successful policy approaches and initiatives in the case study regions and to the studies concerning the relevance of cohesion policy in our regions which will be assessed in detail.

3.2.1 Meta-analysis on elaborated case studies

Even though the selection of case study regions comprises different regions in terms of location with Europe (North, South, East, Central Europe), spatial structures (urban, intermediate and rural regions), renewable potential, renewable energy and energy efficiency regimes, national/regional level laws and policies, cohesion policy regime, etc. it is clear that the five case study reports elaborated by the project team are not able to cover the diversity of European regions at all. Thus findings from other regional case studies were included to integrate as much knowledge from different European countries as possible:

The potential for more ambitious low-carbon development in regions has been acknowledged broadly by a number of research projects. More detailed information on various aspects of implementation and development of low-carbon regions is available from a considerable number of case study reports which have been elaborated in the recent past.

In order to make use of this valuable resource of additional information as a basis for lessons learned, we have screened available sources (initiatives, programmes, research projects, etc.) dealing with regional low carbon development in general or in terms of specific objectives and topics.

In the meta-analysis we defined finding extensive regional case study reports as overall aim. Accordingly, we identified reports which

- do not focus on a specific energy source or technology,
- do not only describe the situation concerning low carbon development in a region or define the vision and an action plan for a specific region,
- but also try to capture the regional situation in terms of low carbon development as exhaustive as possible,
- providing background information on the region including strategies and policies as well as conclusions and lessons learned and experiences from the actual regional implementation
- and thus, allowing for a good understanding why a specific development takes place in the region, who drives/who hinders the development and causes for that (also for experts from other regions), and
- therefore, finally also allow for exchanging and transferring experiences between regions and international experts.

Only such kind of case study reports were supposed to be used as an additional source of information, providing with essential knowledge and explaining the past development and current status in a way that it is possible to compare regions to each other.

Relevant case study sources from the screening of initiatives and programmes aiming at low carbon development

The research started with an in-depth desk research and screening of actual homepages and internet sources on programmes, initiatives and projects dealing with regional low carbon development and offering detailed information on selected regions by providing regional case studies.

The different relevant sources (from European to regional level) are related to stakeholders at different spatial and organisational levels who are actively working to combat climate change at a regional level. According to their homepages the following stakeholders were providing case study reports:

- EU and European Commission initiatives and programmes: EU Parliament ThinkTank, Europe2020 Monitoring Platform, ManageEnergy, IEE projects database, DG Regio Policy Learning Database, EEA database, Smart Cities Info
- Initiatives from various relevant stakeholders and NGOs: Covenant of Mayors (CoM) for Climate & Energy, FEDARENE, Climate Alliance, Under2MOU
- Homepages from research projects and project partnerships dealing with regional/local low carbon development: COOPENERGY, Region202020, 100% RES Communities, go100percent, smilegov, GREECO, ESPON CLIMATE, ESPON 2.1.4., ESPON Energy ReRisk, SPECIAL, Co-Power, EnercitEE
- KEEP database, for identifying relevant projects from Interreg, Interreg IPA cross-border and ENPI/ENI cross-border cooperation programmes (www.keep.eu).

The outcome of the analysis of various sources and existing studies from initiatives and research projects showed that there are rarely regional case study reports offering overall, extensive information on the topic of low carbon development. Most of the case study reports focus on a specific topic or only present summaries or short brochures (1-2 pages) of their case studies.

Nevertheless, the desk research tracked down five sources of comparably comprehensive information on low carbon development for specific regions:

- ESPON GREECO, Territorial Potentials for a Greener Economy, presenting case study reports for nine European regions;
- CEP-REC Regional Energy Concepts, Regional Energy Concepts (REC) financed by the European Programme for Territorial Cooperation “Central Europe 2007-2013”, providing comprehensive information and comparative conclusions for pilot regions in the eight countries (http://www.cep-rec.eu/);
- EU2020goingLOCAL (http://www.eu2020goinglocal.eu), a capitalization project co-funded by INTERREG IVC Programme and a partnership composed of 14 partners from 9 countries;
- MANERGY (http://www.manergyproject.eu/), a transnational initiative financed by the European Programme for Territorial Cooperation “Central Europe 2007-2013”, aiming at promoting innovative and sustainable approaches to environment friendly energy source management;
- Regions4GreenGrowth (http://www.regions4greengrowth.eu), co-financed by the ERDF in the framework of INTERREG IVC, is striving at equipping partner regions with regional policy instruments, mechanisms and approaches to improve access to finance for and

speed up investments in sustainable energy projects (e.g. renewable energy generation capacity, energy efficiency measures) in their territories;

The search for *case study reports* providing detailed information on specific regions has generated an information resource of more than 40 relevant regional reports.

The following table presents those extensive regional case study reports which are up-to-date and seemed promising in terms of topic and depth of information and were therefore examined and used as source of information in the meta-analysis:

Table 3.1: Regional case study reports as a source for the meta-analysis

Project	Title/case studies for
ESPON GREECO Territorial Potentials for a Greener Economy, 2014	Zealand (Sjælland, Denmark), Southern Estonia (Lõuna-Eesti, Estonia), Ruhr Area (Germany), Southern Transdanubia (Dél-Dunántúl, Hungary), Apulia (Puglia, Italy), Malta (Malta), Navarre (Navarra, Spain), Jämtland (Sweden), Cornwall (UK)
CEP-REC in up to 8 sub-reports/deliveries per region [44], 2014	Allgäu (Germany), Borsod-Abauj-Zemplen County (Hungary), Mazovia Region (Poland), Provincia di Torino (Italy), Regione Friuli Venezia Giulia (Italy), Savinjska Region (Slovenia), Südburgenland (Austria), Trnava Self-Governing Region (Slovakia), Zlin Region (Czech Republic)
EU2020 going LOCAL, 2012	Sörmland Regional Council (Sweden), Örebro Development Council (Sweden), Regional Development Agency of the Ljubljana Urban region (Slovenia), Riga Planning Region (Latvia), Zemgale Planning Region (Latvia), South region of Luxembourg (Luxembourg), Region of Achterhoek (Netherlands), Local Government Yorkshire and Humber, United Kingdom
MANERGY, 2012	Treviso (Italy), Muldenland (Germany), Savinska (Slovenia), Oberlausitz-Niederschlesien (Germany)
Regions4 GreenGrowth in 2-3 sub-reports/deliveries per region [45] 2012/2013	Abruzzen (Italy), Valencia (Spain), Västernorrland (Sweden), Noord Brabant (Netherlands), Eszak-Alföld (Hungary), West Greece (Greece), Maramures (Romania), Prahova (Romania), Lazio (Italy), Sofia (Bulgaria), Norbotten (Sweden), Flevoland (Netherlands), Greater Manchester (UK)

Source: ÖIR 2016.

For gaining an even broader geographical coverage of findings, in addition, 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. 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[46].

[44] Sub-reports on: energy supply map, regional energy demand report, energy transfer potential assessment, how-to templates and guides, regional energy balance Sheets, development path of the Region, regional energy strategies, more information about the concept region

[45] Sub-reports on: peer review, action plan, implementation plan

[46] The collected portfolio of available up to date European/international research projects providing with experiences from regional low carbon development does not cover experiences from Finland, Lithuania, Iceland and Liechtenstein.

Table 3.2: Research projects on regional low carbon development (not providing comprehensive regional case study reports) as an additional source for the meta-analysis

Research project (project end), internet link	Regions involved/Project partners from
LoCaRe – Low Carbon Economy Regions (2013), http://www.locareproject.eu	Region Syddanmark (Denmark), Region Västra Götaland (Sweden), Principado de Asturias (Spain), Regione Emilia-Romagna (Italy), Gorenjska (Slovenia) and Province of Zeeland (Netherlands)
ENERGY REGION (2014), http://www.energy-region.eu	Lower Silesia (Poland), Southern Moravia and Region Opavsko (Czech Republic), Podrajve Region (Slovenia) and North Hesse (Germany)
ANSWER – A North Sea Way to Energy-Efficient Regions (2012), http://archive.northsearegion.eu/ivb/projects/details/&tid=73	Suffolk County, Ipswich Borough, Norfolk County, Suffolk (UK), West-Vlaanderen, Oost-Vlaanderen (Belgium), Bremen (Germany), Växjö (Sweden), Stavanger Kommune, Rogaland Fylkeskommune (Norway)
VISNOVA – Clean energy from rural regions (2014), http://visnova.energie-zentrum.com/	Dübener Heide and Schwäbisch-Hall (Germany), Tullnerfeld-West (Austria), Małopolska (Poland) South-Transdanubian Region (Hungary)
GreenPartnerships – Local Partnerships for Greener Cities and Regions (2015), http://www.greenpartnerships.eu/	Podravje (Slovenia), Lakatamia (Cyprus), Provence-Alpes-Côte d'Azur (France), Chania (Greece), Latium (Italy), North Alentejo (Portugal), Tirana (Albania), Koprivnica-Križevci Country (Croatia), Montenegro
North SeaSEP – North Sea Sustainable Energy Planning (2013), http://www.northseasep.eu/home/	Osterholz-Scharmbeck, Wilhelmshaven/Oldenburg/Elsfleth, Hannover, Worpswede, Hambergen, Ritterhude, Grasberg, Lilienthal (Germany), Aberdeen City, Dundee (UK), Leiedal, Harelbeke (Belgium), Provincie Drenthe, Tynaarlo Municipality, Hedensted Kommune (Netherlands), Växjö, Varberg (Sweden), Vejle Kommune, Fredericia Kommune, Kolding Kommune, Middelfart Kommune (Denmark)
recharge.green – Reconciling Renewable Energy Production and Nature in the Alps (2015), http://www.recharge-green.eu/	Austria, France, Germany, Italy, Slovenia, Switzerland
Coopenergy, http://www.coopenergy.eu/good-practice-resources	Best practice examples on: Developing sustainable energy plans: South-East Region (Ireland) Małopolska Voivodeship (Poland) Southeast Sweden, Rhine-Neckar Metropolitan Region (Germany) El Hierro Island (Spain), Autonomous Region of Madeira (Portugal), Zlín Region (Czech Republic), Styria (Austria), Region of Hohenlohe-Odenwald-Tauber (Germany), Saare County (Estonia) Engaging stakeholders: Hampshire County (UK), Liguria Region (Italy), Jönköping County (Sweden), Wallonia region (Belgium), Provence-Alpes-Côte-d'Azur region, (France)

Source: ÖIR 2016.

These reports have been analysed and interpreted concerning their findings for low carbon development in specific European regions which are relevant for the project at hand. The compilation of additional relevant results and lessons learned has been conducted by a structured desk research according to the general outline of research questions for case studies in this project.

Relevant contents of available case study reports

After the detailed analysis of available case study reports it became obvious, that the emphases of reports differ considerably. Even if the topic in general is similar, different priorities in terms of themes and in-depth elaboration were set. When considering the recommendations

and lessons learned the specific background and aim of each of these projects has to be kept in mind.

What is even more important is the fact that – deviating from the study at hand – available regional case study reports mostly put the focus on future chances of regions. Only few reports focus on the collection of data about the recent development and provide (written) explanations or interpretations of the past development within the region. The focus of the major share of reports by far lays on how to make use of future chances and/or describes different scenarios of possible future development including recommendations for their implementation. This narrows down the potential for deriving lessons learned to some extent. Nevertheless, a number of reports also provide very valuable information on experiences from the past.

The findings from the detailed screening clearly show these differences in contents and priorities between different the research projects according to their research questions and the needs of involved regional stakeholders.

The following table presents an overview on these findings. It depicts the share of available regional case study reports providing relevant information[47] concerning important aspects of regional low carbon development and its background compared to the given content for the five case studies elaborated during the ESPON project at hand. Roughly, it can be stated that:

- About half of the reports (52%) provide a general description of the region as background information, mainly concerning location, socio-demographic and regional economic structure and development.
- Information on energy strategy, energy consumption and renewable energy is the central issue in most of the reports (according to our selection criteria), with overall about 60%, up to 100% for key questions as e.g. energy consumption and renewable energy.
- Governance structures and regional policy portfolios are less elaborated, about 40% of all reports provide information on these issues, but at least more than two thirds contain information about the regional governance system itself.
- Interrelation of regional, national and EU policy has been a topic in about a third of the reports, most elaborated in the course of the projects Regions for Green Growth and CEP-REC.
- The role of cohesion policy for regional low carbon development is being discussed in about 23% of the reports, but has been an issue mainly in the project Regions for Green Growth, whereas other research projects did not put emphasis on this aspect.
- Good practices have not been a major issue of these projects at all, only 5% of all reports contain examples for successful implementation of specific activities within their regions.

[47] Information has been classified as “relevant” in case of: reports present detailed information on the respective aspect or reports present at least most important aspects and basic information on the respective aspect. Accordingly, information has been classified as “not relevant” if aspects are only mentioned or if they are not presented at all.

Table 3.3: Meta-analysis: Overview on the share of available regional case study reports providing comparable information

% of reports providing with relevant information:	CEP-REC	EU2020 gLOCAL	MAN-ERGY	R4GG	ESPON GREECO	All reports
General description of the region	**80**	**23**	**55**	**48**	**67**	**52**
Location of region and characteristic	100	63	100	92	89	78
Socio-demographic structure/development	100	13	50	62	78	63
Settlement type and building stock	22	13	75	0	0	14
Transport system and modal split	78	25	0	15	67	40
Regional economic structure/development	100	0	50	69	100	67
Energy strategy, energy consumption and RES	**80**	**48**	**85**	**49**	**56**	**60**
Energy strategy of the region	33	88	50	69	11	51
Regional and local energy infrastructure	89	13	75	54	56	56
Patterns of energy consumption	100	25	100	62	67	67
Regional potential of renewable energy	89	75	100	31	89	70
Use of renewable energy in the region	89	38	100	31	56	56
Governance and regional policies	**33**	**38**	**31**	**50**	**39**	**40**
Regional governance system	67	50	75	62	89	67
Involvement of private sector partners	11	75	0	62	11	37
Regional policies	44	25	25	69	56	49
Membership in low-carbon programmes/initiatives	11	0	25	8	0	7
National and EU policy, complementarity	**44**	**25**	**13**	**46**	**17**	**33**
National policies, inter-relation regional policy	44	50	25	69	11	44
Complementarity regional, national and EU	44	0	0	23	22	21
The role of cohesion policy for regional dev.	**11**	**13**	**0**	**46**	**22**	**23**
Good practices and successful approaches	**0**	**0**	**0**	**15**	**0**	**5**

Source: ÖIR 2016.

Relevant information has been collected from the meta analysis and accompanies the findings from our own comprehensive case study work.

3.2.2 Case studies on selected European regions

In the kick-off meeting, ESPON EGTC and the consortium agreed on the selection of five regions from Austria, Bulgaria, Denmark, Spain and United Kingdom. This selection covers a

diverse spectrum of urban and rural regions, larger cities with their hinterland and small to medium sized city networks as well as service-oriented and post-industrial regions.

In detail, the selection comprises:

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

Following the agreement at the kick-off meeting on the selection of case studies, national experts have been contacted in order to act as local authors for these studies.

Table 3.4: Case study authors – subcontractors

Region/institution	**National key experts**
Greater Copenhagen (Denmark) Systems Analysis Division, DTU Management Engineering Technical University of Denmark, www.dtu.dk	Per Sieverts Nielsen, Angreine Kewo
Burgos (Spain) Agencia provincial de la energia de burgos (agenbur) http://www.agenbur.com	Cristina López Ubierna
Pazardzhik (Bulgaria) Regional Energy Agency of Pazardjik (REAP) www.reap-bg.eu	Georgi Simeonov, Albena Nenová

Source: Consortium 2016

Regional case study reports on the Austrian region (Rheintal) and the UK region (Greater Manchester) have been covered by the respecting teams of project partners ÖIR (Rheintal, Austria) and University of Newcastle (Greater Manchester, UK).

Design of regional case study work

In order to provide relevant findings, a draft of the template as a general guideline has been elaborated to be used as a research framework for the assessment of regional development and relevant strategies applied in the case study regions.

The case studies on selected regions cover available in-depth information, structured in the same way by providing a template according to following content:

(1) General description of the region as a basis to get an idea about the most important regional characteristics, its socio-demographic and economic development and the regional built structures. This information serves as a background for the comparison between the regions in terms of findings and recommendations.

(2) Energy strategy, energy consumption and regional renewable energies. This chapter highlights the specific situation of the region in terms of energy consumption and renewable energies, describes actual plans and strategies for further development and presents information on energy and data for the region in detail. It presents most important issues for the region and describes the development of the past 10 years of regional energy use and energy production.

(3) Governance and important regional policies provides information on the local and regional actors and stakeholders, including formal associations and decision makers as well as informal cooperations. Furthermore relevant regional policies are highlighted and the role of the regions membership in initiatives or climate programmes for the regional development is described.

(4) National and European policy background, complementarity presents the relevant national and EU legislation and policies as a framework for regional development and regional policies. This information is necessary in order to be able to understand how regional policies fit into larger regional (e.g. provincial) or national strategies and programmes and how they (do – or do not) support each other.

(5) The role of cohesion policy for regional low carbon development complementarity deals with the importance of cohesion policy for the respective region. Furthermore, implementation practice and experiences is provided in order to give input for recommendations concerning future cohesion policy support.

(6) Good practices and successful approaches provide (also additional) examples of measures or regional initiatives for implementation of low carbon development in more detail. These examples present various aspects of energy efficiency or renewable energy provision at a regional scale, but also regional policies and strategies or the successful involvement of private sector partners.

These contents – provided by the case study authors – also formed the basis of the content-wise checklist for the meta-analysis of existing case study reports.

Approach for gaining information

In order to gain as much knowledge on the case study regions as possible, the authors of the case study regions made use of all available sources of information:

- extensive secondary research (desk research) on available literature and documents dealing with relevant aspects of low carbon development in the respective region or parts/cities within the region
- collection, processing and presentation of available statistical data, describing the recent economic and demographic development, energy consumption and renewable energy potential as well as its exploitation (past 10 years)
- conducting in-depth interviews with regional key stakeholders (responsible institutions for cooperation, municipal/cities' representatives, economic stakeholders, representatives of energy agencies, NGOs and private sector

The template served as a guideline for case study authors for all case study reports. This document helped to structure desk research, collection of statistical data and interviews in all case study regions and ensured comparable background information, results and lessons learned from the case study reports.

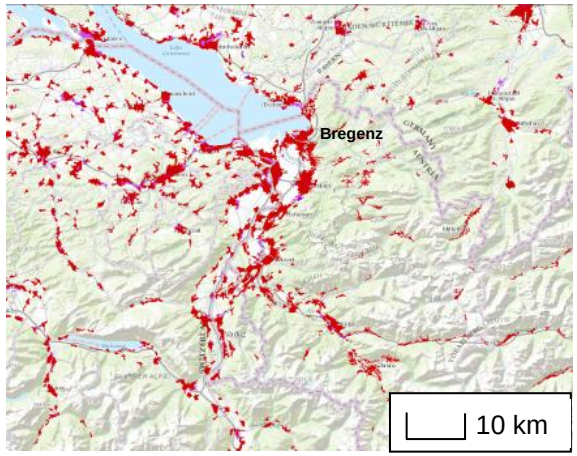
3.3 Fact sheets on case study regions

The following fact sheets provide an overview on selected key information and indicators and a short description about the specific situation in the respective region.

For detailed information about the five regions please have a look into the annex with all case study reports attached.

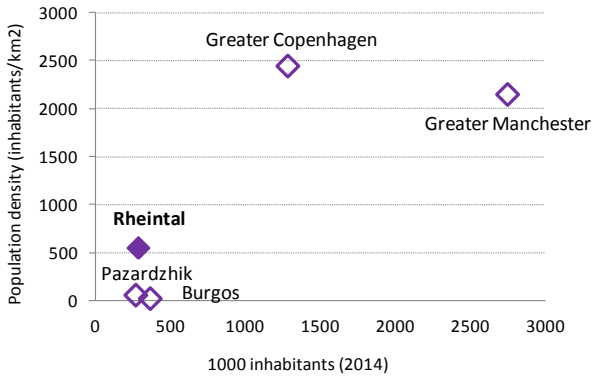
3.3.1 City region Rheintal, Austria

Settlement structure (Corine Land Cover)



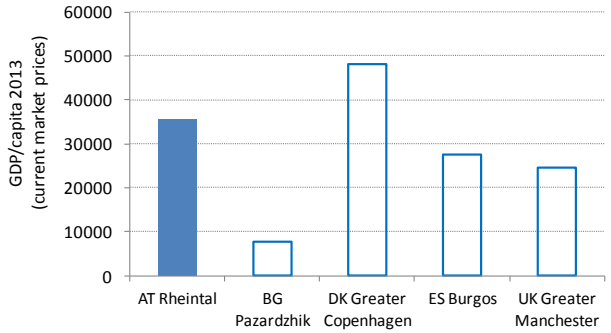
Source: EEA, 2016

Inhabitants and population density (2014)



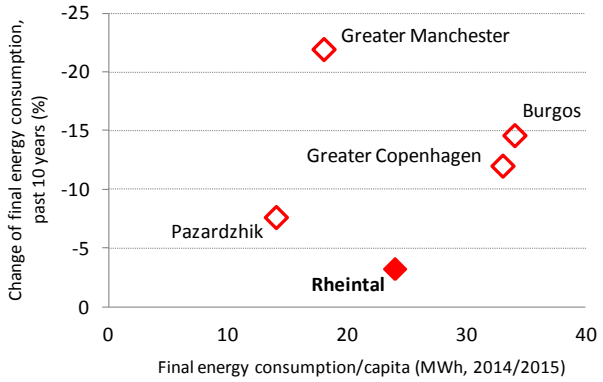
Source: Eurostat/case study reports

Regional GDP/capita (current market prices 2013)



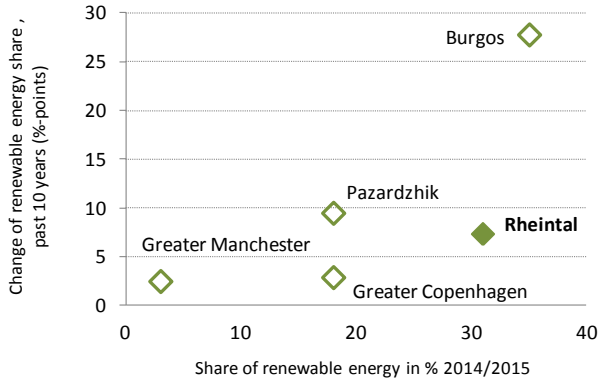
Source: Eurostat

Final energy consumption per capita today and change in the past 10 years



Source: Case study reports

Share of renewable energy today and change in the past 10 years



Source: Case study reports

View towards lake Constanz, Rhine valley

Source: pixabay

Short description of the city region Rheintal

Rheintal is a polycentric urban region of small and medium sized cities. Its polycentric conurbation space is characterized by an almost closed settlement, of 29 municipalities with about 240,000 inhabitants and 12,000 enterprises. In the last decades, the region has developed dynamically with further population growth forecasted.

With a medium population density, its urban structure and a prosperous economy with a relatively high per capita GDP, the region is a stable and productive economic region, which has not changed since the millennium with an very strong economic performance. In addition, the region has a lot of assets referring to energy efficient use of energy and renewable energy. Despite a considerable share of industry in the region, it shows a medium energy consumption per capita. Nevertheless, in the recent years energy efficiency measures have had only limited success in terms of the further decrease of energy consumption. In terms of renewable energy, the regions shows a high share of renewables, especially for an urban region, which has even been increased since 2005.

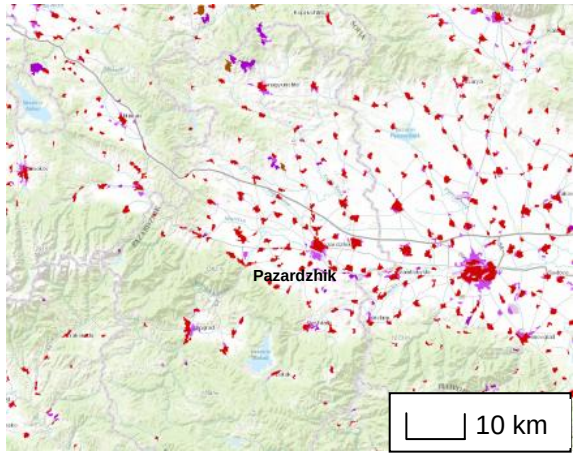
Due to this situation, the region is a model for sustainable regional development in Austria, in terms of low carbon development. There are several smart city pilot projects located in the region and a number of cities and municipalities have been already audited “gold” by European Energy Award. In addition, the energy agency of the province of Vorarlberg is actively engaged in supporting post fossil development in the region. The most important initiatives to be named are the “Energy autonomy Vorarlberg” (top down) with the strategic goal of the “energy future Vorarlberg” 2050 (2009) and the lively regional communal cooperation as well as ambitious implementation at the level of municipalities (bottom up). Before the provincial strategy, in 2003, the 29 municipalities of the region started a formal cooperation (Vision Rheintal, www.vision-rheintal.at). Since then, the region constantly advanced its development and engaged in varying themes as e.g. high quality development of inner-city locations, sustainable quarters, settlements and mobility, regional industrial sites.

A recent project on the Smart City Region Rheintal builds on innovative pilot projects in the fields of renewable energy and energy efficiency, innovative building techniques, sustainable urban and regional development, future-oriented multi-modal mobility as well as research and education. Further successful projects have been dealing with e-mobility and citizens’ energy cooperatives.

According to the prosperous development of the region it is eligible as a “more developed region” by the according actual cohesion policy regime -in the period of 2007-2013 it has been classified as “Competitiveness and Employment Region”.

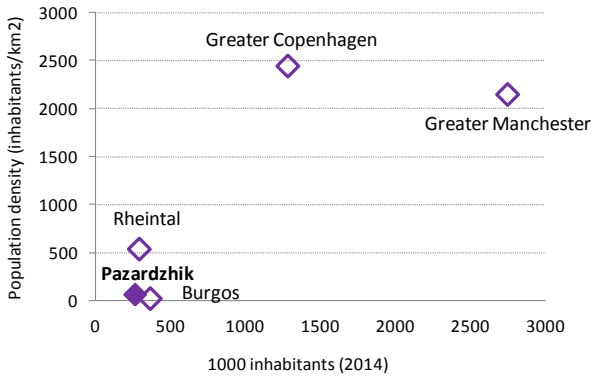
3.3.2 Province of Pazardzhik, Bulgaria

Settlement structure (Corine Land Cover)



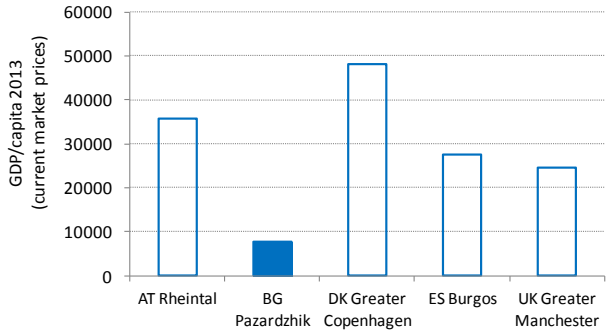
Source: EEA, 2016

Inhabitants and population density (2014)



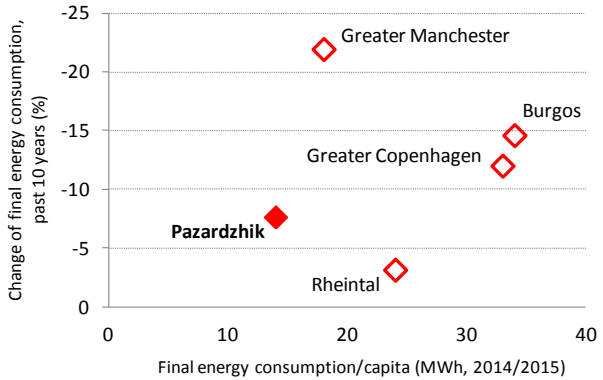
Source: Eurostat/case study reports

Regional GDP/capita (current market prices 2013)



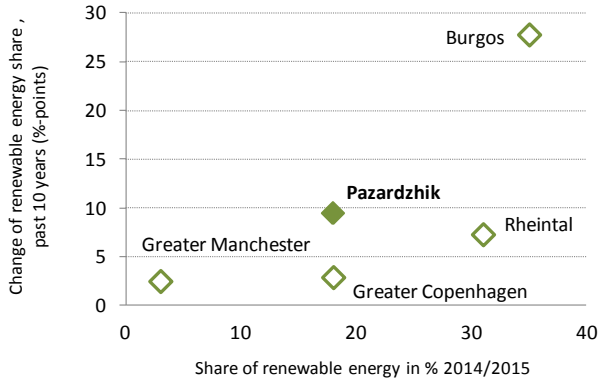
Source: Eurostat

Final energy consumption per capita today and change in the past 10 years



Source: Case study reports

Share of renewable energy today and change in the past 10 years



Source: Case study reports

Aerial photo of Pazardzhik

Source: Google Maps (c)2017 CNES/Airbus, DigitalGlobe

Short description of the province of Pazardzhik

The rural region of Pazardzhik locates in the southern area of Central Bulgaria. The region has about 266,000 inhabitants but has faced a serious population decline since 2001 (ca. -16%). Due to large agricultural-, forestry- and mountainous areas, overall population density is very low.

Despite decreasing population, the industrially characterised rural region shows an increase of GDP in the early 2000s but tended to stagnate and decrease during and after the economic crisis. Compared with other case study regions, GDP/capita is very low. Whereas energy consumption is low and the decrease of energy consumption is presumably at least partly influenced by the economic crisis, the share of renewable energy production ranges average compared with the other case study regions and has been increased considerably between 2004 and 2014. Of specific regional priority is the biomass use for energy purposes, defined by the large agricultural and forestry potential in the Pazardzhik region. Biomass and pellet production is a steadily growing sector of major importance for the region.

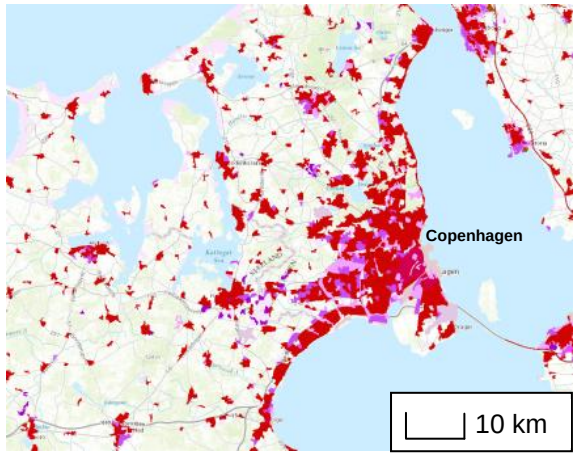
The Regional Governor is responsible to represent the national government at local level and to perform local governance within the region in order to ensure compliance between national and local interests. He has to organize an assembly of the Regional Committee on Sustainable Energy Development twice a year, which defines and outlines key issues and energy policy development at regional and local level, laid down in the Pazardzhik Regional Energy Strategy.

The Regional Energy Agency of Pazardzhik (REAP) has been legally established in June 2005 as a non-profit association according to Intelligent Energy – Europe (IEE) guidelines (www.reap-bg.eu/index.html). The main purpose of the agency is to encourage the development of sustainable energy through local and regional actions for energy efficiency and renewable energy sources. Organized as an association of municipalities from Pazardzhik district together with private organisations and stakeholders operating in the field of energy efficiency and renewable energy sources, the agency supports local authorities in achieving their objectives and strategic planning for renewable energies, as well as develops of a range of initiatives with other local, regional and foreign organisations. Successful approaches have been e.g. the energy help desk for the region of Pazardzhik, energy related consumer purchasing groups, smart metering in public buildings and research on the innovative use of low-temperature geothermal resources.

The region of Pazardzhik is classified as a “Convergence Region” for the period between 2007 and 2013 and still defined as “less developed region” in the actual period of regional EU policies (2014-2020).

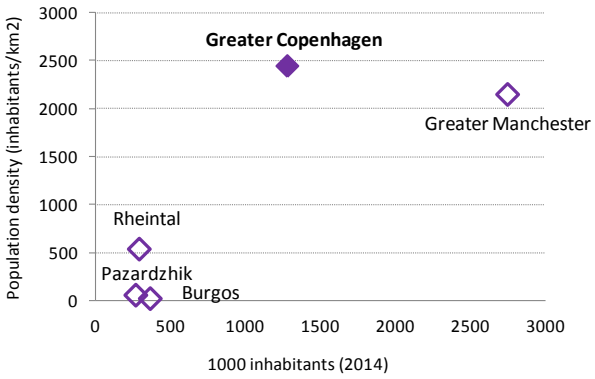
3.3.3 Greater Copenhagen, Denmark

Settlement structure (Corine Land Cover)



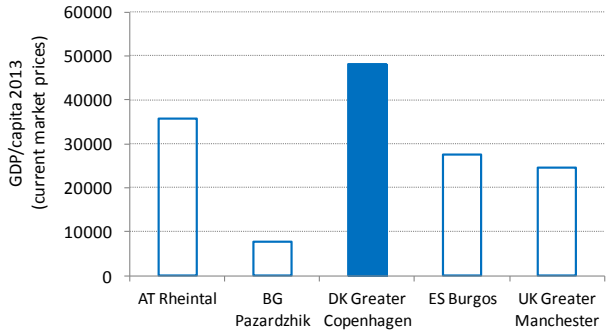
Source: EEA, 2016

Inhabitants and population density (2014)



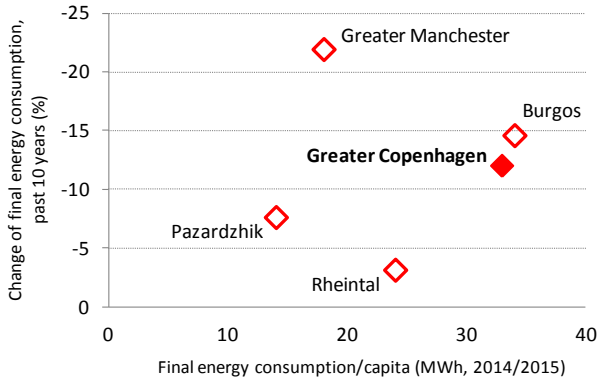
Source: Eurostat/case study reports

Regional GDP/capita (current market prices 2013)



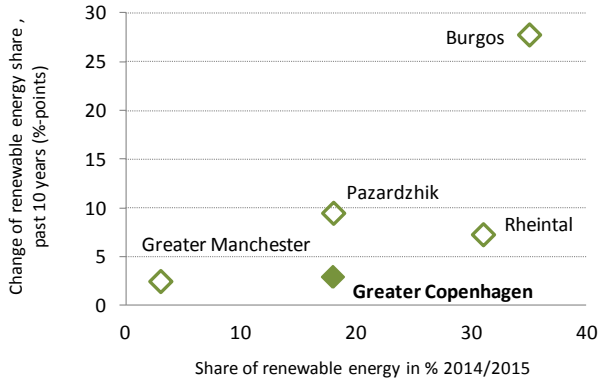
Source: Eurostat

Final energy consumption per capita today and change in the past 10 years



Source: Case study reports

Share of renewable energy today and change in the past 10 years



Source: Case study reports

City of Copenhagen

Source: pixabay

Short description of Greater Copenhagen, Denmark

Greater Copenhagen is the urban metropolitan region of Denmark with about 1.28 million inhabitants living in 17 municipalities. The larger, capital region (Hovestaden) covers Greater Copenhagen, Nordsjaelland and Bornholm with 1.7 inhabitants in total. The economically viable urban region with the highest population density in the sample of regional case studies is constantly growing and clearly shows the highest economic performance (GDP/capita).

Although the region has successfully brought down energy consumption considerably, final energy consumption per capita still is comparably high with transport being a major issue in the region for both, energy consumption and CO_2 emissions from fossil fuels. As an urban region, Greater Copenhagen has already achieved a very high share of renewable energy, supported by an outstanding connection rate of the large regional district heating network (due to the general obligation to connect buildings since the 1980s, e.g. Copenhagen >98%) mainly used in combined heat and power plants fired by waste and (partly imported) biomass.

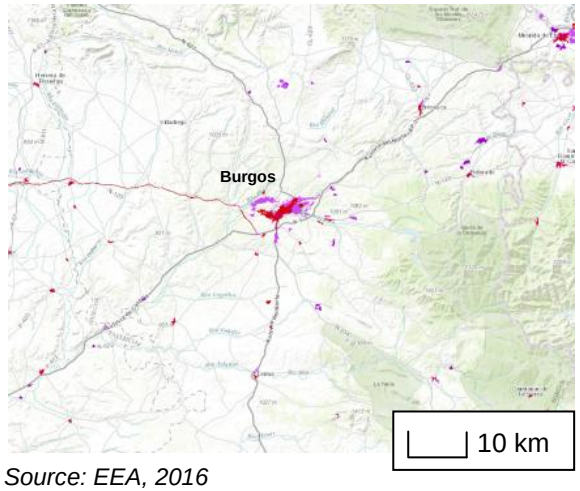
The City of Copenhagen prepared an ambitious plan to become the world's first carbon neutral capital by 2025. Further municipalities followed this ambitious transition path. Green growth forms a key issue of the climate strategy for the entire region which formulates as common climate vision: "By 2025, the capital region will be the most climate-ready and energy-efficient region in Denmark based on strong regional and cross-municipality collaboration, where innovative public–private partnerships contribute to green growth of first-rate international calibre." (Climate strategy for the capital region, 2012). The climate strategy for the capital region follows five strands to achieve this vision: a climate-ready region, climate friendly transport, conversion to a fossil-free energy system, energy-efficient buildings and climate friendly consumption and procurement. Meanwhile green growth initiatives have established more than 90 new green thematic partnerships and beyond 250 events, conferences and activities, successfully boosting green start-ups and green growth in the region.

The Capital Region of Greater Copenhagen has an elected Regional Council, responsible for regional development planning and setting the framework for development planning in the municipalities. The development planning, including the strategic energy planning, is supervised by a standing committee for the Environment and Green Growth with the responsibility to plan for and follow up on the region's environmental and climate efforts. Further stakeholders are involved in the strategic energy planning (municipalities, energy supply utilities, public transport companies, universities and private consulting companies).

As a capital region in western Europe, Greater Copenhagen is depicting a more developed region in terms of the recent EU regional policy. Also in the previous period 2007-2013 it was classified as "Competitiveness and Employment Region".

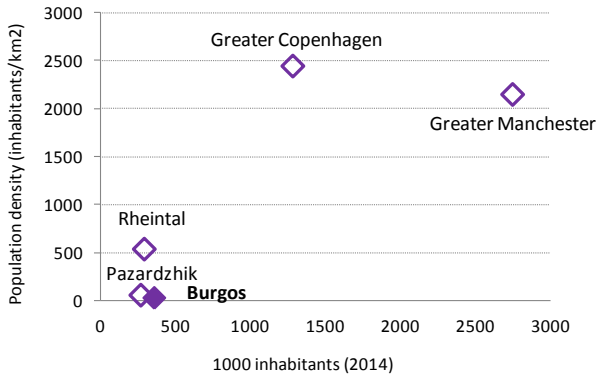
3.3.4 Province of Burgos, Spain

Settlement structure (Corine Land Cover)



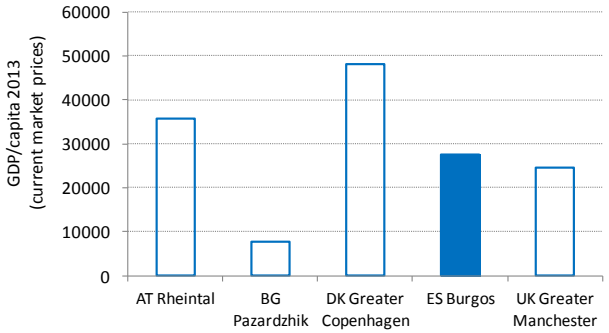
Source: EEA, 2016

Inhabitants and population density (2014)



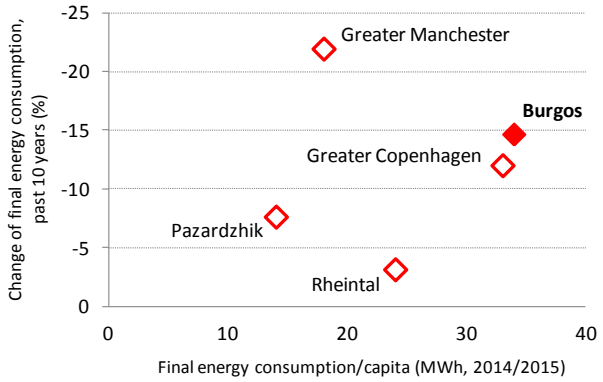
Source: Eurostat/case study reports

Regional GDP/capita (current market prices 2013)



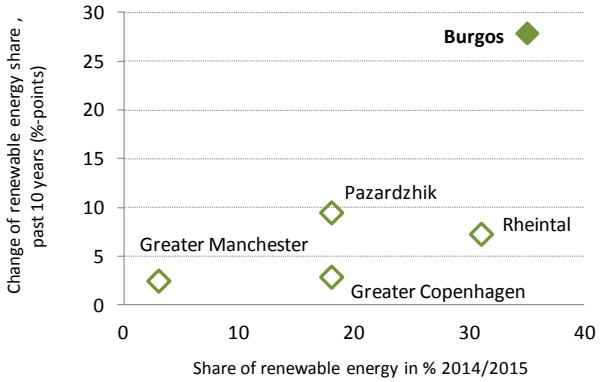
Source: Eurostat

Final energy consumption per capita today and change in the past 10 years



Source: Case study reports

Share of renewable energy today and change in the past 10 years



Source: Case study reports

View from Burgos Castle over the region

Source: pixabay

Description of the province of Burgos, Spain

The province of Burgos is a large rural area in the North-West of Spain with very low total population, a large number of villages and small towns and few small to medium sized cities. Accordingly, it shows a very low population density within the region, since 2012 the region faces constant population losses (minus 3% between 2012 and 2015). Nevertheless, the provincial region with a large share of the industrial sector (33% of GVA) shows a GDP/capita at medium level and only slight decrease of the total GDP since 2008.

As to be seen in the comparison of regions, Burgos shows a considerable energy consumption which was the reason for the provincial Government to found the provincial energy agency (AGENBUR) as an additional institution in order to promote renewable energies and energy efficiency in the province of Burgos. Since 2004, energy consumption has decreased in the region considerably.

Within the larger region of Castilla y León, the province of Burgos is one of the most successful provinces in terms of renewable energy production. Burgos is the largest producer of renewable power and heat within Castilla y León, with the highest shares of wind power and biomass within the region. In 2013, more than 30% of renewable energy within the region (of 9 provinces in total) has been produced in Burgos. It also shows the highest shares of renewable energy and the highest increase in the past 10 years within the sample. These high shares of renewable energy stem from wind power projects (mainly driven by investors) and the use of biomass.

Successful initiatives and projects, supported by AGENBUR, mainly focus on the regional value chain of biomass, matching regional economic actors and supporting municipalities This includes e.g. a biomass atlas[48], the atlas on small to large scale renewable energy plants[49] and a platform for companies working in the field of renewable energy and energy efficiency as well as information on available funds and subsidies at local, national and EU level.

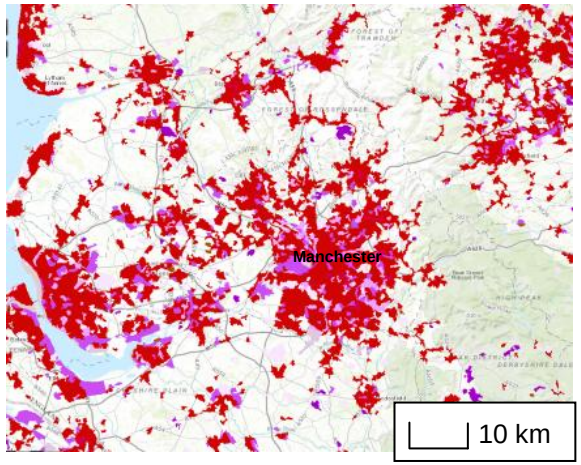
Burgos – as the entire region of Castilla y León – has been classified as a Phasing-in Region in the period of 2007-2013. In the actual period 2014-2020 it is considered as more developed region.

[48] http://sync.cesefor.com/agenbur/flash/export.php?rid=1

[49] http://www.observatorioenergiasrenovables.com/

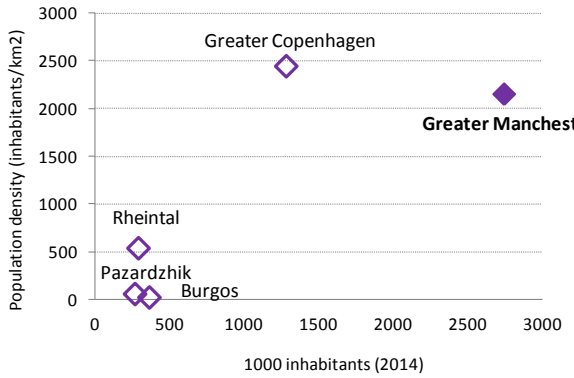
3.3.5 Greater Manchester, United Kingdom

Settlement structure (Corine Land Cover)



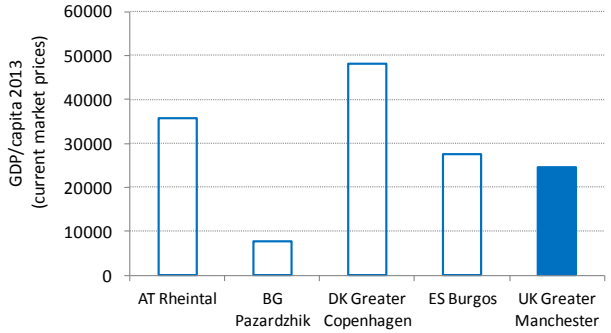
Source: EEA, 2016

Inhabitants and population density (2014)



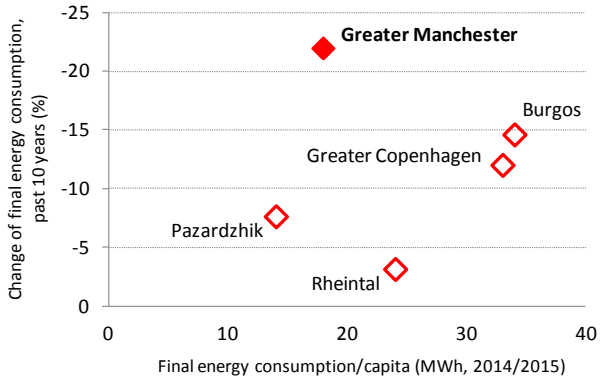
Source: Eurostat/case study reports

Regional GDP/capita (current market prices 2013)



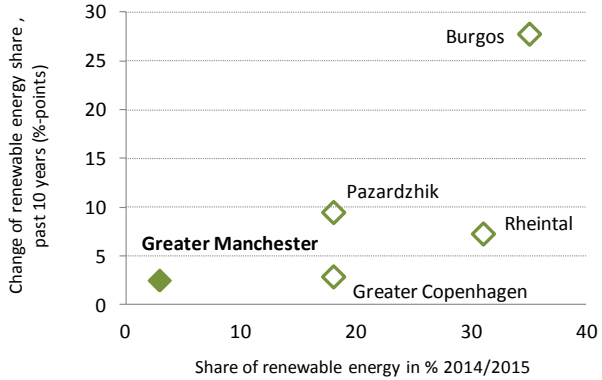
Source: Eurostat

Final energy consumption per capita today and change in the past 10 years



Source: Case study reports

Share of renewable energy today and change in the past 10 years



Source: Case study reports

View over Manchester

Source: pixabay

Description of Greater Manchester, United Kingdom

The urban, post industrial polycentric region of Greater Manchester comprises a number of about 2.7 million inhabitants living in ten metropolitan local authorities. Among others, due to a relatively high share of poorly educated population and the transition from an industrial-manufacturing towards a service –dominated city, Manchester faces a considerable productivity gap. Accordingly the share of poor people and energy poverty is higher than in many other regions within the UK. In terms of GDP/capita, the comparison shows only a medium value, caused by serious geographical disparities within Greater Manchester. Despite the recent city-centre based growth, a clear north-south divide in terms of wealth and pockets of entrenched deprivation over the region have persisted.

In line with the transition towards a service-oriented city, the region shows the highest decrease of energy consumption within the sample of case study regions and a comparatively low energy consumption per capita today. In terms of renewable energy, the metropolitan area clearly lacks a large potential of renewable energy within the city-regions' borders. Nevertheless, available potentials have been put to use in the past years with further plans being elaborated.

The Greater Manchester Combined Authority (GMCA) is representing a single statutory authority for the city- region of Greater Manchester which started with voluntary collaboration of ten local authorities in 2008. The process of collaboration, which has culminated in the formation of GMCA, has enabled the parties to develop strategic capacities at the metropolitan scale. They have been able to attract new powers from the central government through the City Deal, and extend their collaboration with the private sector through Local Enterprise Partnerships. As a major objective Greater Manchester's City Deal has established a Low Carbon Hub, with a plan to reduce emissions by 48% by 2020 (http://gmlch.ontheplatform.org.uk/). The Low Carbon Hub Board meets quarterly, and establishes and supports public and private sector initiatives, groups and projects. Small teams within the delivery organisations support the work of the Low Carbon Hub. The Climate Plan shall contribute to the 48% carbon reduction target by 2020. In detail, it is planned to integrate a delivery of multiple carbon-reduction measures, combining the knowledge of universities with the innovation of businesses, under the governance of the Greater Manchester Combined Authority.

According to its economic strength and dynamic population growth, Greater Manchester region is classified as more developed region in terms of the recent EU regional policy, and has been defined as "Competitiveness and Employment Region" in the previous period 2007-2014.

3.4 Comparison of findings from case study regions of ESPON Locate

3.4.1 The case study regions in an overall comparison

The selected case study regions provide a sample of metropolitan urban to rural areas. Even though two of the regions – the metropolitan regions of Greater Copenhagen and Greater Manchester – cover NUTS 2 regions (with four respectively five NUTS 3 regions), the regions are comparable in terms of area and outreach of governance structures.

Population and settlement structures, economy and cohesion policy regime

The following table highlights selected descriptive indicators for the sample of case study regions.

Table 3.5: Regional case study regions, regional characteristics

Region	NUTS code	Type of region	population 2015	area (km^2)	cohesion policy regime 2007-2013	cohesion policy regime 2014-2020
Austria, Rheintal	NUTS 3 (AT342)	urban region	289,734	727	Competitiveness & Employment	more developed region
Bulgaria, Pazardjik	NUTS 3 (BG423)	rural region	266,549	4,332	Convergence	less developed region
Denmark, Greater Copenhagen	NUTS 3 (DK011, DK012) Larger Capital city region including: DK013, DK014	urban region	1,280,371 (1,768,125)	523 (2,559)	Competitiveness & Employment	more developed region
Spain, Burgos	NUTS 3 (ES412)	rural region	362,913	14,291	Phasing-in	more developed
UK, Greater Manchester	NUTS 2 (UKD33, UKD34, UKD35, UKD36, UKD37)	urban region	2,745,985	1,276	Competitiveness & Employment	more developed region

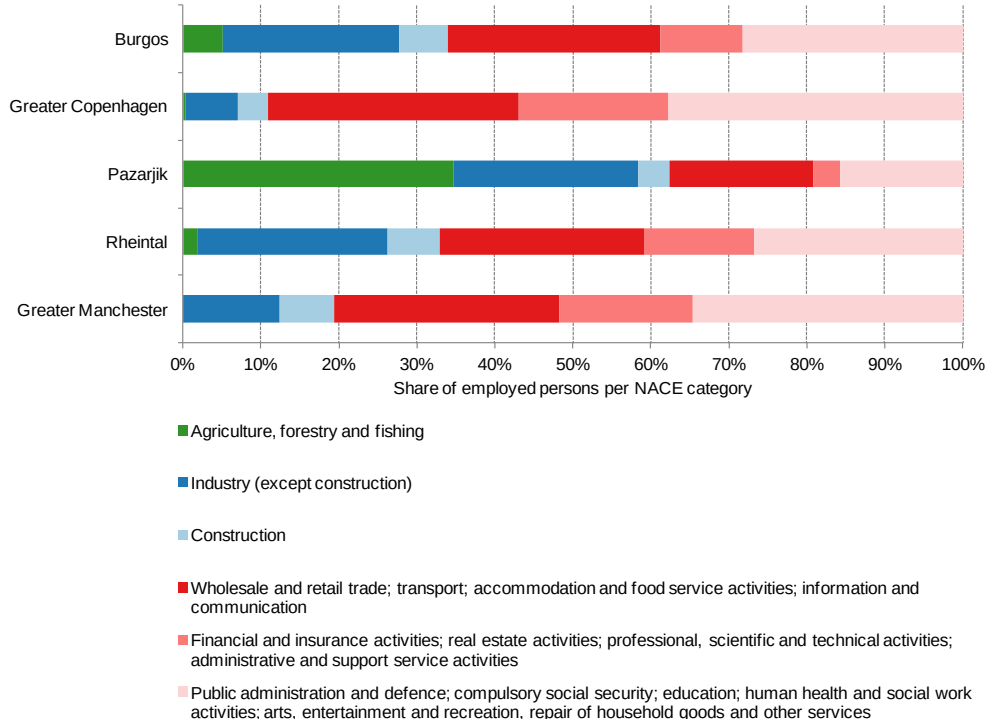
Source: Eurostat 2015.

The selection of case study regions has been based on the consideration of a number of different aspects. As presented by the following figure, in terms of economic profiles the selected regions provide a divers regional economic spectrum.

These extremely different situations in terms of regional characteristics and governance systems had to be considered carefully, when deriving conclusions and recommendations for regional low carbon development in general.

The specific type of the region is an important aspect for regional development, not only the question of urban versus rural areas, but also concerning the respective settlement structure within the region.

Figure 3.2: Share of employed persons per NACE category 2013



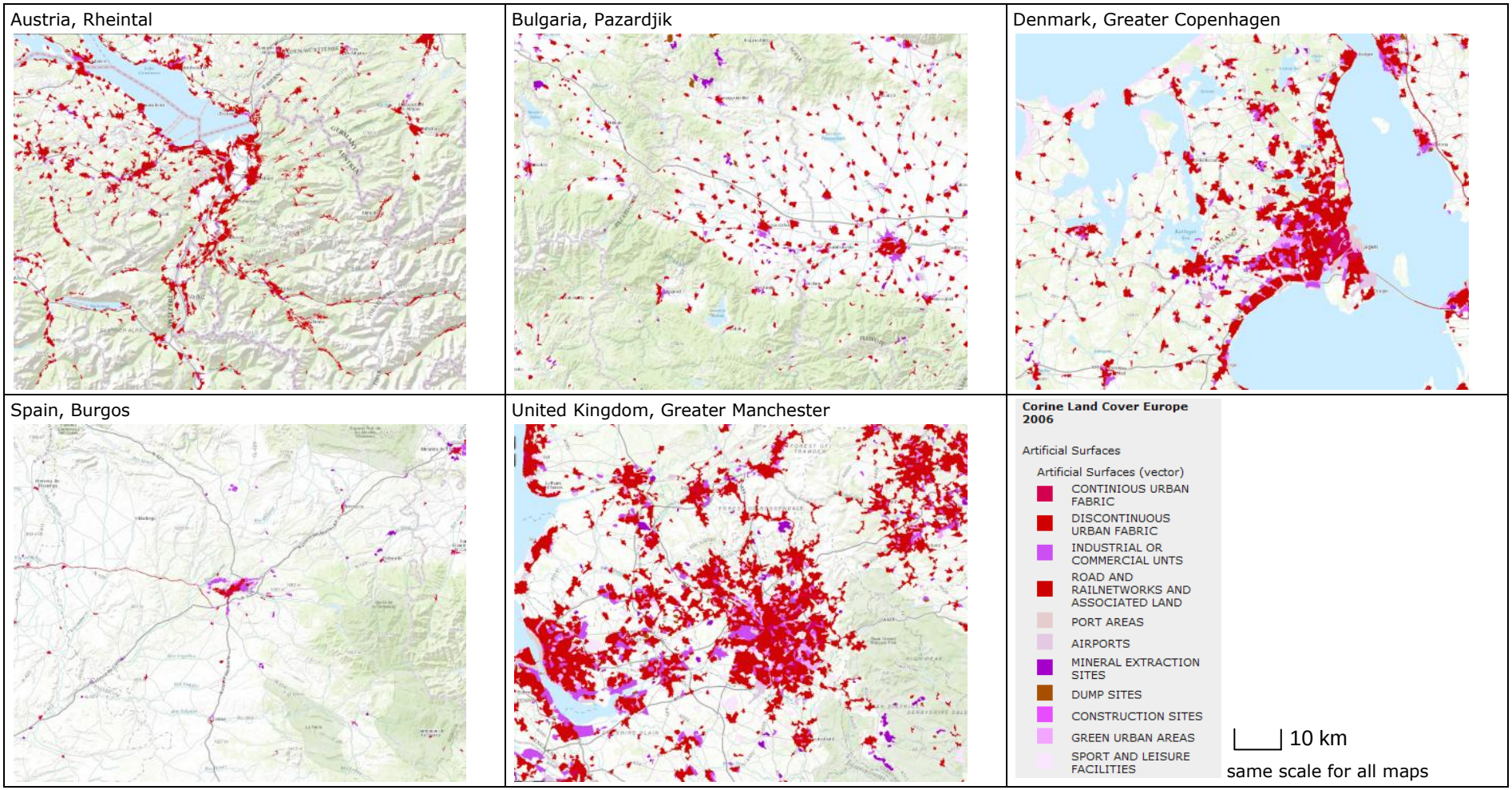
Source: Eurostat.

The following details from the Basicviewer of the European Environmental Agency on artificial surfaces (Corine Land Cover 2006) clearly show again the major differences which are even to be recognised between the two regions of rural type. Whereas Pazardzhik is a rural region with several small cities (Pazardzhik: 110,000 inhabitants, other municipalities 5-34,000 inhabitants), Burgos shows an extremely dispersed settlement structure with 1,273 villages/small cities in 371 municipalities in total, of which the major share is very small (Burgos: 177,000 inhabitants, Aranda de Duero: 33,000 inhabitants, Miranda de Ebro: 36,000, all other villages mostly far below 4,000 inhabitants).

In contrast to these two regions, Greater Manchester as urban region with a number of larger cities within the metropolitan area and Greater Copenhagen with its large densely built up area across many municipalities on one side and the polycentric region of Rheintal with small cities and rural hinterland on the other side show variations between urban regions.

These differences are decisive for the energy use of a region e.g. concerning energy use for transport (options for public transport versus private traffic) or energy infrastructure, heat densities and efficient use of district heating networks.

Figure 3.3: Type of regions and settlement structures in case study regions



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

Energy consumption and shares of renewable energy

As already presented in the factsheets above, energy consumption and the share of renewable energy sources (RES) differ considerably between the case study regions. The following comparison (Table 3.6) presents the major differences in terms of actual final energy consumption per capita, prevailing heating systems in the regions and the share of renewable energy used as well as the renewable energy sources used in the regions.

In terms of heating systems, it shows major differences even between similar types of regions as in the urban region of Greater Copenhagen district heating is prevailing, whereas Greater Manchester is highly dependent on natural gas and the Rheintal region shows a mix of different heating systems applied.

The same is true for renewable energy sources used for energy production. Even more, this pattern is influenced by the available renewable sources in the region (and their deployment).

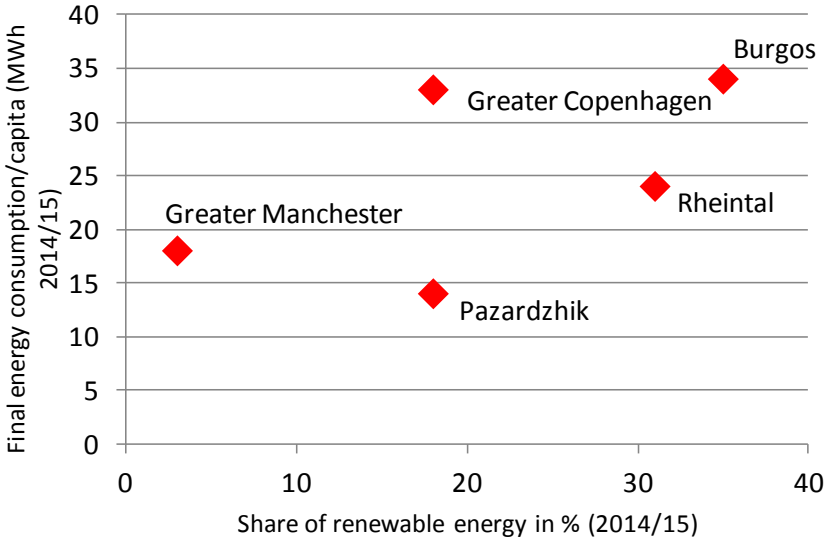
Table 3.6: Regional case study regions, energy use today (2014/2015)

Region	final energy consumption/capita	Prevailing heating systems	RES share (%)	Main RES sources in use
Austria, Rheintal	24 MWh Rheintal 29 MWh Vorarlberg	natural gas (35%), fossil fuel (27%), biomass (21%),district heating (9%), heat pump and solar (8%) Vorarlberg (NUTS 2)	31% Rheintal 40% Vorarlb.	hydro power (60%), wood/ biomass (19%), biofuels 7%, renewable district heat (7%) Vorarlberg (NUTS 2)
Bulgaria, Pazardjik	14 MWh	electricity (towns), firewood, coal (villages)	18.5%	hydro power (49%), biomass and waste (34%), solar (9%), geothermal energy (8%)
Denmark, Greater Copenhagen	33 MWh	district heating (obligated connection 1982, electric heating ban 1988)	17.5%	waste (69%), wood/ biomass (17%), wind (7%)
Spain, Burgos	34 MWh	fuel (44%), piped natural gas (37%), propane (14%), butane (4%)	35%	wind energy (>90%)
UK, Greater Manchester	18 MWh	natural gas (96%)	2,9%	electricity generation: landfill, sewage and anaerobic digestion (74%)

Source: Case study reports.

The following figure (Figure 3.4) presents the actual situation in the sample of analysed Locate-regions. Manchester shows a considerable low energy consumption per capita, but also a low share of renewable energy, whereas two further regions achieved higher shares of renewable energy, namely Greater Copenhagen (combined with a high level energy consumption) and Pazardzhik (related to a considerably lower overall energy consumption). Nevertheless, referring to the high share of renewable energy in the urban region of Copenhagen, together with the consequent use of waste as a heat-source for the large metropolitan district heating system, a relatively large contribution of biomass from outside the region has to be considered. The highest shares of renewable energy have been achieved in Burgos (mainly by new wind plants) and Rheintal (with a long tradition of hydropower in the region).

Figure 3.4: Comparison of case study regions in terms of energy consumption and renewable energy production today (2014/2015)



Source: Case study reports.

Exploring the regions' path referring to their transition towards low carbon economy in the past 10 years, the comparison (refer to Table 3.7) shows that especially Greater Manchester, followed by Burgos and Greater Copenhagen have been successful in decreasing the energy consumption side (even though varying shares of this success have to be credited to the recent regional economic changes). In contrast, Rheintal and Pazardzhik – from different levels in the year 2004 – have been more successful in terms of increasing renewable energy deployment in the recent past.

Table 3.7: Regional case study regions, change of energy use during the past 10 years

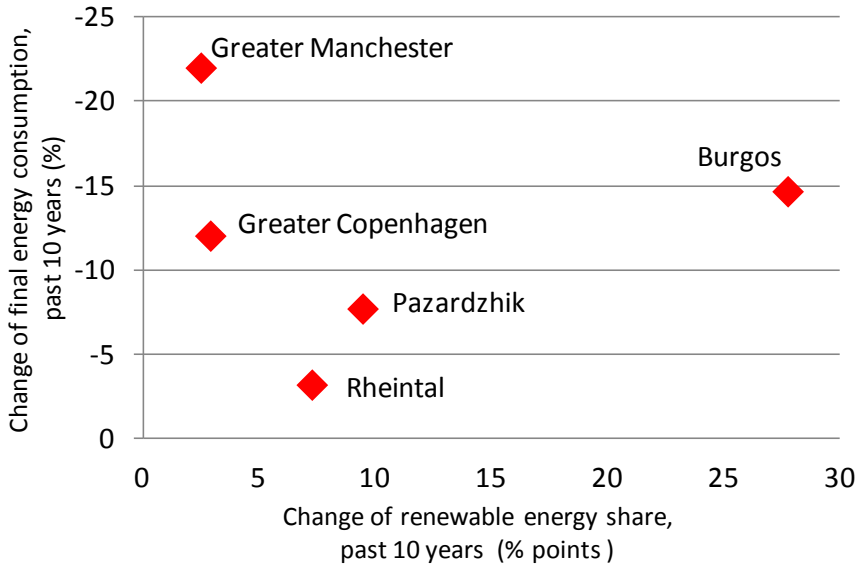
Region	**final energy consumption (10 years)**	**change of RES share in percentage points**
Austria, Rheintal	-3	7,3
Bulgaria, Pazardjik	-8	9,5
Denmark, Greater Copenhagen	-12	2,9
Spain, Burgos	-15	27,8
UK, Greater Manchester	-22	ca. 2,5

Source: Case study reports, please note: as available data describes developments within 8, 9 or 10 years, the change of final energy consumption and RES has been normalized for the period of 10 years

The region Burgos presents an outstanding result of the development during the past years. The very positive renewable energy development in the region has been driven by both, the regional efforts in terms of awareness rising, education, matching of actors as well as supporting the regional value chain of biomass, and the national legal framework supporting the deployment of high regional wind potential by large investors has to be considered as a reason for this considerable increase.

The following Figure 3.5 highlights the outstanding development of the region of Burgos during the past 10 years once more.

Figure 3.5: Comparison of case study regions in terms of the transition towards low carbon economy (past 10 years)



Source: Case study reports.

Besides a number of others, these facts form important preconditions for future strategies and for the setting of priorities by regional stakeholders for future measures and activities in the regions.

3.4.2 Regional governance in the case study regions

Certainly, the respective situation of regional governance is decisive for the way regions are able to steer their development – also in terms of energy. From the five Locate case studies and the meta-analysis, we may state that:

Only few regions dispose of formal competences and common structures for at (sub)regional level. As Greater Manchester with its city-region as statutory metropolitan government is one of those regions, we have the opportunity to learn about experiences in such governance structures in detail.

In most regions putting together municipal competences forms the basis of regional development activities. In these cases,

- either municipalities use their room for action and their competences together in order to cooperate and trigger a common development (in the case that added value is expected), this might be due to a tradition of (informal) cooperation between municipalities dealing with various issues (not only energy), which may be additionally supported by an energy department or energy agency from the government from the same regional level or a higher level; (Rheintal, Copenhagen)
- or regional energy development is triggered and supported by coordination and consultancy from a regional energy agency, engaging in a region in order to enhance municipal (and regional) measures for low carbon development (Burgos, Pazardzhik – together with the obligation for regional energy plans)

Usually in all types of regions, there are to be expected both, more ambitious as well as reluctant local authorities within those regions.

The following tables present an overview on governance systems of the five case study regions at hand.

Table 3.8: Governance system of Rheintal-region (Austria)

	Most relevant institutions	**Main competencies**	**Most relevant documents**
National level	Ministry of Research, Science and Technology, Ministry of Agriculture, Forestry, Environment and Water Management, Ministry of transport, innovation and technology, KLIEN (KEM), Austrian Energy Agency	national laws, Feed-In tariff for renewable energy production National funding schemes	Energy Strategy for Austria (2010) Electricity Act 2012, Feed-In tariff ordinance 2012, Energy Efficiency Act 2014
Larger regional level, province of Vorarlberg (NUTS 2)	Provincial Government of Vorarlberg Energy department of the province Energy agency Vorarlberg (including coordination of e5 municipalities)	provincial laws, public transport various subsidies for small RES installation and energy efficiency measures	Energy Future Vorarlberg, 2007 Energy Autonomy Strategy, 2009 Transport concept, 2006
Regional level **Rheintal/Vision Rheintal (ca. NUTS 3)**	Vision Rheintal	no formal regional competencies, but informal importance by cooperation of municipalities	Vision Rheintal 2004-2016
Local level	municipalities	spatial planning, Partly additional subsidies for small RES installation and energy efficiency measures	municipal energy strategies (e5) according to European Energy Award for selected municipalities (ca. 50%)

Source: Case study report.

Table 3.9: Governance system of Pazardzhik (Bulgaria)

	Most relevant institutions	**Main competencies**	**Most relevant documents**
National level	State Energy Regulatory Commission, Sustainable Energy Development Agency (SEDA)	Feed-In tariffs for renewable energy production. Approves rules on the work with energy services consumers. Carries out energy price regulation. Adopts and controls the application of a balancing electricity pricing methodology as part of the Electricity Market Rules under Art. 21, para. 1, p. 9 of the Energy Act.	Energy Efficiency Act, Energy From Renewable Sources Act National Action Plan for Energy from Renewable Sources 2011-2020, National Development Programme Bulgaria, Bulgarian National Programme for Energy Efficiency (NPEE)
Larger regional level, South Central Region (NUTS 2)	Ministry of Regional Development and Public Works	Manages ERDF programmes like Interreg, South East Europe, Balkan-Mediterranean, etc.	Regional Plan for the Development of the South Central Planning Region, 2013
Regional level **Province of Pazardzhik (NUTS 3)**	Regional Government, Regional Administration Regional Committee on Sustainable Energy Development (incl. NGOs)	Energy planning at regional level. Adapt national policies to the local context and integrate them into the regional strategy documents.	Pazardzhik Regional Energy Strategy (PRES), obligatory for the region, not yet finalized

	Most relevant institutions	Main competencies	Most relevant documents
Local level	Self-governing municipalities – 12 municipalities within the Pazardzhik Province	The municipalities manage the National programme for energy refurbishment of multi-residential buildings at local level. Spatial planning. Adapt and follow the national energy legislation to the local level/context.	Local sustainable energy programmes (obligatory for municipalities)

Source: Case study report.

Table 3.10: Governance system of Greater Copenhagen (Denmark)

	Most relevant institutions	Main competencies	Most relevant documents
National level	Ministry: Danish Ministry of Energy, Utilities and Climate Danish Ministry of Transport, Building and Housing Departments:	Development of national climate, energy, building policy and transport.	Energy Strategy 2050 Action Plan for Renewed Energy Conservation Energy agreement, March 2012 Subsidy scheme to promote energy efficient use of renewable energy in industrial production processes Statistical Yearbook 2016 World Energy Trilemma Index 2016 – Denmark (World Energy Council) Nordic Energy Technology Perspectives 2016 – Denmark: Cities, flexibility and pathways to Carbon neutrality
	Danish Energy Agency (DEA): Energistyrelsen	Domestic energy production, supply, transportation and consumption, including energy efficiency and savings as well as Danish national CO_2 targets and initiatives to limit emissions of greenhouse gasses.	
	Danish Meteorological Institute (DMI)	Meteorological services include forecasting and warnings and the monitoring of weather, climate and related environmental conditions in the atmosphere, on land and at sea	
	Energinet.dk	Control and maintain the national electrical transmission grid and the national gas distribution grid.	
	The Danish Energy Regulatory Authority	Regulates the Danish markets for electricity, natural gas and district heating.	
Larger regional level Hovestadn NUTS 2	Hovedstaden	Regional competitiveness, growth and job creation. Shared values on green growth, green transport, clean water and sustainable energy in an international and environmentally metropolis.	Regional growth and development strategy: Greater Copenhagen (2016) Statistical Yearbook 2016
Regional level **Greater Copenhagen (two NUTS 3)**	Byen København Københavns Omegn	Collaboration growth and development in province level: energy, transportation, building and climate. Sharing Copenhagen: one of the world's greenest, most resource-efficient and attractive cities to live in.	Statistical Yearbook 2016 Greater Copenhagen: Regional growth and development strategy (2016)
Local level	Municipalities: København, Frederiksberg, Drager, Tårnby, Albertslund, Ballerup, Brøndby, Gentofte, Gladsaxe, Glostrup, Herlev,	Decision making for local authorities Managing local programmes and ambitious goals. Example: Climate projects. Collaboration with public and	The City of Copenhagen's Business and Growth Policy 2015-2020 Copenhagen Energy Vision (2015)

	Most relevant institutions	Main competencies	Most relevant documents
	Hvidovre, Høje-Taastrup, Ishøj, Lyngby-Taarbæk, Rødovre, and Vallensbæk	private sectors and knowledge institutions.	Copenhagen Climate Projects (2015) Copenhagen Climate Report (2014) Copenhagen City of Cyclists (2014) European Green Capital (2014) District Heating in Copenhagen: Energy-efficient, low-carbon and cost-effective (Hofor) Copenhagen Climate Plan: Copenhagen Carbon Neutral by 2025

Source: Case study report.

Table 3.11: Governance system of Burgos (Spain)

	Most relevant institutions	Main competencies	Most relevant documents
National level	-Ministry of Industry, Energy and Tourism, State Secretariat for Energy -Institute for Energy Diversification and Saving (IDAE)	-Issuing regulations concerning energy and mining matters. -Legislation on the tariff structure, prices of energy products, and levies and tolls. -Legislation to save energy, promote renewable energy and support new energy and mining technologies. -Legislation and, if needed, adoption of measures to ensure energy supply.	-Laws -Recommendatory documents
Larger regional level, Castilla y Leon (NUTS 2)	-Goverment from autonomous region -Energy agency of Castilla y Leon (EREN)	-Competences related to authorising power plants < 50 MW, distribution networks of electricity and natural gas.	- Sustainable Energy Action Plan - Energy plans by technologies according with the market development
Regional level Province of **Burgos (NUTS 3)**	-Burgos Provincial Government -Burgos Provincial Energy agency (AGENBUR)	-Coordination of municipal services -Technical assistance to municipalities	- Strategic Plan Burgos Rural, 2015-2020 with a specific chapter about energy. - *Tools:* *Study of potential of using of biomass (http://sync.cesefor.com/agenbur/flash/export.php?rid=1), * Atlas on small to large scale renewable energy plants (http://www.observatorioenergias-renovables.com/)
Local level	-Local authorities of Municipalities	-Management and coordination of public services for citizens.	-Municipal regulations (In order with national level)

Source: Case study report.

Table 3.12: Governance system of Greater Manchester (United Kingdom)

	Most relevant institutions	**Main competencies**	**Most relevant documents**
National level	UK Department for Business Energy and Industrial Strategy (DBEIS)	DBEIS is the new UK Government Department (since 2016) that brings together responsibilities for business, industrial strategy, science, innovation, energy, and climate change mitigation. It leads policy areas on Climate Change Agreements, Climate Change international action, Energy and Climate Change, Energy Demand Reduction, Greenhouse Gas emissions, Energy reduction, Low Carbon Technologies, Energy Security and City Deals. (UK Department for Environment Farming and Rural Affairs (DEFRA) leads on climate change adaptation)	UK Climate Change Act 2008 Green Deal Programme (2011-2013) Energy Company Obligation (ECO) since 2013 City Deal
	UK Committee on Climate Change (CCC)	CCC is an independent statutory body established under the Climate Change Act 2008 to advise the UK Government and Devolved Administrations on emissions targets and report to Parliament on progress on emissions reduction and adaptation.	
	The Energy Savings Trust (EST)	EST began as an independent not-for-profit government sponsored organisation in 1992 to provide free advice on energy efficiency and sustainable energy and access to grants to domestic households.	
	The Carbon Trust	The Carbon Trust is a not for dividend company established 2001 to provide advice on energy efficiency to businesses and public sector organisations, now trading globally.	
Larger regional level	No formal structures since 2011 but new schemes emerging eg. **North West Leaders Business Council**		
Regional level **Greater Manchester (NUTS 2)**	GM Combined Authority (GMCA) Association of GM Authorities (AGMA) 5 joint GMCA/AGMA Commissions: GM Low Carbon Hub, GM Interim Health and Wellbeing Board, Planning & Housing CommissionTransport for GM Committee, Manchester Family/Centres of Excellence	City-region as statutory metropolitan government (formal, 2011) with responsibility for transport, planning and economic development (including low carbon programmes on retrofitting buildings, green&blue infrastructure, energy, transport, municipal waste and recycling) Within Low Carbon Hub there are 5 themed groups (Buildings, Energy, Transport, Natural Capital Sustainable	GM Climate Change Strategy 2012-2020, Climate Change and Low Emissions Implementation Plan (2016-2020) (Draft) GM Spatial Framework (2016) GM Strategy 2013-2020, Growth and Reform Plan 2014, GM City Deal 2015 GM Spatial Energy Strategy Evidence

	Most relevant institutions	Main competencies	Most relevant documents
		Consumption & Production) and two cross cutting themes (Low Carbon Goods and Services Sector Growth, and Low Carbon Skills)	Base GM Third Local Transport Plan 2011-2016 GM Green Deal Housing Retrofit Scheme Low Carbon Investment Fund (2017)
	GM Local Enterprise Partnership (LEP)	GMLEP has responsibility for private sector leadership across Greater Manchester prioritising: worklessness and skills, supporting business, creating conditions for growth, and public sector reform	
	Business Leadership Council (BLC)	GM BLC acts as a key strategic advisor to the LEP and the Greater Manchester Combined Authority (GMCA).	
	GM Chamber of Commerce (GMCC)	GMCC supports businesses across Greater Manchester	
Local level	Municipalities (Local Authority boroughs) Manchester Climate Change Agency (MCCA)	decision-making power over all other local authority functions	

Source: Case study report.

Due to the different types of regions and varying situations of regional governance also the challenges for implementation differ between the regions. The following experiences from the implementation in our five case regions provide an idea on the diversity of both, the understanding of the role of the regional level and the challenges for regional low carbon development:

- The ability for implementation of low-carbon development in Greater Manchester is based on the new style of local government by the definition of a statutory city-region, allowing strategic working across administrative boundaries and organisations. This regional government has officially published the GM Low Carbon Implementation Plan 2016-2020 which will hopefully give evidence to the claim "With more local control comes the enhanced ability to deliver" (GM Low Carbon Implementation Plan). The strong focus of Greater Manchester to address climate change and economic growth ambitions together also lead to a firm involvement of the private sector in regional governance through the Business Leadership Council and the Local Enterprise Partnership. These regional stakeholders advise the regional authority and provide a forum to have a single conversation with business leaders.
- In the urban region of Greater Copenhagen, the implementation of renewable energy technologies is understood as a joint responsibility between several actors, in which municipalities have a vital role in planning and coordinating these activities. In order to address different climate-related challenges, the region serves as a facilitator and "platform" by bringing together professionals and users.
- The region of Rheintal is mainly driven by the ambitious implementation of energy transition of the levels above and below. Many municipalities have started to implement energy issues into their communal work early, at the higher regional level, the province of Vorarlberg and the provincial energy agency are very active in supporting municipalities

and municipal cooperation. Vorarlberg's policies tend to be more progressive than their national counterpart. The region of Rheintal has a long tradition of cooperation especially in the fields of spatial planning, transport and mobility.

- As in many rural regions, the example of Pazardzhik shows that smaller local administrations lack administrative capacity needed to implement activities concerning energy efficiency demands, application of RES and energy planning. In order to support these activities and to provide services for elaborating the obligatory local and regional energy plans, the regional energy agency (REAP) is an essential partner for working with municipal authorities and implementation of low carbon development.
- This is also true for the region of Burgos, where the province has established the regional energy agency in order to support municipalities to implement energy transition within their room for action. Despite the lack of competences at the provincial level of implementation in terms of energy issues, the regional energy agency provides technical assistance to municipalities, coordinates municipal activities and elaborates information and tools in order to support a regional value chain (e.g. in terms of regional biomass production and use).
- In general, regional energy agencies play an important role within the 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.

Case study Greater Manchester – Specific added value of the formal city-regional "Combined Authority"-model (GMCA)

A great deal of strength for the city-region is perceived through the following qualities that come from working at a regional or city-regional scale:
1) *Strategic prioritisation* in the Combined Authority model joint governance arrangements allow for strategic prioritisation across the functional economic area. This enables activity to be undertaken more flexibly and more strategically than if all 10 local authorities operated separately.
2) *Integration* – The GMCA also identifies integration of service delivery across boundaries. This enables GMCA to look at the needs of GM population and their needs that cross the 10 local authorities' geographical boundaries. It also allows working across organisational boundaries, exemplified by Transport for Greater Manchester which facilitated e.g. much greater integration and closer working relationships with the Highways Agency and the 10 local authorities on the operation and development of the road network. Real innovation comes from looking at the overlaps between some of those boundaries and looking at the innovation across.
3) *Stability* – The long history of collaborative working since 1986 has allowed the development of shared knowledge, trust and capacity. This provides stability of working relationships at a local level. In addition such stability is also perceived by central government and is highlighted particularly strongly in the decision to build a city deal with Greater Manchester. For this the legal constitution of the GMCA is important. It is Manchester's stable and accountable governance provided through the GCMA and the fact that GMCA has powers in its own right that provides stability and accountability.
4) *Leadership brings gravitas and access to resources* – The ability to work and speak collaboratively gains Greater Manchester greater gravitas in dealing with UK Central Government and national agencies. With the backing of the 10 constituent local authority elected leaders and a scrutiny committee comprised of 30 elected members through the Association of Greater Manchester Authorities, stakeholders feel a strong democratic legitimacy for such leadership.

5) *Co-operation facilitates Smooth Project Delivery* – The Greater Manchester Energy Plan identifies cooperation leading to greater delivery capability. Ten local authorities working together with the private sector allow for increased project development capacity, single points for contact for the private sector, economies of scale, knowledge transfer and less duplication of effort. In particular, cooperation between sectors early on in project planning allows sharing of practical knowledge and expertise that facilitates project development and streamlines the identification and circumventing of potential challenges to energy project delivery.
6) *Allows strategic reframing to fit different agendas* – What is perceived important with this agenda is to see low carbon, or the green agenda more broadly speaking from different stakeholders perspectives. The low carbon hub provides a space for that. By reframing the low carbon economy to the perspectives of different stakeholders it is hoped that it will achieve greater resonance with core activities and encourage action to be taken.

3.4.3 Energy strategies, quantitative targets and monitoring at regional level

Different regional governance systems have a direct impact on the form and content of regional energy strategies due to the different relevant actors and stakeholders with varying competences and powers. Concerning the five case study regions at hand, the following table presents quantitative targets which have been published officially.

Table 3.13: Regional case study regions, quantitative targets

Region	**Relevant document, character of objectives**	**regional quantitative energy/CO_2 targets**
Austria, Rheintal	Energy-Autonomous Vorarlberg 2050 (NUTS 2), voluntary long-term goal Action Plan 2020, voluntary: Continuous renovation rate for buildings 3% and reduction of energy consumption for heating -20% by 2020 energy efficiency of industry + 1% per year +10% energy from hydro power by 2020 additional solar installations (15,000 m² per year), PV (40,000m² per year) until 2020 number of heat pumps + 50% until 2020 Change of modal share + 5% for cycle traffic 5% electrical vehicles by 2020. good transport from/to the region: increase share of rail transport from 22% to 30% by 2020	energy autonomy 2050 -20% energy consumption for heat +1% industrial energy efficiency p.a. quantitative energy related targets for RES installations and transport
Bulgaria, Pazardzhik	Pazardzhik Regional Energy Strategy (in elaboration), obligatory for the region, qualitative objectives: (1) improve performance of private and public buildings, (2) energy efficiency and RES in industry	in elaboration
Denmark, Greater Copenhagen	The overall ambitious aim of Greater Copenhagen, defined in the Greater Copenhagen Regional growth and development strategy (2016) is, to be "World's first fossil free metropolitan region". Quantitative targets comprise the energy and transport sector, resource efficiency and green growth related economic growth. Additionally, the capital region shall be widely recognised internationally as being climate-prepared by 2025	Fossil-free electricity and heating by 2035, transport sector by 2050 protection of drinking water: 80% of groundwater resources safeguarded by 2025 8% annual growth in the green business and cleantech sector by 2025 2.5% annual increase in light railway passengers by 2025, in addition to 1% annual increase in related job creation by 2025

Region	Relevant document, character of objectives	regional quantitative energy/CO_2 targets
Spain, Burgos	Strategic Plan Burgos Rural, 2010, qualitative objectives: (1) optimize energy consumption, (2) develop RES potential, esp. biomass potential	-
UK, Greater Manchester	Climate Change Strategy 2012-2020, voluntary aim, reduction of CO_2 emissions GM Greater Manchester Spatial Strategy 2050, voluntary aim, reduction of CO_2 emissions Important aspect: The strategies are addressing climate change and economic growth ambitions together.	-48% CO_2 by 2020 -60% CO_2 by 2035 (baseline 1990)

Source: Case study reports.

As presented, these objectives and quantitative targets differ considerably from region to region – in terms of time perspective, of target course and ambition. Whereas some regions do not publish quantitative targets at all, others present overall aims on reduction of final energy consumption or CO_2 emissions and others again concentrate on the definition of (sub)sector-related objectives e.g. for the building, the transport or the industrial sector.

3.4.4 Membership in low carbon programmes and initiatives

As for the membership in international low carbon programmes and initiatives the comparison of the five case study regions suggests that urban regions with larger cities find it easier to join international programmes and initiatives, again probably due to the lack of capacity to do so in small municipalities (at least partially).

Table 3.14: Regional case study regions, membership in low carbon programmes and initiatives

Region	Climate Alliance	Covenant of Mayors	ICLEI	European Energy award	Others
Austria, Rheintal	15 municipalities (out of 29)	Bregenz, Wolfurt	Dornbirn	e5 energy-efficient municipalities	2000-Watt-Society (cross border initiative, 2 cities in the region)
Denmark, Greater Copenhagen	Albertslund	Albertslund and Copenhagen	Albertslund and Copenhagen		C40 (network of megacities, Copenhagen)
UK, Greater Manchester		Greater Manchester			Under 2MOU (GM) *UNISDR's* "Resilient Cities: My City *is getting ready"* campaign (GM) Euro Cities (GM)

Source: Case study reports

In both of the rural regions, Burgos and Pazardzhik, neither municipalities nor the region did join international programmes or initiatives so far. As main reason for that in Burgos mainly the small size of the municipalities and corresponding capacities has been highlighted. In the province of Pazardzhik the obligatory local energy strategies (energy efficiency and renewable energy plans and programmes) resemble to a great degree the Sustainable Energy Action Plans (SEAPs) which have to be developed and implemented within the Covenant of Mayors initiative. They set up a baseline and objectives which must be achieved within sev-

eral years – in terms of energy savings; in terms of CO_2 savings; and in terms of RES energy share. Even though, the municipalities did not join the CoM initiative until the time of writing this report in 2017.

Nevertheless, represented by their energy agencies, both regions (as well as the three urban regions) have been acting as project members in several European research projects dealing with relevant issues.

Added value of membership in international programmes and initiatives has been mainly highlighted by the two large metropolitan regions:

- Greater Copenhagen: The municipalities' involvement with the low carbon associations helps to strengthen low carbon solutions' role in planning and influence the policies made in the fields of energy. Having the same vision and goal, sharing inspiration and methodology, and most of all implementing the local innovative programmes, are the reasons why municipalities in the Greater Copenhagen joined these associations. As representatives in the Climate Policy Forum of the Capital Region, the two local authorities Albertslund and Copenhagen are also most often members in international programmes and initiatives.
- Greater Manchester: The stakeholders suggested that the signature of the Covenant of Mayors operated symbolically. For local authorities signing was driven both politically and from Chief Executive level. As such, Bloomberg's involvement as UN Secretary-General Special Envoy for Cities and Climate Change and the letter sent to City Mayors had had a big impression. However, whilst being a signatory is often cited in policy documentation and it was suggested this should give greater clout and justification for taking action, doubt was expressed about the effect this had in day to day practice. Nevertheless, politically that signatory agreements provide useful frameworks. In addition, being part of the Covenant of Mayors has required increased data collection at the Greater Manchester level, and led to the development of a new data framework for GM to become compliant with the CoM-reporting protocol.

Although the Rheintal-region in Austria (respectively its municipalities) is acting as a member of several international initiatives and programmes, it seems that the intensive collaboration in national and regional programmes has been of higher practical value in terms of cooperation and implementation, municipal support and exchange of best practices.

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

Implementation at regional level, particularly below NUTS 2 level, goes beyond the measures neighbouring municipalities set within a common boundary. This is especially important for measures and projects which are depending on municipal cooperation as for instance the construction of a large district heating system in densely built up urban areas, building up regional platforms for an energy and resource efficient economy and obviously for the question of 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)*

> *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)*

> *"If investors get good decision support by regional mappings of suitable sites for PV the already high rate of installations could get to a new level." (R4GG, case study Abruzzo, peer review)*

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

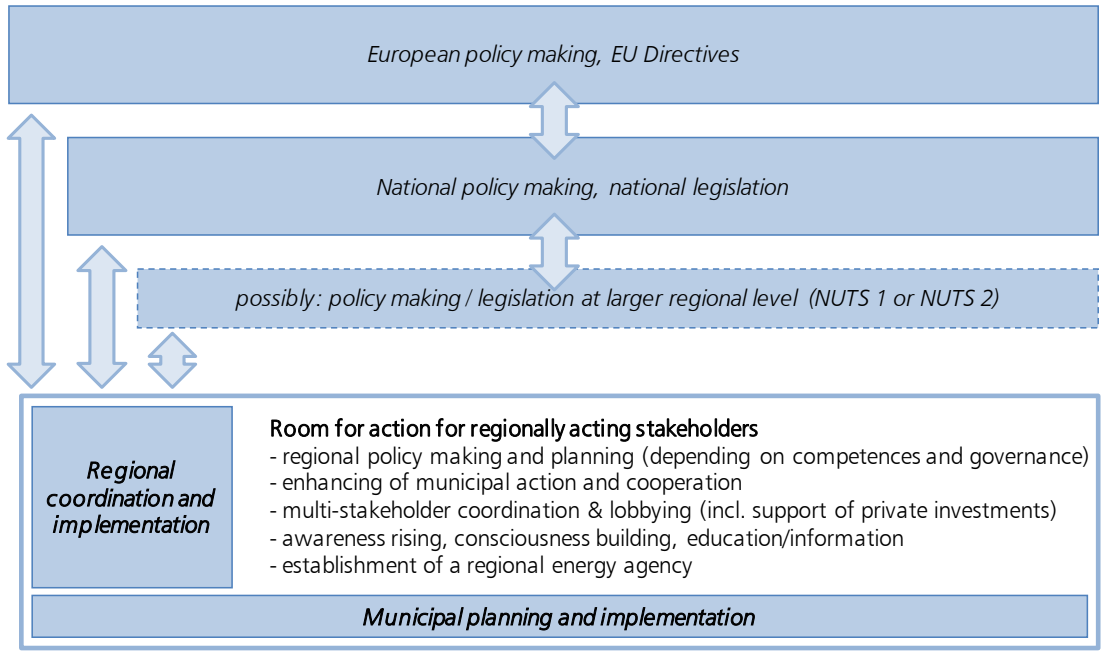
> *"In that complex arena of different stakeholders the role of the Region is important. The leadership of the Region is most effective in an equivalent and facilitating mode: ready to involve partners, to listen to the stakeholders and willing within to adapt schemes, instruments and even operational goals as long as the joint agreement leads to the long term goal of a low carbon economy." (Vollaard, 2013, New Reality, Final Report LoCaRe-Project 2010-2013)*

The conclusions from a recent workshop "Smart Specialisation in Energy, driving societal challenges" (June 21, 2017) in the framework of the Smart Specialisation Initiative strongly support this opinion about the importance of the regional level also referring of 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." (http://s3platform.jrc.ec.europa.eu/-/smart-specialisation-in-energy-driving-societal-challenges?inheritRedirect=true&redirect=%2Fs3p-energy)*

The following figure illustrates the overall system of interrelated governmental levels and highlights the room for action for regional authorities and stakeholders acting at the regional level. As presented, close cooperation between the regional and the municipal level by an integrated approach of municipal planning and implementation and the respective regional perspective are key for the successful implementation at regional level.

Figure 3.6: Low carbon implementation – interrelation between governmental levels and room for action at regional level



Source: ÖIR

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

- coordination and implementation of regional measures which only make sense at regional level by making use of synergies between municipalities and introducing an integrated regional perspective in order to take advantages of common and complementary strengths;
- resource pooling (capacities, human resources, know-how) and creating a critical mass of actors and options, this is especially important for smaller municipalities; regional cooperation allows for (1) larger projects, coordinated gathering of funds and (2) coordination of activities/building platforms for combining low carbon development and regional economic growth
- direct exchange of experiences between neighbours and positive competition within the region, supporting ambitious municipalities to develop further and stimulating less motivated municipalities to make use of best practices from other municipalities within the region (successful examples from other municipalities within the region may be rolled out easily in order to stimulate low carbon action);

These benefits may be supported by focused interventions at the level of the region, which are described below. In any of those cases there is a need for human resources providing work capacity and professional knowledge at regional level, be it as civil servants or experts working in an intermediary body, an NGO or for 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. In addition, projects such as local heating grids or institutional solutions for exploitation and integration of renewable energy sources require cooperation between various partners. Continuous recording and assessment of energy consumption, compilation of corresponding energy saving measures (both those involving investment and otherwise), or regular reporting as a basis for*

strategic, tactical and operational decision making in the context of communal buildings must be ensured.
These considerations lead to the conclusion that a coordinating body is necessary for implementation of the energy and climate protection concept. This could be the project/energy manager, active across the various municipalities. The tasks of a coordinating body (regional project and energy manager), would be: establishment of an energy management system in every community involved, networking between the relevant regional actors, process monitoring and evaluation, acting upon projects and solutions and supporting them in the pilot stage, in cooperation with local authorities." (MANERGY, case study Muldenland)

3.5.1 Regional policy making and planning

Competences for policy making at (sub-)regional level

Certainly, the respective situation of regional governance 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 dispose of formal competences and common structures at (sub-)regional level.

In most regions supporting and coordinating municipal competences form the basis of regional development activities. In these cases,

- either municipalities use their room for action and their competences together in order to cooperate and trigger a common development (in the case that added value is expected), this might be due to a tradition of (informal) cooperation between municipalities dealing with various issues (not only energy), which may be additionally supported by an energy department from the government at the same regional level or a higher level;
- or regional energy development is triggered and supported by coordination and consultancy from a regional energy agency, engaging in a region in order to enhance municipal (and regional) measures for low carbon development (see below).

Contrary to regions without these formal competences, regions with such competences are acting as responsible authority for policy making and planning, substantially extending their room of action. In this case public resources are provided at a defined authority-level (at least for policy making and planning).

"The Ruhr Regional Association can take over a central role and responsibility for the development of renewable energy in the Ruhr area. The RVR can materially influence the development of renewable energy through its formal regional planning competence as well as by informal control instruments. Particular to achieve the objectives of the state government of NRW in the Ruhr area, a positive planning management for wind energy is required to define regional development areas, i.e. priority areas for the development of wind energy. To increase photovoltaic on roof surfaces, informal planning strategies and concepts are necessary to motivate the homeowners for such use. Since especially the housing associations have a long tradition in the Ruhr area owning a large housing stock, this actor can play an important role in the expansion of photovoltaic on rooftops." (Greeco, case study Ruhr area)

Nevertheless, requirements, topics to be dealt with and objectives, competences and power for implementation depends on the countries legislative framework and therefore varies considerably between regions. At the same time the national framework is very important. This background is decisive for both, the actual development in the regions and the room for action regions do have in practice.

One example from the regional case study region Burgos that might illustrate this situation very well is related to wind power in Spain. The region of Burgos is very successful in producing energy from wind, providing the highest share of renewable power and heat production within the NUTS 2 region of Castilla y León, mainly from wind power and biomass. In 2013, the region of Burgos produced more than 30% of renewable energy within the region (of 9 provinces in total). Even so, the energy agency of Burgos does not deal with wind power issues a lot. The reason for that is that the regulation of wind power in Spain is a competency at national level. The regional level of Burgos does not have an impact on this terms. As this is the case, main plants of wind power are being planned, built and operated from big companies, which are able to deal with these regulations.[50]

Regional energy strategies and target setting

Due to these different regional governance systems, regional energy strategies are elaborated and laid down by different actors and stakeholders with varying competences and powers. Together with national laws (and the way EU directives are implemented nationally) this governance background has a major impact on the way regional energy strategies are being formulated, their contents and definition of priorities, their time perspective (short-term action plans to long-term strategies), and on the decision of regional stakeholders whether to define (binding/non-binding) quantitative targets and according monitoring activities or not.

[50] In Spain, the generation of electricity from renewable sources was mainly promoted through a price regulation system. Plant operators could choose between two options: a guaranteed feed-in tariff and a guaranteed bonus (premium) paid on top of the electricity price achieved on the wholesale market. The price regulation system was phased out through Real Decreto-ley 9/2013. The reason for this suspension is traced in the preamble of RDL 1/2012. A different regulation that had previously suspended the support schemes, before their final phasing out RD 6/2009 established that by 2013 a part of the consumers“ electricity bill (the “peajes de acceso”) should be able to fully balance the costs incurred by the State arising from the support scheme. It was deemed, however, that the situation would not have allowed this goal to be reached by 2013. For this reason, and together with the high growth of RES-E in the past years, even beyond the set goals, all support schemes for RES-E were blocked.
The Real Decreto 947/2015 was approved to regulate the premium tariff (“Régimen Retributivo Específico”), aiming at supporting new biomass plants located in the mainland electricity system and existing or new wind energy plants. The selected procedure to allocate the premium tariff is a call for tenders regulated through Order IET/2212/2015. The latter also approved the value of the different compensation parameters for the reference RES plants under the new remuneration regime or premium tariff.
In 2015 Real Decreto 900/2015 was approved, establishing charges on existing and new self-consumption RES plants, both on capacity and generation levels. According to RD 900/2015 these are not taxes or compensation for utility losses, but contributions to overall system costs. Self-consumption installations under 10 kW and plants located not on the Spanish mainland will be spared the generation charge, but will still be subject to a fixed charge per kW of capacity.

Even though the importance of quantitative targets as an impulse for implementation and for keeping up activities is stated manifold, a lot of regions seem to hesitate from defining such measurable target figures. Quantitative regional targets and monitoring are (more often) laid down at the (sub-)regional level mainly in following cases:

(1) In some countries it is mandatory for the regional level to strive for quantitative energy targets by law. This is e.g. the case in Bulgaria where regional energy strategies are mandatory (e.g. Pazhardzhik) or in Italy where the state has passed national targets on renewable heat and electricity targets on to regions which are now obligated to contribute by a binding regional targets (e.g. Friuli, according to CEP-REC);

(2) Without such a top-down obligation for regional/local targets, quantitative target setting is rather to be expected in the case of formal regional governance structures with competences and power for implementation at the regional level (e.g. Greater Manchester, which forms a NUTS 2-region though).

In contrast, municipalities/local authorities forming the regional governance system by cooperation, cooperative projects and initiatives usually hesitate to lay down binding quantitative targets due to a lack of regional power of implementation. This often leads to reluctance/prudence concerning the setting of quantitative measurable targets and their monitoring as single municipalities will not have opportunities to steer the development of the region. Accordingly, a lot of regions presented in case study reports, did not lay down quantitative, measureable targets for future development which are officially agreed and published by the region.

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[51]) 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.

[51] 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)

3.5.2 Enhancing municipal action and cooperation

In addition to elaborating overall regional strategies and plans, actors at regional level 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) and implementation of measures (municipal buildings, service facilities, vehicle fleet) and function as role model for their population in terms of behaviour and implementation of projects. Hence, on the one hand, municipalities are most important actors for the transition low carbon economy, on the other hand these local actors have to deal with a large range of tasks and especially small municipalities are often lacking capacity and specialized know-how for additional (even more demanding) tasks.

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

> *"Although the Peer Review team recognition of this as a strength, it should also be noted that the 22 municipalities of the Sofia region seem to lack the capacity to develop project ideas to the point of seeking external funding support. It might also be argued that there is a similar lack of technical capacity that can develop both energy efficiency projects (across all sectors) and renewable energy projects." (R4GG, case study Sofia, peer review)*

> *In some countries an essential lack of human resources has been identified, such as Estonia, hindering successful regional forthcoming: "Among other things, the cooperative culture among the municipalities should be supported, which is currently very weak or even non-existing. The problems concerning the lack of human resources should also be addressed. There is a strong need to attract staff with the requisite skills and technical expertise for an effective regional development." (Greeco, case study Southern Estonia)*

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 – but also within these countries ambition and requirements of these energy concepts show major differences). In other countries, the national (or larger regional) level provides incentives for municipalities in order to elaborate local energy concepts (e.g. Austria). In this case the focus is rather put on ambitious local actors.

> *"The importance of cooperation and consensus when implementing these strategies cannot be overestimated! The alignment of regional master plans should be reflected in the municipal energy plans. The Country Administrative Board, the Regional Council and all the municipalities in Sörmland must work together in order for the measures to be successful or even possible. It's vastly important that all 'master plans', local and regional, are signed by the appropriate political representatives and incorporated in the activities affected." (EU2020goingLOCAL, case study Sörmland)*

Case study Rheintal – the Austrian e5-programme

The energy agency of Vorarlberg – among others – developed and coordinates the e5 Programme for Energy Efficient Communities. It was established 1998 (developed mainly by the energy agency Vorarlberg) to support communities to identify their energy saving potential and increase the use of renewable energy. In 2004, klima:aktiv, the climate protection initiative of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management took on the task of managing and developing the e5 programme in Austria at national level. The annual monetary contribution for the e5 programme membership of a municipality depends on the size of its population. The e5 programme correlates with the European system "European Energy Award".

In this role it offers long-term support to the network of e5 municipalities to identify their energy saving potential and increase their use of renewable energy. The core element of the e5 programme is a comprehensive and structured catalogue of all energy-related measures relevant for municipalities. This catalogue serves as the basis for their communal action programme, which is prepared annually and also sets out an internal structure suitable for steering the process. Each year, the municipalities carry out an internal audit to determine their progress. At least every three years they are subject to an external assessment. The success of the communities is measured in "e". The best communities achieve up to "eeeee", corresponding to having implemented 75% of all possible energy measures according to the catalogue.

This network is very powerful in Vorarlberg, and even more so in Rhine Valley where more than 50% of the municipalities, and all major cities take part in that programme. Its established standards, methodologically sound procedures, and the opportunities for communities to exchange on related topics is very appreciated in the region and the network regarded as key governing body. Its effects are:

- increased networking, exchange of experiences and tools and subsequently more collaboration and positive competition between the municipalities
- increased willingness of communities to take action in their energy policy
- establishment of quality orientated processes and structures for implementing energy-saving measures
- higher number of implementations of energy efficiency measures and policies.

The "landscape" of awarded "e"s can also hint at the regions frontrunners and followers in the region.

Nevertheless, even if there is a legal obligation for elaborating local energy concepts for municipalities, support at regional level is sometimes essential, as shown for the region Pazardzhik and the work of the regional energy agency REAP:

> *"An important lesson learned when working with municipal authorities so far: the local administrations from Pazardzhik Province, especially small ones, lack of administrative capacity needed for fulfilment the activities concerning energy efficiency demands, application of RES and energy planning. REAP offers the municipal authorities approach to integrated energy planning." (Locate, regional case study Pazardzhik)*

Luxembourg has undergone a coordination process, in which the Ministry of Sustainable Development and Infrastructure (MDDI) launched a Climate Partnership and a Climate Pact with

interested municipalities of the southern region of Luxembourg. The Climate Pact depicts the general mechanisms of the European Energy Award, which have been adapted to the Luxembourg situation (see also the example of Austria and the e5-programme). This tool comprises a standardized catalogue of 79 non-obligatory detailed measures which the municipalities may choose and implement depending on their prerequisites and abilities. The syndicate PRO-SUD offers to support the municipalities in the whole process, including implementation of regional projects, accompanying support of work and provision of know-how, organisation, coordination and communication during the whole process (EU2020goingLOCAL, case study Luxembourg).

In terms of this field of action, also *regional signatories to the Covenant of Mayors* ("CoM-signatories") are providing support for municipalities. Main 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).

> *"For the region to work as a role model it should strongly consider joining the Covenant of Mayors (CoM), as a regional coordinator providing strategic guidance, financial and technical support to the municipalities signing up to the Covenant of Mayors." (R4GG, case study Lazio, peer review)*

Case study Rheintal – the Austrian climate and energy model regions

The Climate and Energy Model Regions are a bottom-up approach in the field of climate change and energy funded by national climate and energy fund. The region (the municipalities who are willing to cooperate and contribute) has to apply for funding with a regional concept that describes the status quo, sets goals and benchmarks, identifies potentials and sets out concrete actions for the defined region (max. 60,000 inhabitants). After a successful application, a regional manager is driving the implementation of projects of the action plan. This person also acts as contact person for the stakeholders of the region. The development process requires integration of the region by cooperation with stakeholders, local economy, local policy makers and citizens awareness for the project and its development can be increased and anchored within the region.
The programme is divided into three phases:
Phase 1 – Development of an implementation concept with predefined requirements with involvement of essential stakeholders.
Phase 2 – A model region manager receives funding and support for the acquisition of know-how for a period of 2 years (max. amount of funding for phases 1 and 2 is € 145,000, co-financing by the region is required). Prolongation is possible, but requires successful evaluation.
Phase 3 – The Climate and Energy Fund supports the Climate and Energy Model Regions with exclusive investment grants for projects in the fields of PV, wood heating systems, solar thermal energy, electric vehicles (in combination with PV) and the refurbishment of buildings.
After these phases, the municipalities working together as climate and energy region are meant to further cooperate, but without public money for keeping up the cooperation.

3.5.3 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 and convincing local population.

Whereas multi-level cooperation (in terms of governmental levels) is legally binding and implemented widely, cooperation with stakeholders from various fields and inclusion of the population is much less regulated and depends on the ambition, knowledge and capacities within regions.

> *"The development of the regional strategies should be a systematic work and based on a broad cooperation, with representatives from the regional and local government, the public, the academic, the R&D institutes, the financing sector, the main business/industry sectors in the region and the relevant civil sector. This way of increases the confidence of the society, stakeholders and of investors and thus ultimately the success of the implementation of the strategies.*
> *Strategy development processes are important means to engage stakeholders, to build knowledge and consensus and to enhance action. It is necessary to keep all these stakeholders involved during the whole process, in order to increase confidence in the work and to prevent opposition during the realization phase. Furthermore, continuous evaluation of the work is a critical part of the regional governance, in order to adapt the implementation to changes in the society. The energy and climate strategy and action plan should be an ongoing process where objectives have to be updated and actions have to be evaluated and renewed annually or every second or third year.*
> *The regional strategies should be formally endorsed by regional politicians." (R4GG, case study Lazio, peer review)*

> *"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 and enterprises and research

Referring to regional economy, partnerships between the region and its municipalities with SMEs and large enterprises, educational and research institutions as well as NGOs can act as important driver of a regional low carbon economy.

> *"A low-carbon economy should be highlighted here as it is the benchmark of future growth with its environmental products and services. The low-carbon economy is characterised by high innovation potential, positive employment expectations, high competitiveness and strong international networks." (ANSWER, 2012)*

> *"It is essential that these regional strategies include the development of both use and supply of EE and RES as a growth mechanism for regional development, in order to highlight the importance and to be able to use structural supports for this issue. By including that the vulnerability due to a high dependency on imported natural gas could be decreased by both EE and a diversified supply of RES, this factor increases the benefits. The importance of RDI, business development, commercialization and financing within*

RES and EE needs also to be emphasized." (R4GG, case study Eszak-Alföld, peer review)

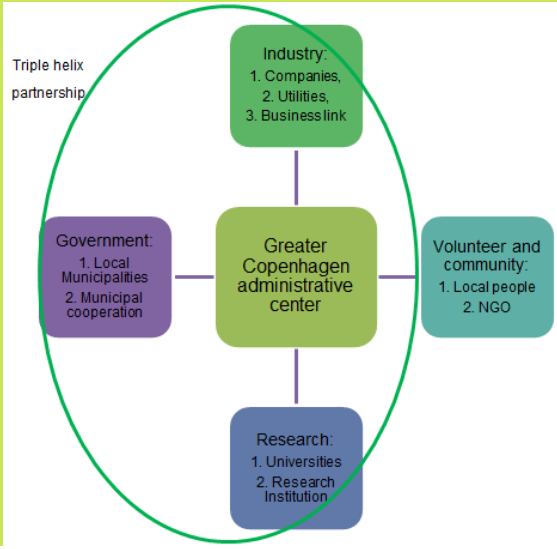
"The region should hold a regional development strategy with objectives, priorities and suggested measures. The strategy should of course be in line with EU and national strategies while reflecting and focusing on the regional characteristics. The regional development strategy should also be related to a regional innovation strategy. It is important that these regional strategies include the development of both use and supply of EE and RES as a growth mechanism for regional development, in order to highlight the importance and to be able to use structural supports for this issue." (R4GG, case study Lazio, peer review)

"Another important aspect when designing a project that is supported by the government, is to start with the perspective of 'adding value' to the community. This means that renewable energy production or energy saving is not the primary goal. Instead, adding economic, environmental or even social value should be the main objective. This asks for a more integrated and holistic approach in project development. This also means that more parties can be involved in the financing of the project, as more stakeholders will have a (direct or indirect) benefit from the project.
An example, is for instance to include job creation in the business case. Every extra job created means less social payments need to be paid by the government. This leads to a reduction of cost, which can be used to invest in the business case." (R4GG, case study Valencia, peer review)

Very good examples for initiatives aiming at a fruitful combination of low carbon development and economic prosperity can also be found in the case study regions of ESPON Locate.

Case study Greater Copenhagen – Green growth project Greater Copenhagen

Greater Copenhagen's green growth project, laid down in the Regional Growth and Development Strategy, includes conversion of the energy and transport system and green job creation. The organisation structure provides a responsive structure as the key competence to support the implementation of low-carbon economy. Greater Copenhagen employs a collaborating main actor of triple helix approach that involves government, industry and research institutions and also local community and NGOs. NGOs are mainly concentrated on the issues related to environment and sustainability that are related with each specific project.



The traditional triple helix governance architectures usually conduct partnership activities related to "co-ordinating" and the more successful ones emphasizing on "co-operating", while the Greater Copenhagen governance structure can be defined as "collaborating". Collaborating means making compromises and jointly forming a commitment to achieve a defined goal. This structure emphasizes on a strong commitment, collaboration and integration of good governance process in multi-

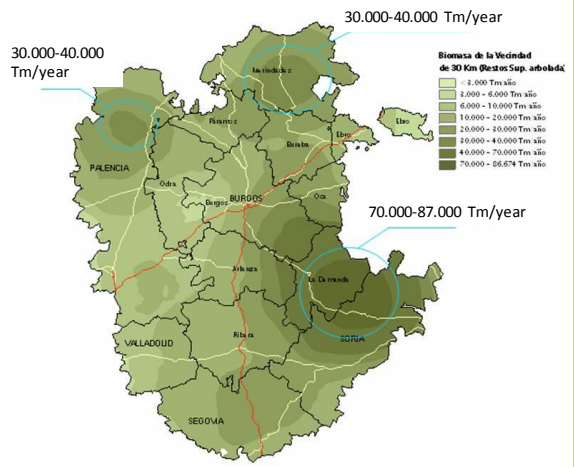
disciplinary areas and inter-sector solutions. Utilities play a big role because they are core actors in the energy efficiency activities and innovation. According to Danish Energy Agency, utilities are responsible for more than 50% of the annual energy savings in Denmark.
The Capital Region of Denmark, both as a business enterprise and as a regional player, will invest in creating a fossil-free metropolitan region by 2050. Between 2012 and 2015, green business has increased by 20%. Despite the financial crises, many local clean-tech companies grew, half of them hired additional employees.

Case study Greater Manchester – The Low Carbon Hub

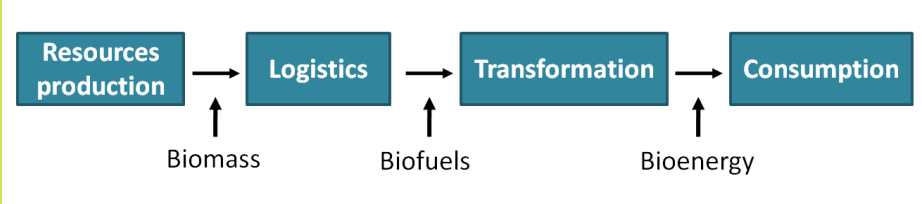
In Greater Manchester climate change and transition towards a low carbon economy are led and coordinated through the GMCA Low Carbon Hub (with the Greater Manchester Combined Authority acting as city-region with common planning competences). The Low Carbon Hub is working towards a target of 48% reduction in carbon dioxide emissions by 2020 based on a 1990 baseline. This target was inherited from the Greater Manchester Climate Change Strategy (2011). In addition to this central carbon reduction target, the Low Carbon Hub has 5 headline goals which are being addressed through fived themed and two crosscutting work programmes each with its own key goals and an annual work programme:
transport (1), energy (2), buildings (3), natural capital (which includes adaptation and environmental quality concerns) (4), consumption and production (5)
and two underlying economically driven themes: low carbon and environmental services sector growth (a) and skills development (b).
Activities and progress undertaken by a range of public, private and third sector partners to meet these goals are currently collated and reported through two Low Carbon Hub action plans – the first running from 2012-16, and the second running from 2016-20. Delivery is overseen by the Low Carbon Hub Board, which meets four times a year and is made up of representatives from the public private and voluntary sector. The Low Carbon Hub Board reports to the regional authority as one of its six boards.
The Low Carbon Hub is a light structure (around 10-12 people) that co-ordinates people and resources funded by a variety of mechanisms and makes them work better together. The Low Carbon Hub itself co-ordinates these partnership activities through specific themed groups which lead delivery on each of the crosscutting work programmes. The remit of these activities is wider than either carbon reduction or low carbon economy and is more accurately focussed on environmental sustainability. The addition of the two crosscutting themes in the Low Carbon Hub's work programme can be seen as to reflect the increasing national policy focus on economic growth. The strong focus of Greater Manchester to address climate change and economic growth ambitions together also leads to a firm involvement of the private sector in regional governance through the Business Leadership Council and the Local Enterprise Partnership. These regional stakeholders advise the regional authority and provide a forum to have a single conversation with business leaders.

Case study Burgos: Biomass-Tool, value chain for local use

Burgos is very rich of forestry products. Nevertheless, most of the biomass is exported because the local demand is lower than the production. Hence the energy agency of Burgos (AGENBUR) is aiming at generating a higher demand of biomass in order to close the circle extraction-production-use within the province of Burgos.



As large parts of the province are clearly rural, most of the peripheral villages are losing population due to insufficient jobs. Supporting biomass as a local resource provides a chance for generating local jobs, to put local biomass in value and to increase the use of renewable energies.



In order to support this value-chain, a tool has been elaborated, providing information for planning for all kinds of biomass, all types of energy conversion (electric, thermal and mechanical) and all models of bio-business.

AGENBUR is also active in knowledge transfer and dissemination and has published a biomass atlas providing updated information on the biomass potential within the region. The web-tool (including an aerial image and GIS maps) presents the assessment of availability and costs of extracting forest and agricultural biomass in the region.

(http://sync.cesefor.com/agenbur/flash/export.php?rid=1)

Strategies as low carbon related regional clusters, Technology Districts (D.I.T.N.E., Italy[52]) and Smart Specialization Strategies represent other relevant forms of regional partnerships with the economic sector for the implementation of a low carbon economy.

> *"There are some examples of clusters within the energy sector such as the South Transdanubian Energy Cluster which unite organisations with interest in the energy sector, to promote cooperation, to improve competitiveness, to support presence on the domestic and international markets, as well as to increase the efficiency of energy consumption of consumers. The cluster is also supporting energy consciousness, attitude forming activities and social involvement, Alternative energy producing systems, energy*

[52] 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)

efficiency and building engineering developments, complex energy efficiency and energy production advising for public and office buildings and residential communities.
Further develop cluster networks – the SMEs can decrease their competitive disadvantage by forming cooperative alliances, since on account of their size they are often unable to organise the individual activities required for successful performance in the market. Cooperation will enable the SMEs to unite their comparative advantages and overcome the relative disadvantage of the individual firms. There are a number of positive examples of cluster formations supporting green economy development of local SME's that could be further supported and developed." (Greeco, case study Southern Transdanubia)

"Technological Districts are bodies that foster the integration between the knowledge resources of universities and research centers and the innovation needs of companies in specific technological areas. They have been formally created in some Italian regions, including Apulia, thanks to a State-Regions agreement.
DITNE (National District for Energy Technologies) created in 2008, is the cornerstone of the energy strategy of Puglia and since 2012 and also leads the recently created Energy Cluster. D.I.T.N.E was set up in Brindisi, with the aim to strengthen contact and scientific cooperation between research and industrial institutions, strengthen competitiveness of the region, international wide visibility and encourage quantitative growth of business and skills in the field of renewable energy and production of electricity. Its main goals are:
DiTNE, in synergy with DHITECH (for hi-tech) in Lecce, District of Mechatronics of Bari and DARE of Foggia (for food), will help to create in Apulia, a public-private research network and technology transfer in the field of energy. DiTNE promotes development and production of new components, constituting in this way, a strong and strategic choice for sustainable industrialization at the national level as well as in the Apulian Region.
According to the GreenItaly 2012 report (Fondazione Symbola – Unioncamere, 2012), thanks to this programme, many companies have made investments in the green economy that would not have been made otherwise, considering the barriers that SMEs have to face when operating in isolation is such an uncertain context of operation." (Greeco, case study Apulia)

"It is also important for the local and regional authorities to pay attention to the need for positive incentives and institutional framework to promote cooperation in networks and clusters, including technology centers/institutes of technical and vocational training, to encourage cooperation between public funded support agencies and private venture capitalists. The regional/local level are therefore a very important functional unit of economic activity and thus for business development.
It is the level at which small and medium sized companies can benefit a lot from the physical proximity to other businesses and make effective use of a specialized public infrastructure. Within a limited geographic area, such as a region or part of a region, it is easier to develop trusting relationships – A form of 'social capital' – which significantly facilitates the spread of experience based knowledge and information. It is important that the region meets this need to create and maintain the tacit knowledge that exists in this cluster." (R4GG, case study Noord-Brabant, peer review)

"One approach to developing incentive and support systems for business is through energy clubs, networks and partnerships. These are strategies that primarily support and involve businesses, e.g. in the field of energy efficiency. Certificates and awarding schemes are tools and means to enthuse the economy to take steps toward acting in a sustainable manner or even become forerunners and role models in their sectors.

The different approaches for successful cooperation with the business sector throughout the ANSWER regions show the variety with which it is lived and successfully realised. The regional projects differ according to local needs and frameworks, but follow generally the principles of transparency, trust and participation as named above." (ANSWER, 2012)

The regional strategy of Navarra (MODERNA) has been stated as one of the early regional smart growth strategies.

"The most remarkable feature of Navarra is that over the last decades it has built a solid policy framework to foster its priorities (i.e. renewable energies in the 1990s, innovation) and monitored the evolution of measures adopted. In this regard, due to the fact that Navarra has its own tax regime, policies such as innovation and renewable energies have been complemented with tax incentives which boosted the growth of both sectors. In addition, strategic investment in R&D infrastructure and continuous support for technology commercialisation has led to a global recognition of Navarra as being at the cutting-edge of renewable energy production. (MODERNA 2013)." (ESPON Greeco, case region Navarra)

"The key features of MODERNA, which could be taken into account by other regions, may be summarised as follows:

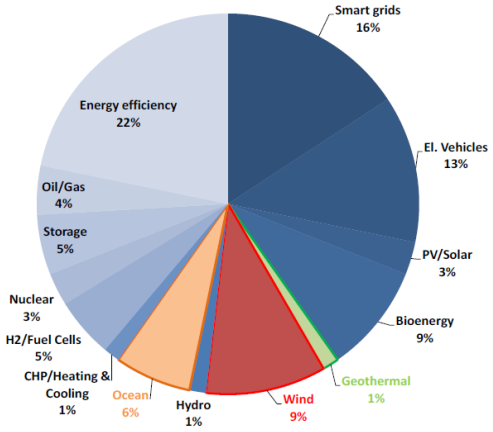
- *It has medium-long term duration, up to 2030, so that it provides a stable and durable framework.*
- *The plan was promoted by the main political, education, business and social institutions, grouped together in the management board of the Plan (i.e. institutional consensus).*
- *It was prepared by a stakeholder consultation process by involving business representatives, citizens, research institutions and public organisations*
- *The first step was to analyse the regional potential Diagnosis. This diagnosis comprised over 1500 interviews. The objective of the diagnosis was to analyse Navarra's economy in the different macroeconomic magnitudes and the performance of its key economic sectors and to assess the contribution of regional competitiveness factors (human capital, infrastructure, innovation, entrepreneurship, etc.). Then, the main challenges to be faced and the strengths and opportunities to prosper in the global competitive environment were identified.*
- *Then a strategy (a vision) to develop regional potential was proposed by an expert committee. This second phase established the long-term vision and objectives of the Plan for Navarra's economy in the coming decades: more prosperity, more human development and environmental sustainability.*
- *Next, concrete actions were proposed to develop the strategy. These actions and specific targets were defined together with stakeholders, in discussion forums, and they were prioritised (short, medium, long term). For that purpose, 14 working groups were formed for each specific cluster and transversal factor, with the participation of 258 agents from the main companies, knowledge centres and public institutions.*
- *A set of indicators have been defined to monitor and evaluate the progress of the action plan as a whole and the evolution of the sectors prioritised.*
- *The MODERNA Foundation was established as an institution for the public-private cooperation in charge of the management of the Plan, with the main objective of carrying on with the previous work done by the agents implied in the design and development of the strategy.*

- *A specific funding model was defined with five tools designed to enhance the development of business projects aligned with the Plan for the different business stages: creation (seed stage), start-up and growth.*
- *It is aligned with EU policy: European Sustainable Development Strategy, Europe 2020, etc. In fact, it some cases it fixes stricter goals (e.g. renewable energies).*

In summary, MODERNA is a smart, inclusive and sustainable growth strategy that aims at changing the economic paradigm of Navarra and by 2030 achieving a leadership position in terms of production, quality of life and environmental standards." (Greeco, case region Navarra)

The European initiative for Smart Specialization Strategies is related to technological innovation and intends to support the implementation of the European Energy Union by the support of (regional) bottom-up activities. This initiative enables regions to engage and exchange knowledge and relevant approaches. According to the report on "Mapping regional energy interests for S3P-Energy", most regions (at NUTS 2 level) show energy technology related interest in energy efficiency (22%), followed by smart grids (16%), electrical vehicles (13%), bioenergy and wind (9% each) (JRC, 2016).

Figure 3.7: Share of energy technology interest at regional level



Source: JRC, 2016

In the framework of the Smart Specialisation Platform on Energy the so called "S3 Energy Partnerships" offer support for interregional cooperation in five priority fields related to energy: Bioenergy, 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)

Support of private involvement

In addition to the involvement of the economic sector, the important role of civil society and involvement of private households in order to achieve the aim of transition of European re-

gions is undoubted. In this context, regional level stakeholders may play a key role as trusted motivators and information source in terms of investment decisions, projects and suitable technologies (esp. for the population in small municipalities without capacities to offer such services).

Case study Greater Copenhagen – Green partnership approach of European Green Capital Copenhagen 2014

As European Green Capital 2014, Copenhagen has created a green partnership, which includes private sector partners and the co-creation platform in Greater Copenhagen. This platform resulted in many projects that contributed to the city development with:

- Establishment of more than 90 new green thematic partnerships
- Execution of more than 250 events, conferences, guided tours and other activities through the year.
- Co-creation of one point entry for green visits to Greater Copenhagen
- More than 60 guided green tours in the year.
- More than 4,800 Copenhageners or tourists took a free electric boat trip through the European Green Capital
- A range of related reports and publications regarding green initiatives and climate were carried out.
- A boost to a range of green start-ups.
- The creation of new full time “green jobs”.

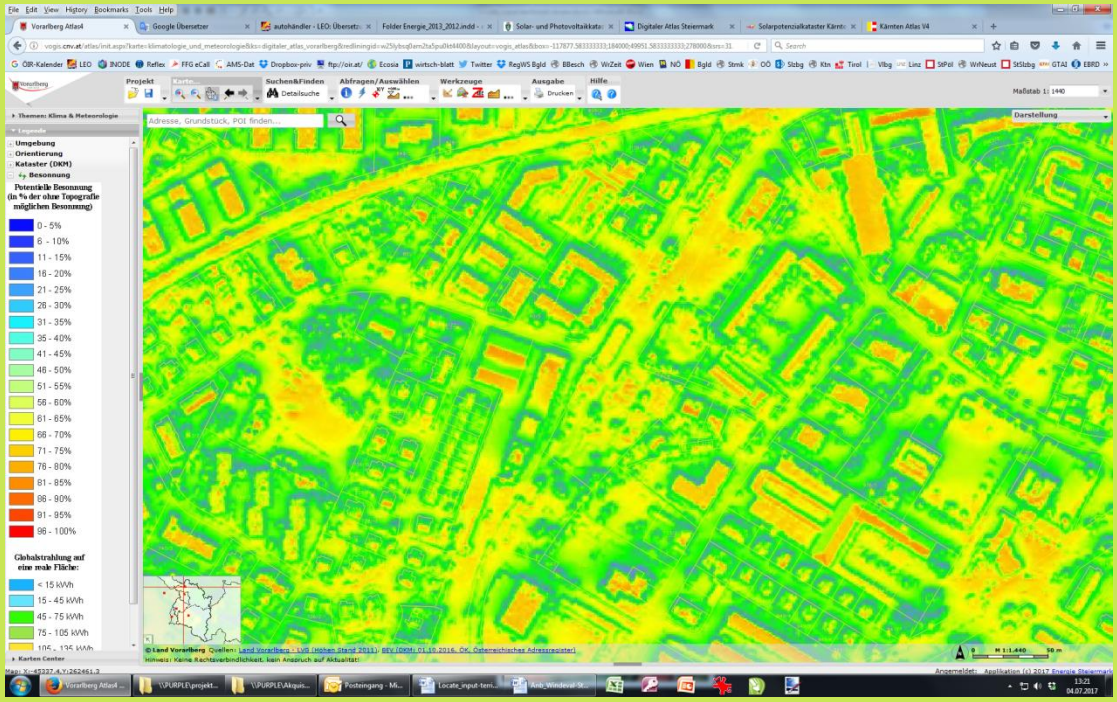
In the initiative of Sharing Copenhagen, the region has collaborated with companies and research institutions in a public-private innovation partnership in order to test and develop new intelligent traffic solutions on the basis of early feedback from citizens and the users themselves.

Case study Rheintal – Solar atlas

The solar atlas is a service of the region and offers landowners and building owners the opportunity to a ex-ante online check whether such an investment in solar energy makes sense. By means of laser scanning, data were determined and evaluated in terms of the orientation and inclination of the surfaces (including roof surfaces) as well as shading through vegetation and surrounding buildings. The local global radiation value was used to calculate the overall solar potential. This overview provides a first impression of which locations are better or not so good for solar use – i.e. whether there is very good or good potential on the areas and roofs of the region.

The service cannot be seen as a substitute for expert advice, but serves as an initial information. It has the potential to convince in case of very good prerequisites and avoids further expenses of private persons and enterprises in the case of very poor suitability.

Figure 3.8: Solar atlas Vorarlberg (detail)



http://vogis.cnv.at/atlas/init.aspx?karte=klimatologie_und_meteorologie&ks=digitaler_atlas_vorarlberg&layout=vogis_atlas

In the recent past, the cooperation with *Energy Service Companies* – ESCOs – has proven successful in many cases. Municipalities as well as owners of large housing facilities, other premises or production facilities may profit from such services, provided by commercial or non-profit businesses. Mostly they combine energy solutions (e.g. energy savings projects, retrofitting, operation of energy infrastructure, power generation and energy supply, etc) 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. Risk minimizing is ensured by the ESCOs guarantee to take over commercial, technical implementation and operation risks over the whole project term (typically 10 to 15 years).

Citizens' energy cooperatives have been documented as another successful approach for involving private households and communities in various regions. These initiatives are often organized and managed either by regional NGOs (representing civil societies' aims and supporting private contributions) or by energy utilities (facilitating private contributions in combination with their obligations related to EED). They may be organized in different models of collective citizen ownership including limited partnerships, stock companies, private partnerships or loans repaid via vouchers. In general, these initiatives provide the option to contribute to the investment for renewable energy production (most often solar PV and wind-turbines) with a fixed financial contribution and return rate within a given period. Such energy cooperatives have been established in the case study region of Rheintal (Austria), providing with the possibility to privately invest in both, in public renewable energy projects (solar use on public

buildings, small hydro plants) but also in financially reasonable private projects providing for small long-term returns on investment, which are screened and accompanied by a regional NGO providing objective information (Locate, regional case study Rheintal).

Case study Greater Manchester – the Carbon Co-Op in Manchester

The focus of the Carbon Co-Op is private owner-occupied domestic low carbon retrofit. First conceived in 2008 and incorporated as a not-for-profit community benefit society "Society for the Reduction of Carbon Limited" in 2011, the group known as Carbon Co-op is made up of private householders interested in improving their homes to 2050 standards. They receive support from Urbed – an urban design and sustainability consultancy company based in Manchester and London which provides discounted rate (between £ 300-600) home energy assessments to Co-Op members. Works can either be taken forward through recommended architectural consultancy services or through DIY approaches. Carbon co-op has so far conducted over sixty whole house retrofit assessments and demand has exceeded support capabilities.

Funding from InnovateUK has enabled the home energy assessment tool to be made available online open source and Carbon- Co-Op are piloting social franchise replication with other community energy groups. The online tool available at: https://openenergymonitor.org is supporting the assessment. As well as assessing what needs to be done, Carbon Co-op offers training in procurement of services and bulk discounts are sometimes negotiated. A series of demonstration homes are being developed through funding from DECC, ECO subsidies on certain measures and access to zero interest loans.

Carbon Co-Op works through community champions, trailblazers and piloteers who are prepared to trial new approaches and snowball interest among others. The group organises information sharing events and connects with other communities to learn from best practice demonstrating. Carbon Co-Op interacts with regional governance through collectively responding to consultation on the approach to low carbon within the draft Spatial Framework and Greater Manchester Climate Change Strategy and National Government through co-ordinating responses to consultations such as the call for evidence on smart systems and energy storage.

Case study Rheintal – Citizens' energy cooperatives

In the region of Vorarlberg, there are two organisations providing the opportunity for private households to involve in energy transition and offering regional added value:

AEEV (http://www.aeev.at/), offering crowd funding/financing for projects, is organized as an association. Its members, sponsors and funders are regional citizens, enterprises, municipalities, other associations and organisations. The association is financed by membership fees, consulting services and additionally sponsored by the government of Vorarlberg. The applied participation model allows citizens to finance sustainable business and get back the invested money in the form of repayment and interest either cash or as regional currencies/vouchers. Since the start of this option, more than € 4 million have been invested in municipalities and companies in citizen projects. It is successful, because it provides advantages for all municipalities or enterprises: it may present a positive image, makes them more independent from bank services, citizens' money works regionally and the population can identify themselves with sustainable actions. The programme strengthens regional economic cycles and supports municipalities and enterprises in order to actively implement sustainable energy and environmental protection projects.

The second organisation, Allmenda (http://www.allmenda.com), is organized as a cooperative. It offers members the possibility to contribute to regional renewable energy projects by crowd financing. The members of Allmenda are private households, companies, but also municipalities and regions who are willing to act as supporters of the energy transition in Vorarlberg. The cooperative provides a platform for those who realize projects and people who want to invest funds into such investments and allows for joint financing in order to realize solar power installations even with little or no public funds. By ensuring professional services, the platform facilitates realization of private renewable installations by

- conducting an analysis of the relevant prerequisites (location, orientation, feasibility)
- providing an offer for financing the installation including conditions and considering available public funds (to be paid in monthly rates), taking over the liability for the investment and
- installing the renewable energy facility and putting it into operation.

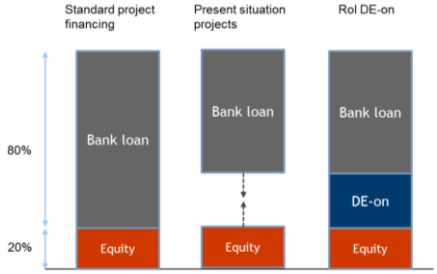
In order to maximise regional added value, the installation is assembled by components from the wider region (defined as Austria, Germany and Switzerland). The members of the cooperative who are financing a project may choose between a 1% rate of return (either cash or provided as regional currency) or to forgo the return in favour of low-cost investments.

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.

DE-on Flevoland is an example for such a regionally set up revolving fund:

> *"They are tuning now a new financial instrument for developing and financing sustainable energy projects in Flevoland. This instrument is a new foundation, called DE-on, that will contribute to projects covering the gap between the equity and the funds from the loans. Next figure illustrates the concept." (R4GG, Flevoland, peer review, https://deonflevoland.nl/)*

Figure 3.9: DE-on mechanism to promote investments in energy projects



Source: R4GG, Flevoland, peer review, 2014

Case study Greater Manchester – Levering private sector funds through revolving loans

The city-region of Greater Manchester Combined Authority (GMCA) is currently in the process of establishing a Low Carbon Investment Fund, which, when operational later in 2017, will use £ 15 million ERDF funding to leverage low carbon investment by the private sector through a revolving loan. This model is only for private sector projects up to 50% CapEx to a maximum of £ 3 million over a period of up to 15 years (due to ERDF regulations). Here the emphasis is on carbon savings and over the whole fund there is a commitment to achieve 10,000 tonnes carbon saving. The model is based on experience of the Greater Manchester Core Investment Fund, which uses public sector sources – Regional Growth Fund, ERDF, Growing Places Fund, GM Loan Fund, and NW Evergreen (JESSICA) funds – to offer a debt-funding programme to support development of commercial property and infrastructure projects.
While, the fund will operate as a revolving loan fund with the private sector repaying loans in full with interest, management of the fund relies in the first instance on funding for staffing coming from ELENA. In future years it is suggested this will be financed from fees on low carbon loans. This is increasingly perceived as a future direction for financing low carbon investment in Greater Manchester. The Low Carbon Fund will run in parallel to the BEIS Heat Network Investment Project (HNIP) which is a UK national programme of £ 320 million over 5 years. As HNIP can be matched with European funds (subject to state aid) it is envisaged as match funding for some of the Low Carbon Fund projects.

3.5.4 Awareness rising, 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 in order 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 to get in contact with the population, capture regional issues, present good practices and specific challenges from the region.

> *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. (GreenPartnerships, The final publication, 2014)*

> *"Abruzzo Region already started the planning of a communication plan. As a result of this activity an animation operation programme, with future actions and dissemination objectives, has been realised. The mission of the programme is to involve all the stakeholders on the territory to stimulate an active participation, together with the institutional, economic and social actors, to the regional policies. The main objectives of the plan are:*
> - *Inform and diffuse all the stakeholder about the energy efficiency and renewable energy*
> - *Support local authorities to define the shared strategies*
> - *Promote the use of the technologies that use renewable energy*
> - *Diffuse the models of efficient energy management*
> - *Stimulate the diffusion of rational use of energy*
> - *Increment the knowledge of the impact of actual energy consumption*

- *Act as a multiplier of the benefits and the expected results of incentive policies provided by the ERDF 2007-2013 in renewable energy and energy saving*

The strategy of the communication plan will take into account the use of the various communication tools available, from traditional flyers and leaflets to the modern newsletters and social networks. Moreover, training and seminars will be organized in the schools on the territory and even some events to involve the citizens to the new policies." (R4GG, case study Abruzzo, peer review)

"Other barriers beside financial for realization of renewable energy projects, like permissions, environmental, resource availability, public opinion and opposition etc. can be solved on regional and local level. It is known from wind power projects that local ownership also mean a higher grade of acceptance, and the creation of a regional organisation for project development and financing would have possibilities to allocate regional financing instruments." (R4GG, Eszak-Alföld, peer review)

"Possible actions can be: i) the creation of a centralised support office, based on a specialised Province energy unit; ii) the supply of standard contracts for committing to private companies the implementation of an energy efficiency programme, in the frame of a Public-Private partnership. The Province of Treviso has recently signed one such contract, obtaining significant results in terms of energy saving and supply of biomass heat to its buildings.

The second possible target are the citizens themselves, who could benefit of an energy desk, operating as front-office to the public, capable of giving information and tailored advice to dwellers and SMEs, for energy efficiency and renewable energy investments, and covering both technical aspects and financial incentives. Clusters of Communes could share the staff of such office, opening to the public for example two days per month in each Town Hall." (MANERGY, case study Treviso)

Case study Pazardzhik – Energy help desk Pazardzhik region

In 2015, the municipality of Pazardzhik (as administrative centre of Pazardzhik region) opened an Energy Help Desk (EHD) that supports citizens by means of counselling activities and door to door energy audits. This initiative was funded by an EU Programme – the Intelligent Energy Europe Programme, and the municipality intends to retain the operation of the desk beyond the project end. Two professional energy advisors provide consulting services at the Energy Help Desk. These services are offered to citizens of the region of Pazardzhik and include:

FIESTA energy audits for families to make families aware of their own energy consumption and identify energy saving measures which can be implemented by beneficiaries. Energy saving measures are split into three categories:

- Behavioural measures – not requiring any financial resources and focusing mainly on information (as e.g. monitoring of energy consumption, changing or adopting of habits, awareness of home appliance settings and regulation).
- Low-cost measures – including replacement or purchase of energy efficient equipment, which is affordable for beneficiaries (no significant financial resources).
- Investment measures – new heating/cooling installations, building renovation, etc.

Direct and on-line consulting provides the possibility for consultations regarding energy consumption issues, possibilities for installation of RES heating/cooling systems, and measures to reduce energy consumption at home. The EHD is open at least 2 working days per week, and citizens may receive energy consulting services either at the office, by e-mail and by telephone.

Organisation of workshops in order to reach a high number of representatives of target groups and to disseminate EHD activities with: (1) Social housing residents, (2) students and (3) local retailers and installers of heating/cooling systems.
Organisation of Consumer Purchasing Groups (CPG) involving a large number of consumers of a certain heating/cooling equipment or system, in order to negotiate better conditions in terms of prices, delivery, installation, and maintenance with local retailers/installers of energy products. After the first successful call the winning company is currently linking with end-users, the selected company gave the best offer in terms of: price discount for the required EE equipment; installation conditions; and warranty and beyond warranty maintenance.
Organisation of local energy lotteries to attract a large number of citizens to visit the EHD and be informed of its activities. The main messages disseminated to citizens during lottery organisations are: "If you don't save energy, you can't win" or "Saving energy = saving money". Lotteries are being organized in a very attractive way and prizes for winners include only energy efficient devices and equipment.
Dissemination activities like publication of articles in local media, participation in thematic conferences and seminars, several radio campaigns are being performed in order to inform local target groups, distribution of dissemination materials, and organisation of local energy stands during popular local holidays.
So far, the project has been very successful by involving more than 1,500 citizens and with about 160 families from the region who benefit from the various activities and services offered by the EHD. In addition, 20 workshops with children from primary schools in the region, 2 workshops with local installers and maintenance companies in the field of EE and RES products and services, and 2 workshops with representatives of the residential sector have been conducted.

3.5.5 Establishment of a regional energy agency

The professional field of energy consumption, distribution and renewable energy production is changing rapidly, not only in terms of technology but also in terms of costs and legal frameworks. Regional authorities, actors and decision makers are responsible for a wide range of regional development activities and day to day issues, at the same time they are often decisive for the implementation of low carbon development and should be aware of options and solutions in order to be able to consider this information.

Energy agencies can steer and enhance regional activities and support the ongoing need for staying updated. In an evaluation of the value and impact of energy agencies at local and regional level (Matrix Insight and Ecologic Institute, 2010), the authors describe the value of energy agencies by providing information and advice to energy users, technical assistance and policy advice to public authorities, and facilitate the development of local sustainable energy markets. They also highlight that for many of these activities a long-term mandate and commitment from public authorities is necessary.

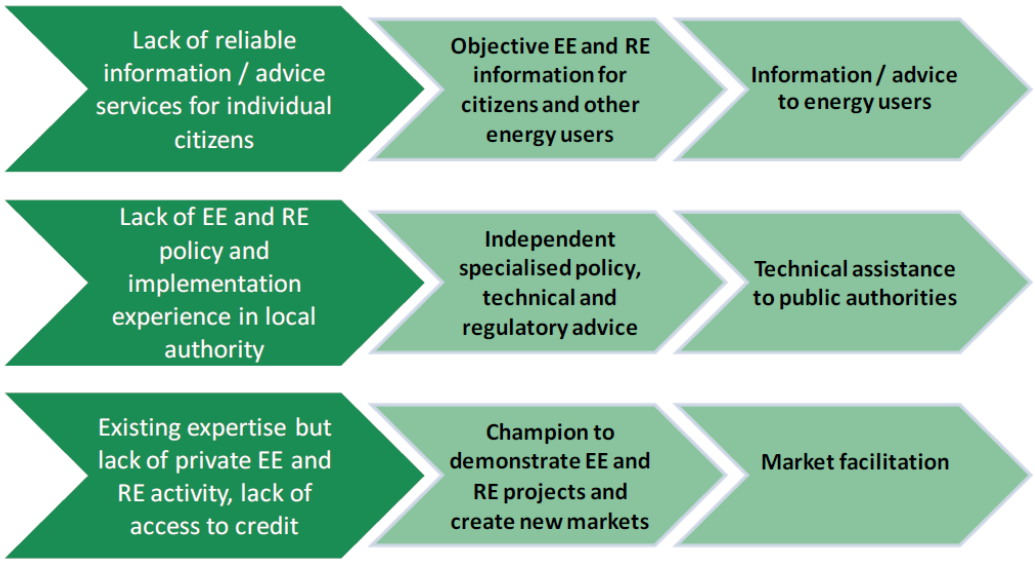
The study highlights three main types of added value from energy agencies for groups of local communities:

- ***"For local energy users:*** *provision of independent information and advice. While there is a growing need at local level, such services are also of little commercial interest, and therefore not readily provided by the market. The added value of these activities lies*

primarily in areas where reliable information and advice for individual citizens are not yet prevalent.

- ***For public authorities:*** *provision of assistance/policy advice including technical assistance and training; advice and training on energy policies and legislation; implementation of local or regional energy policies; setting local rules and defining minimum standards; overseeing the implementation of policies and monitoring adherence to standards; and serving as a catalyst for institutional change in local government and public administrations. The added value of these activities is highest where technical expertise is scarce.*
- ***For commercial actors:*** *market facilitation by providing a platform for exchanging experiences, generating and disseminating innovative ideas and facilitating take-up and piloting innovating market-oriented projects. The added value of these activities is highest where there is a lack of private activity in EE and RE and a lack of access to credit." (Matrix Insight and Ecologic Institute, 2010, pg.5)*

Figure 3.10: The local value of energy agencies



Source: Matrix Insight and Ecologic Institute, 2010

Furthermore, the authors have found different forms of legal and administrative structures of energy agencies, which they classified under four broad models (based on ownership structure, legal status, mandate and financial support):

- *"Model 1: Internal unit or department – fully subsumed in the public authority and publicly financed. This model can work well where the public authority is permitted to employ a dedicated team of energy staff.*
- *Model 2: IEE model – independent, mostly publicly funded, not-for-profit agencies, with a broad long term mandate and mostly publicly financed.*
- *Model 3: Public/private – independent, part-privately funded not-for-profit agencies, with a broad long term mandate and financed both publicly and privately. This model is typically adopted by agencies at the end of an IEE establishment grant in cases where the establishing public authority is unable or unwilling to significantly increase its annual funding.*
- *Model 4: Consultancy – independent, for profit agencies, with a project by project mandate, limited in scope and mostly privately financed." (Matrix Insight and Ecologic Institute, 2010, pg.8)*

The regional energy agency of Pazardzhik (REAP) is one of the IEE funded energy agencies in Europe.

Case study Pazardzhik – regional energy agency REAP

Regional Energy Agency of Pazardjik – REAP was established in 2005 within the project "Setting up of new energy management agencies in Malaga, Massa-Carrara, and Pazardjik", co-financed by the Intelligent Energy Europe Programme and supported by the Regional Administration of Pazardzhik Province.

Main domains of activities of the energy agency in Pazardzhik are:

- Energy audits of small and medium-sized enterprises (SME), residential and public buildings;
- Energy planning and programming at local and regional level;
- Promotion of EE, RES and sustainable urban mobility strategies, policies and practices at local/regional level;
- Dissemination of best European practices in these topics
- To promote international programmes that focus on the financing and marketing of projects which emphasize on energy efficiency;
- Sectoral and horizontal initiatives which aim at fostering rational use of energy, energy saving technologies, and RES;
- Development, implementation and funding of energy efficiency projects through energy performance contracting involving ESCOs;
- Awareness raising campaigns, and training in the area of energy efficiency, RES, and sustainable mobility;
- Collaboration and development of join initiatives with partners from Bulgaria and abroad.

The Agency developed a manual on "Use of local energy sources and improve of energy efficiency in public buildings from Pazardzhik Province". The manual aims to support local authorities from Pazardzhik Province in implementation of energy efficiency measures, and larger deployment of renewable energy sources, and includes the following topics:

- Legal framework in the area of energy efficiency and RES, and rights and obligations which arise for the local authorities from this framework;
- Planning documents which provide opportunities to local authorities to develop projects in the area of EE and RES;
- Financial tools to be used to finance energy saving measures and RES projects;
- Good practices from public buildings

As the local administrations from Pazardzhik Province, especially small ones, lack of administrative capacity REAP offers better approach to integrated energy planning including:

- Identification of local RES;
- evaluation of their economic feasibility if used as alternatives to mineral fuels;
- identifying the municipal energy consumption;
- evaluating (calculating) energy losses in municipal buildings and elaborating proposals for reducing these losses through renovation and automation measures;
- creating local legislations in order to stimulate energy efficiency and RES projects.

Regional energy agencies acting as intermediary bodies are widely perceived as 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. (Covenant of Mayors[53])*

> *Recommendation: "Found and establish a regional energy agency like the Energie- and Umweltzentrum Allgäu (eza!). It can act locally, gives productive impetus regarding energy aspects and comes up with new ideas in regard of climate protection for the concerned region. It promotes energy efficiency, energy savings and an enhanced use of RES. It also serves as an important contact point for the regional residents with respect to energy related topics, like e.g. refurbishment of buildings for house owners or landlords. A public sponsorship is helpful." (CEP-REC, case study Allgäu)*

> *"With experience from several different types of energy agencies the Peer Review Team feels that the regional Agency can develop a lot. First step is to get a staff that could deal with energy issues at a full time basis. This will automatically lead to a more powerful and useful agency. There are some of the questions that a renewed energy agency could handle:*
> - *Deal with investors and companies willing to build RES plants and give them support in the process of getting permissions and other bureaucratic thresholds.*
> - *Ability to set up a regional know-how base for both RES and EE. Special knowledge around refitting of historical housing to get them convenient to live in, without being to energy demanding.*
> - *To be a support for municipalities and to interconnect experience between different municipalities.*
> - *Compose, develop and implement an information strategy.*
> - *Deal with information and information campaigns both to public and to local companies.*
> - *Be a partner with other regions to exchange experiences.*
> - *Be a more substantial lobbyist regarding historical building legislation.*
> - *Responsible for information and showrooms showing the reason for changing from fossil to RES fuels and the utmost importance of EE. Shortly: Decreasing supply of cheap energy from fossil-fuels as one of the big issues to deal with now.*
> - *Initiate and inform about green public procurement, a powerful tool to get a local market for EE products and services and to raise the knowledge in the society of the necessity to rethink around energy issues." (R4GG, Abruzzo, peer review)*

> *"Efforts and initiatives of a relatively small group of people at the regional energy agency in Southern Estonia made a great contribution to popularizing green building and energy*

[53] http://www.covenantofmayors.eu/about/local-and-regional-energy-agencies_en.html

issues. Thus, a great starting point of the development is to ensure that there are the people with the right skillsets and experience in place. In addition, the experience of the regional energy agency showed that providing practical advice and hands-on knowledge directly to the enterprises and public authorities is an effective measure in promoting greener solutions." (Greeco, Southern Estonia)

In general, regional energy agencies play an important role within the 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 at that levels.

Case study Burgos – regional energy agency AGENBUR

Due to increasing energy needs, dependency from energy imports and environmental commitments of public bodies, Burgos Province Government promoted the creation of the regional energy agency AGENBUR in 2003. The purpose of this initiative was to establish a new culture in energy consumption, saving and promotion of RES. Currently four people are working in Burgos Provincial Energy Agency to fulfil the following objectives:

- Increase of the public awareness about the energy sources shortage and their rational and compatible with economical and environmental issues use.
- Promotion of Renewable Energies.
- Development of saving energy policies and promotion of the rational use of energy.

The main activities and services of Burgos Provincial Energy Agency are:

- Supporting actions aimed at the sustainable development of the province (evaluation and analysis of the energy structure, assessment of the potential renewable sources, study on the availability of biomass in the province of Burgos, search for investors in the renewable energy sector, etc.)
- Training, dissemination and promotion activities: information campaigns, good practices, manuals, mass media, conferences, courses, workshops, spreading of the regulation and technological innovations in the fields of energy and environment, etc.
- Technical advising in RES and energy efficiency technologies
- Information for the public sector, companies and citizens about financing programmes, economical incentives and subventions
- Institutional support as intermediary body between public organisations and the actors of energy market, establishing national and international contacts to promote the exchange of information and energy technology
- Development of European projects in different sectors (RES, energy efficiency, transport, biofuels, biomass, etc) under different European Programmes.

3.6 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, the regional level is an important actor within the different forces engaging for a transition of Europe towards low carbon economy, whose contributions provide added value to the actual implementation. In the framework of ESPON Locate, lessons learned from our regional case studies and a meta-analysis of additionally available regional case study reports from previous research projects have been combined. The following *regional actions and policies* derived from this work, have been identified as important and most *successful:*

- *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 implementation 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 have a holistic, cross-sectional perspective and is able to work in an integrated way.* It cooperates with the local level intensively, contributes added value by pooling of resources and finding synergies, and acts as an important linkage between national and European frameworks and the local level.

> *"At the local and regional level, low carbon energy development is, therefore, an integrated pathway where technological, structural and social changes would need, ideally, to be pursued altogether to meet the challenge of a future energy system transformation." (European Union/Committee of Regions, 2011)*

> *"As focus changes to implementation, the importance of the action taken at local and regional level, increases. To have more profound change there is a need for co-operation between committed partners from all sectors of society. Our conclusion is that it makes a difference if the commitment to a Low Carbon Economy is expressed in a long term, high level, regional, vision, and translated into some kind of a 'masterplan'. The 'plans' will differ according to local circumstances, but to get all partners on board, the long term goal must be clear. Political leadership is absolutely essential." (LoCaRe, Green New Deal, Policy Recommendations, 2014)*

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. In order to stir bottom up activities and motivate the local public and economic sector as well as private households in all European regions, this level of action seems significant.

> *"Perhaps the most important lesson is that people as well as techniques and natural circumstances are important sources for renewable energy projects. Maintaining the vitality of the network is a large part of the work in creating energy policy. This leads to new projects and partnerships, local results and support of the internal organisation. In this way, new concepts receive a chance through a concentration of manpower and substantive resources. Showing concrete numbers based on studies of the local potential for renewable energy and energy saving is a necessity. It lays the focus on the regional challenges and helps to communicate EU objectives to residents." (North-Sea-SEP, Final Compendium, 2013)*

> *"The ANSWER project strongly believes that successful cooperation of local authorities and businesses needs push and pull factors, as a well-designed combination of top-down and bottom-up approaches. The different approaches as described above; a basket of various incentive systems, funding programmes, information, trust and dialogue are key to driving the economic sector to act sustainably and thereby to shaping the future in a responsible way. In order to reach as many businesses as possible from different sectors of various sizes and at various stages of development, the basket of approaches needs to be filled with many different options. An easy concept fitting all solutions does not exist." (ANSWER, 2012)*

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 the region towards green growth and a low carbon economy.

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

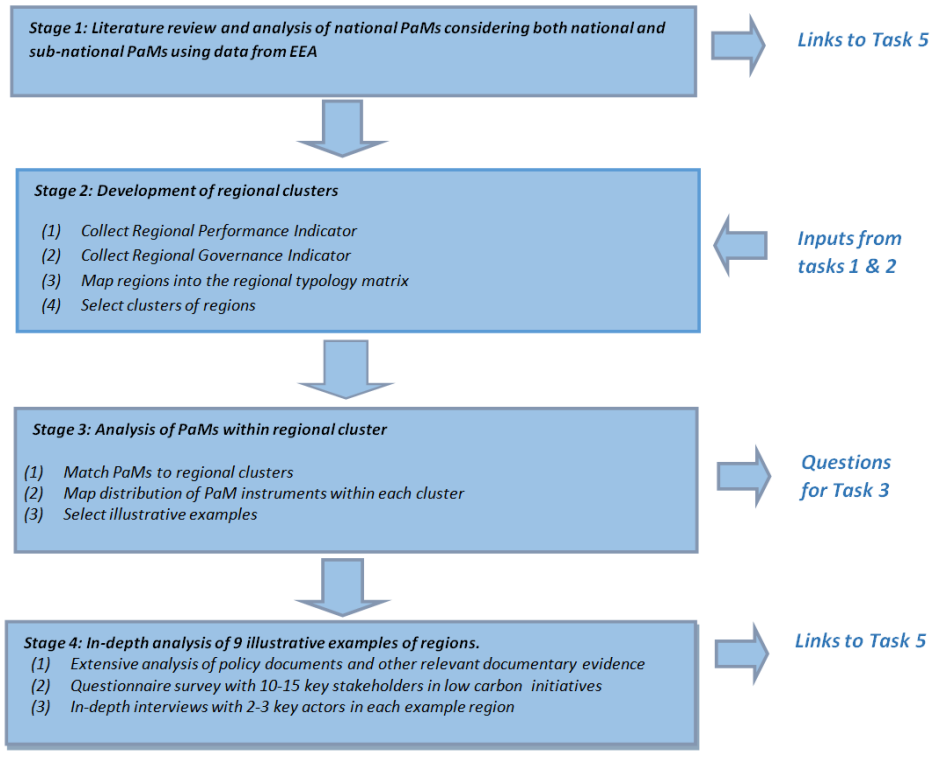
4.1 Introduction: Sources of information, general basis: NUT2-regions

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 the 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 Tasks 1 and 2. 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.

The approach adopted in Task 4 includes four main stages involving mixed, quantitative and qualitative methods. These are:

- Stage 1: Literature review and analyses of national PaMs
- Stage 2: Development of regional typologies
- Stage 3: Selection of illustrative examples
- Stage 4- in-depth study of illustrative examples

Figure 4.1: Task 4 Conceptual diagram



PaMs = short for Policies and Measures. Source: Consortium 2016

4.1.1 Stage 1: Literature Review and analyses of national PaMs

In the last decade there has been a marked increase in national and sub-national legislation, policies and initiatives seeking to promote and enable transition to a low carbon economy both globally (Somanathan, 2014) and across the EU Member States (EEA, 2015). This strategic ambition for transition has often been connected with changes in institutional and governance frameworks including changes to legislation, strategies, policies, planning and coordination mechanisms. Recent changes encompass great diversity in terms of approaches, scales, emphases, and level of implementation as well as success in achieving their objectives.

In some countries, the formulation and implementation of national policies are devolved to sub-national levels with differing levels of central coordination depending on national contexts and institutions. There are also many cases of bottom-up initiatives where actors in cities and regions have added value to national policies and/or led the design and development of their own policies and initiatives. Furthermore, the involvement of the private and voluntary sectors and the local communities have been a key feature of some of these initiatives. Therefore, the sub-national policies and actions on transition to a low carbon economy are often a mixture of the implementation of top-down policies and bottom-up experimentations, leading to multi-actor, multi-level and cross-sector governance.

At the European level, in 2007, the European Parliament adopted a resolution and set out legally binding targets on climate mitigation. This was followed by the Commission's 2008 EU Climate Change and Energy Package 2020 which was replaced by the EU's 2030 Climate and Energy Framework, 2014. The latter builds on the 2020 strategy and is in line with the Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 and the Transport White Paper. The Framework includes measures to achieve what is known as the 20-20-20 strategy which refers to a set of three targets to be met by 2020: 20% reductions in GHG, 20% of energy use to be supplied from renewables, and 20% reduction in energy consumption. The Package mentioned energy efficiency in sectors such as transport, building power generation, transmission and distribution as examples of how the first and the last targets could be achieved.

At the national level, Member States have since been required to develop a national action plan to demonstrate how they will meet these targets, based on their national and regional capabilities (Greiving et al, 2013; ESPON Climate).

While the EU and national targets are important for creating the overall framework and for providing the momentum, the role of the regions should not be underestimated in relation to firstly, the effective implementation of the EU and national policies, and secondly in adding value and creating innovative, bottom-up policies and initiatives. However, there exists a substantial diversity in a) the powers, authorities, responsibilities and capabilities of European regions and b) their social, economic, environmental and territorial contexts. Therefore, firstly the EU and national policies will have different effects depending on the type of regions they

are applied in and their particular geographical contexts; and secondly, the legal, administrative and other capacities of the regions for designing and implementing new low carbon initiatives vary across Europe. For example, the ESPON GREECO Project argues that, “the significance of regions is bigger in larger, more decentralized countries such as Spain, Germany and Italy. Other countries like Sweden and Denmark have weaker regions with limited jurisdiction but do instead have strong city regional governance. The regional/local role is harder to nail in smaller countries without strong regional administrative traditions such as Hungary and Estonia” (p.49 Main Report). This diversity indicates the need for a) the development of a robust typology of the extent and nature of regional governance, and b) in-depth qualitative study of a number of “illustrative examples” representing different types of regions.

Analyses of national PaMs

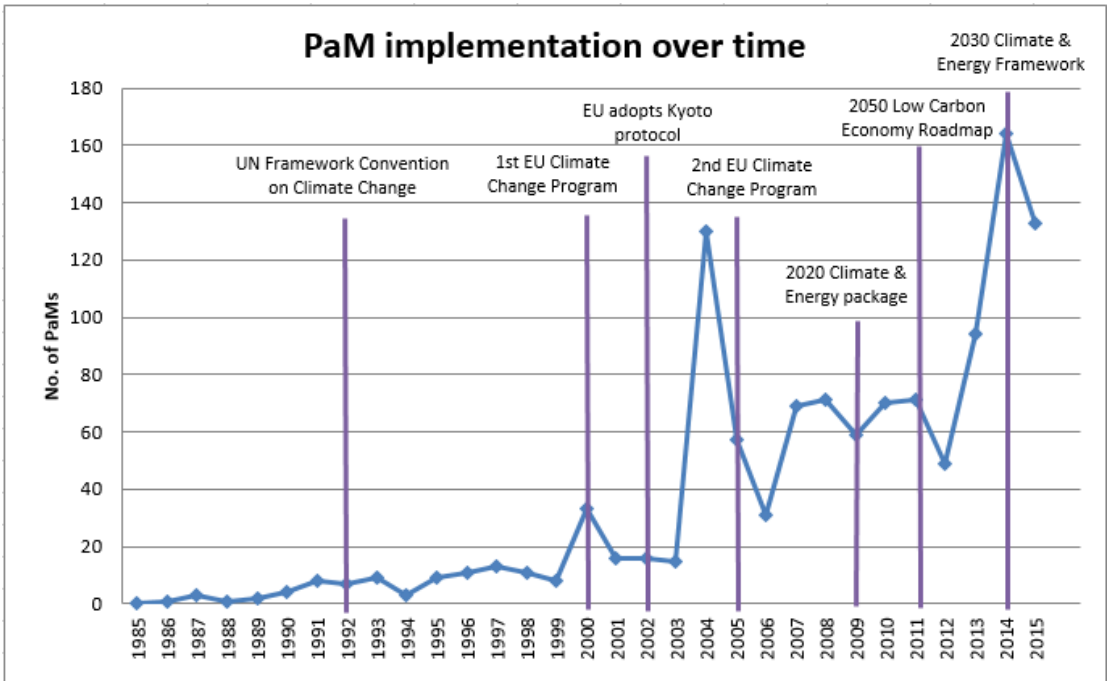
There are a number of databases which provide information on energy-related Policies and Measures (PaMs) taken or planned to either reduce GHG emissions or to encourage the uptake of renewable energy. From a global perspective, these include for example, databases provided by the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), and from a more European perspective, the online database developed by the European Environment Agency (EEA) collating information on climate change PaMs reported by the EU Member States. It is the latter database that has been used in the analyses presented below.

History of PaMs

Following the EU ratification of the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, 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 and hence climate change mitigation. 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 4.2 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 might be due to policy initiatives. The period between 1985 and 1999 shows a very low level of PaM implementation with an annual average of only 9.4, reflecting the relatively low profile of climate change in the international policy arena. The first significant increase in PaM implementation coincided with the first EU Climate Change Programme and the negotiations surrounding the adoption of the Kyoto Protocol in 2000. The EU formally ratified the Kyoto Protocol in 2002 which arguably led to the first peak in PaM implementation in 2004. The 2014 peak could be due to the significant enlargement of the EU and hence the addition of the new Member States’ PaMs to the overall PaM implementation numbers.

Figure 4.2: PaM implementation 1985-2015



Source: Author based on data provided by EEA

The period between 2005 and 2016 shows a much higher level of PaM implementation with an annual average of 83.2. Compared with the previous average of just 9.4, even accounting for the inclusion of 10 new members and their PaMs, this shows a step change in activity since 2004. Climate change and the growing awareness of its potential impacts have almost certainly provided the necessary spur for national governments to make a step change in their attitude to the implementation of PaMs. This analysis shows the importance of international and EU initiatives in driving the climate change agenda. Within the EU there has been a clear mechanism, through the EU Directives and Climate Change Programmes to transmit this urgency down to the national level.

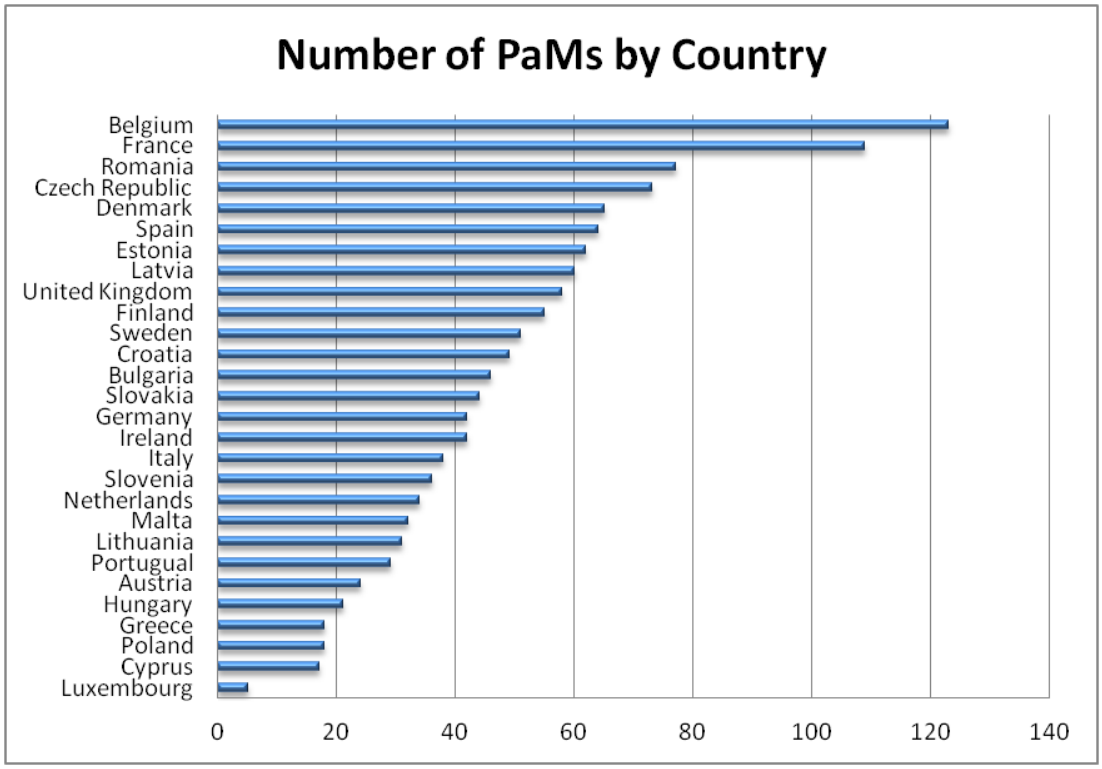
Overview of PaMs

By 2016, there was a reported total of 1323 individual PaMs across the 28 Member States. There are considerable variations in the number of PaMs reported in each Member State. As Figure 4.3 shows, there is a significant range between the lowest, Luxembourg which has introduced only 5 PaMs, and the highest, Belgium which has introduced the highest number of single PaMs at 123, followed by France and Romania. While the size of country seems to be a factor, there remain exceptions. For example, two large countries, Greece and Poland have introduced only 36 PaMs and are the 3rd and 4th from bottom of the list (see Figure 4.3).

In the following sub-sections, we focus on three categories of PaM analyses:

- Types of instruments used for implementation
- Sectors targeted by PaMs
- Governance levels of implementation of PaMs

Figure 4.3: Number of PaMs by country



Source: Author based on data provided by EEA

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 a low carbon economy. This includes: 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 reports use of eight types of policy instruments as listed in Table 4.1 below (EEA: 2015: 25).

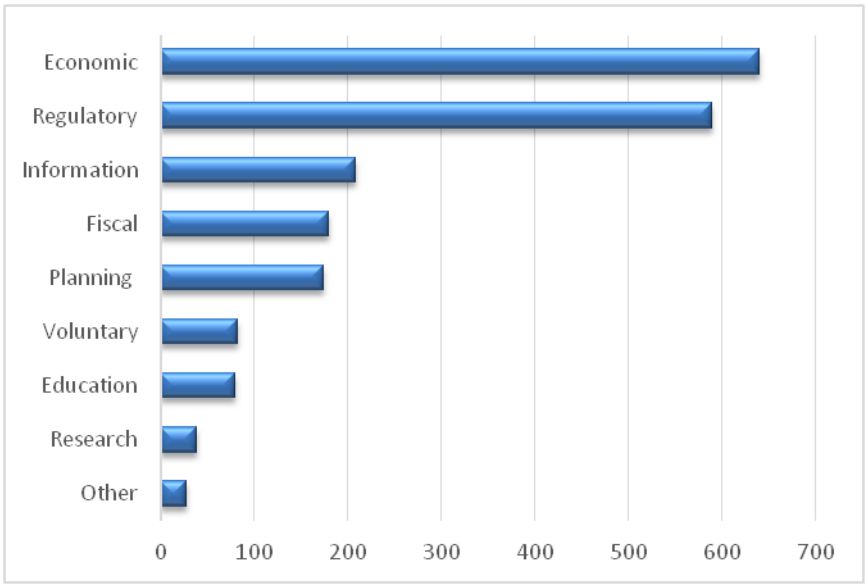
Table 4.1: Types of instruments used in national PaMs

Economic: economic incentives including measures such as: infrastructure programmes, subsidies, investment programmes, feed-in tariffs, loans/grants and trading schemes (e.g. EU ETS).
Fiscal: financial incentives through taxation including both increases and decreases in taxes
Regulatory: measures that set binding standards and regulations such as building regulations or eco-design standards
Planning: measures such as waste management plans, transport plans, urban planning
Voluntary/negotiated agreements: a binding or voluntary standard/regulation as in regulatory and information measures, but agreed between regulators and the sector targeted
Information: measures such as labelling, awareness rising, voluntary standards when the objective is to disseminate information to the general public or to specific target groups
Education: measures such as training programmes and capacity building
Research: research programmes and demonstration projects
Other: measures that do not fit in any of the above categories

Source: Author

The distribution of PaMs instrument type across all 28 Member States is shown in Figure 4.4.

Figure 4.4: PaMs by Instrument Type



Source: Author based on data provided by EEA

As can be seen from the table above there are some interesting differences in the type of instruments used to implement PaMs. Overall, economic and regulatory instruments are the form of instrument most often used accounting for 61% of all PaMs. Research and other category are least frequently used. Economic and regulatory instruments are also dominant across most Member States (21 Member States use them in over 50% of cases).

The choice of instrument a country adopts is usually determined at a national level. Table 4.2 shows the distribution of PaM instrument type for each country. It should be noted that the total number of instruments (2033) shown in Table 2 is greater than the total number of PaMs (1323) outlined above, as a significant proportion of PaMs are reported to encompass more than one instrument.

Most countries seem to favour either financial or regulatory instruments with little use of informal instruments. However, a small minority of countries favour a particular type of instrument. The most extreme case is Luxembourg, who 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). They are installed by the central government but then need further implementation by regional or local authorities. It should be noted that in countries such as Sweden where planning regulates the waste sector, building and infrastructure, the PaMs are classed as “regulatory”.

Table 4.2: Number of PaM Instrument Type by Country

Country	Type of Instrument								
	Financial		Regulatory			Informal			
	Eco-nomic	Fiscal	Regula-tory	Plan-ning	Volun-tary	Infor-mation	Re-search	Educa-tion	Other
Austria	6	4	18	4	6	8	3	5	0
Belgium	38	13	31	15	7	35	4	15	1
Bulgaria	35	2	28	2	0	1	3	0	0
Croatia	21	7	32	4	6	8	3	5	0
Cyprus	4	9	7	3	6	4	0	5	0
Czech Republic	38	7	29	9	6	11	0	5	1
Denmark	37	15	22	0	6	16	0	5	0
Estonia	40	3	20	8	6	9	1	5	0
Finland	16	9	35	7	6	15	2	5	2
France	35	18	22	18	6	21	8	5	7
Germany	11	11	19	0	6	6	0	5	0
Greece	10	9	17	7	6	8	0	5	0
Hungary	16	8	8	6	6	5	0	5	0
Ireland	12	4	17	5	6	9	2	5	1
Italy	18	2	12	4	6	0	0	5	0
Latvia	25	5	20	3	6	5	0	5	0
Lithuania	12	0	14	10	6	8	2	5	0
Luxembourg	0	1	4	0	6	2	0	5	1
Malta	16	2	6	4	6	3	0	5	3
Netherlands	9	7	10	0	6	3	0	5	0
Poland	10	4	17	0	6	2	4	5	1
Portugal	7	8	22	8	6	2	0	5	0
Romania	2	0	55	23	6	0	0	5	0
Slovakia	24	0	43	0	6	0	0	5	0
Slovenia	13	11	19	9	6	14	3	5	5
Spain	18	2	17	25	6	3	0	5	3
Sweden	22	12	13	0	6	5	1	5	1
United Kingdom	20	7	33	0	3	5	2	1	1

Source: Author based on data provided by EEA

Sectors targeted by PaMs

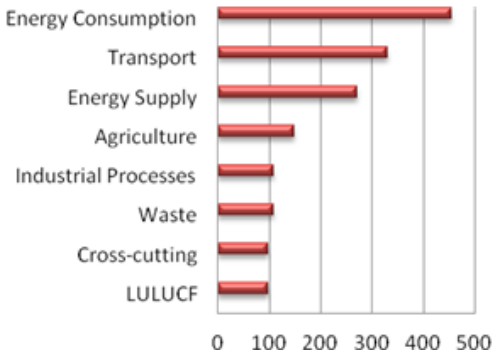
There are seven economic sectors that are targeted by PaMs as main sources of carbon emissions including: energy consumption; transport; energy supply; agriculture; waste; land use, land use change and forestry (LULUCF); and industrial processes. It is possible that a PaM may target more than one sector, meaning that each PaM can have more than one sector associated with it. It is also possible for a Member State to report a PaM that targets more than one sector as being cross-cutting.

The vast majority of PaMs (2/3rds of all) target: energy consumption (26%), transport (23%) and energy supply (10%) sectors. These three sectors are the most important sources of carbon emission in Europe. Sectors that are least targeted by PaMs are LULUCF (5%), waste (7%), agriculture (9%) and industrial processes (5%). These sectors make a relatively smaller

contribution to total carbon emissions. Most PaMs aim to improve the energy efficiency of buildings (18%) and increase the share of renewable energy (11%). Figure 4.5 gives the overall distribution of sectors targeted by PaMs.

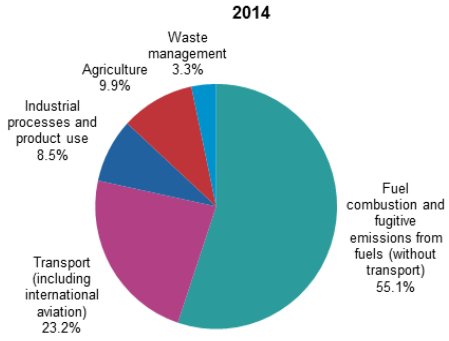
Figure 4.6 shows key sectors that produce greenhouse gases in 2014, with Transport, Fuel Combustion and fugitive emissions from Fuel accounting for 78.3% of all GHG emissions. There is therefore a logical relationship between the number of PaMs targeted at a particular sector and that sector's contribution to total GHG emissions.

Figure 4.5: Distribution of PaMs by Sector



Souce: Author based data provided by EEA

Figure 4.6: Greenhouse gas emissions, by source sector, EU-28



Source: http://ec.europa.eu/eurostat/statistics-explained

However, the overall distribution of sectors targeted by PaMs masks some significant differences between the individual countries and the sectors they target. Table 4.3 shows the sectors targeted by PaMs for each country. The darker orange blocks highlight the sector with the highest number of PaMs for that country, the lighter orange blocks are the second most important sectors with green being the least important sectors or where the sector is not targeted at all by that country.

Most countries have a similar pattern to the overall pattern of all Member States, with the main sectors targeted being Energy Consumption, Transport and Energy Supply. There are however a number of countries which target different sectors, for example Estonia has a significant proportion of PaMs targeting the LULUCF sector. These differences might reflect the specific physical situation of a country, which means that it makes more sense to target the particular sector which significantly contributes to GHG emissions.

Table 4.3: Sectors targeted by PaMs by Country

Country	Energy Consumption	Transport	Energy Supply	Agriculture	Waste	Industrial Processes	LULUCF	Cross-cutting
Austria	11	9	10	6	2	5	0	3
Belgium	46	33	23	7	2	13	2	19
Bulgaria	6	7	12	8	5	1	6	6
Croatia	14	13	17	2	12	8	5	5
Cyprus	5	3	4	1	2	1	1	0
Czech Republic	31	20	18	9	2	4	6	6
Denmark	24	19	14	9	11	3	6	0
Estonia	10	14	13	4	8	2	13	0
Finland	23	10	7	6	6	12	2	6
France	44	40	14	19	4	7	15	2
Germany	20	5	5	0	6	10	0	0
Greece	6	4	4	3	3	1	1	0
Hungary	9	8	7	4	4	0	2	7
Ireland	25	10	8	1	1	1	0	1
Italy	13	8	12	2	1	1	0	0
Latvia	18	8	17	14	2	3	4	0
, Lithuania	3	8	8	4	4	2	5	0
Luxembourg	4	0	1	0	0	0	0	0
Malta	15	5	5	4	5	1	1	0
Netherlands	12	8	5	3	1	0	0	8
Poland	3	4	5	5	3	3	1	0
Portugal	11	13	7	2	1	2	4	2
Romania	24	14	20	10	9	4	4	11
Slovakia	15	7	3	7	3	6	4	1
Slovenia	9	11	9	3	2	6	1	5
Spain	15	24	5	7	6	6	5	6
Sweden	13	16	7	3	1	3	4	10
United Kingdom	25	9	11	5	1	2	6	0

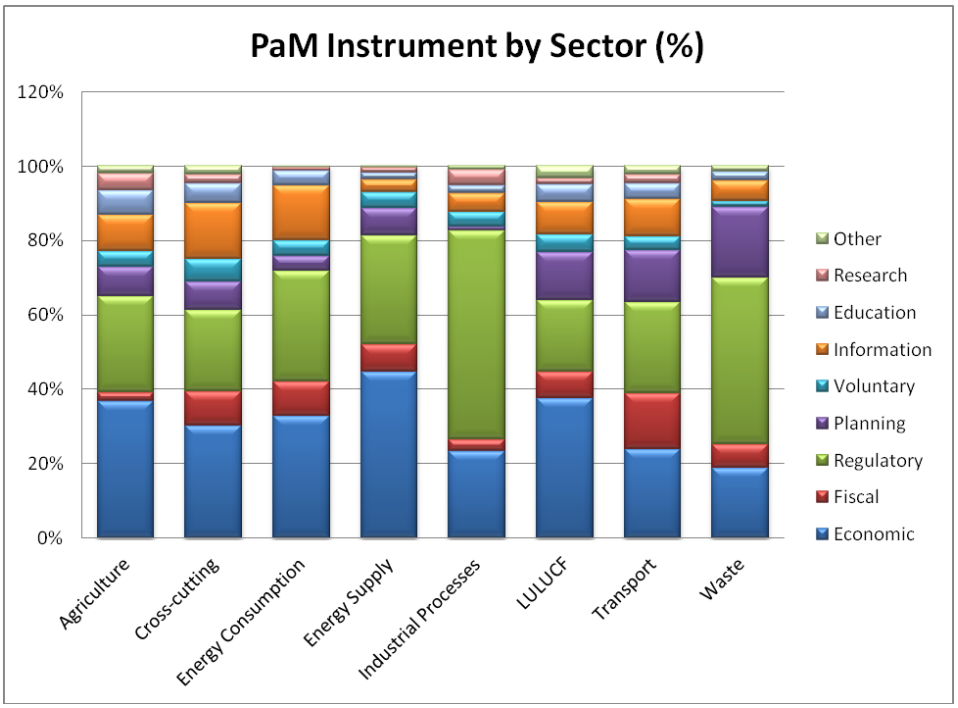
Source: Author based on data provided by EEA

There are also some interesting relationships between the sector targeted by a PaM and the type of PaMs adopted by Member States. Figure 4.7 shows the breakdown of policy instrument for each sector.

The two extremes can be seen between the Energy Supply sector and Industrial Processes. The dominant instrument within the Energy Supply sector is economic PaMs (these are instruments such as feed-in tariffs), accounting for around half (49%) of all PaMs. In contrast nearly 2/3rds (61%) of all PaMs targeting Industrial Processes are regulatory in nature. The nature of the sector clearly influences the type of PaM used to target that sector. Factors such as the distribution of businesses or the types of activity undertaken by the sector will also determine the nature of the PaM that will be most effective in changing practices. Larger industries, such as energy supply, may respond better to regulation. In contrast, sectors which

have a more diverse make-up, such as energy consumption, may have a more even distribution of instrument types, reflecting the differing end users in that sector.

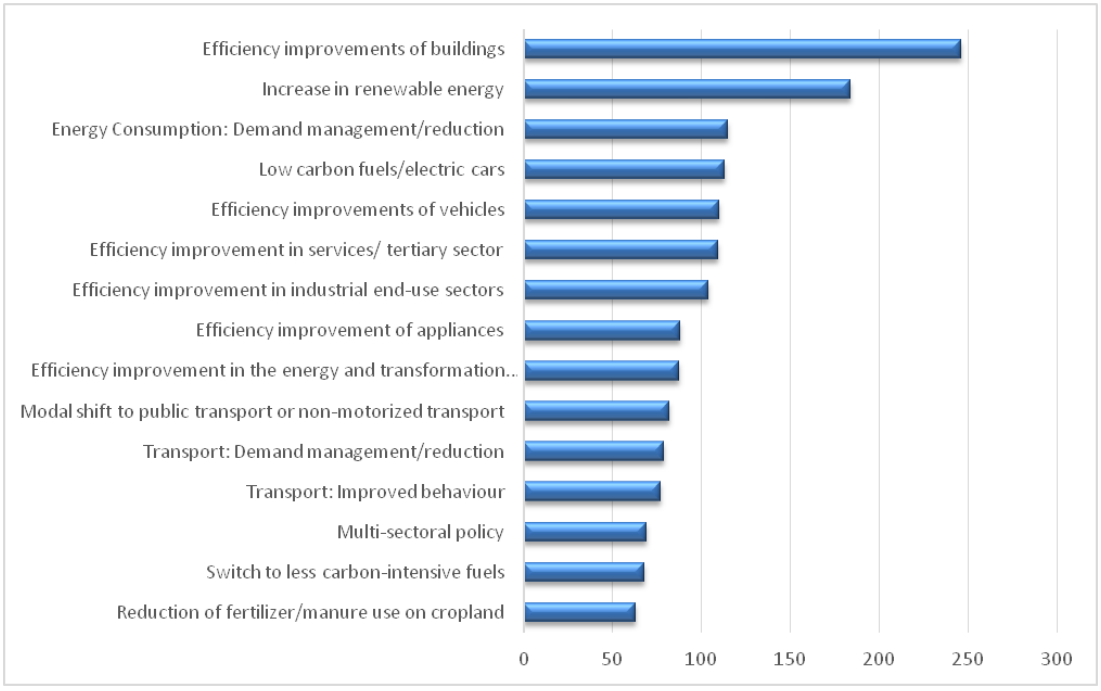
Figure 4.7: PaM Instrument by Sector



Source: Author based on data provided by EEA

The regulatory and legislative structure of a country will also affect the type of policy instrument used to affect a particular sector, as can be seen in Figure 4.8.

Figure 4.8: Number of PaMs reported per objective



Source: Author based data provided by EEA

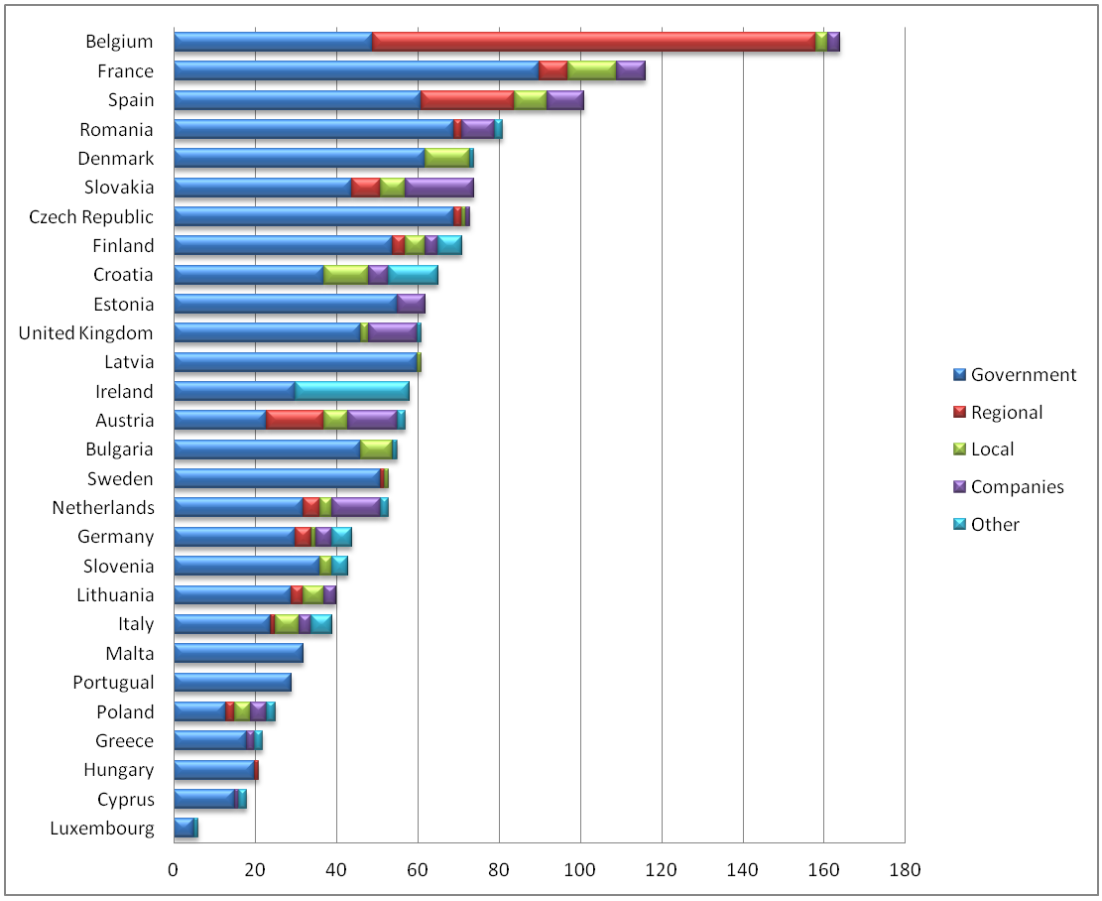
With the switch to the MMR regime in 2015 Member States had specified a particular objective for each PaM, selecting them from a predefined list. This gives a greater level of detail over and above the particular sector targeted

As can be seen from Figure 4.8 energy efficiency of buildings was the objective most often cited in the PaMs. Across the EU, buildings are responsible for 40% of energy use and 36% of CO_2 emissions so it is not surprising that they are a major focus for PaMs. Another important sector is the transport sector, where six of the most reported objectives relate to transport. Transport accounts for around a quarter of the EU's greenhouse gas emissions, so this is also an important sector for all Member States to target.

Governance level for implementation of PaMs

As was shown in Figure 4.3 there is a wide distribution in the number of PaMs each country has implemented. There is also a marked difference in the way each country delegates responsibility to implement the PaMs. PaMs can be implemented by national, regional or local government. In addition, companies can also be responsible for the implementation of some PaMs, often when the EU policy which instigated the PaM has direct effect in the nation states.

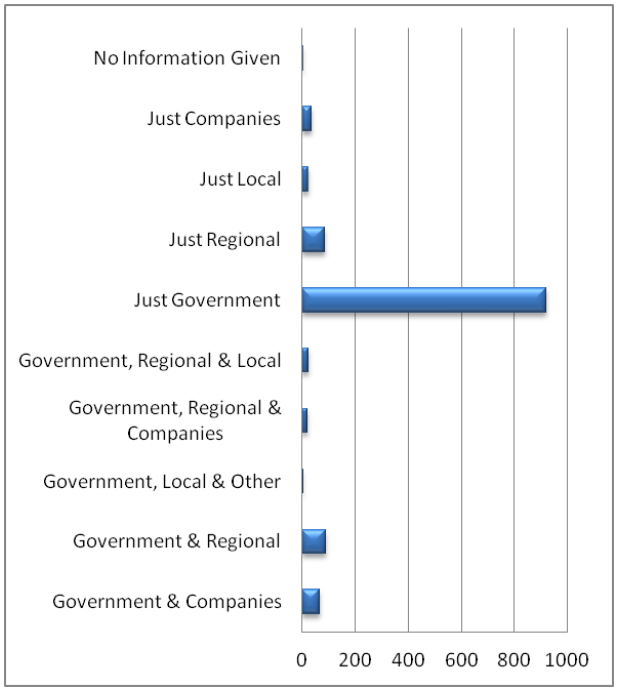
Figure 4.9: Entity responsible for implementing PaMs



Source: Author based on data provided by EEA

Figure 4.9 shows how each country delegates responsibility for implementing the PaMs they are seeking to enact. It is worth noting that the overall distribution is slightly different for the Country level figures, as often more than one entity is responsible for implementation. What is clear from an initial view of the figure is the dominance of national government in the implementation of PaMs. National government on its own is responsible for the implementation of 72% of all PaMs. The regional level of governance plays only a minor role in the implementation of PaMs. This is even more evident when looking at Figure 4.10 which shows the combination of institutions responsible for the implementation of PaMs. Regional government on its own is only responsible for 6.5% of all PaMs.

Figure 4.10: Entity(ies) responsible for implementing PaMs



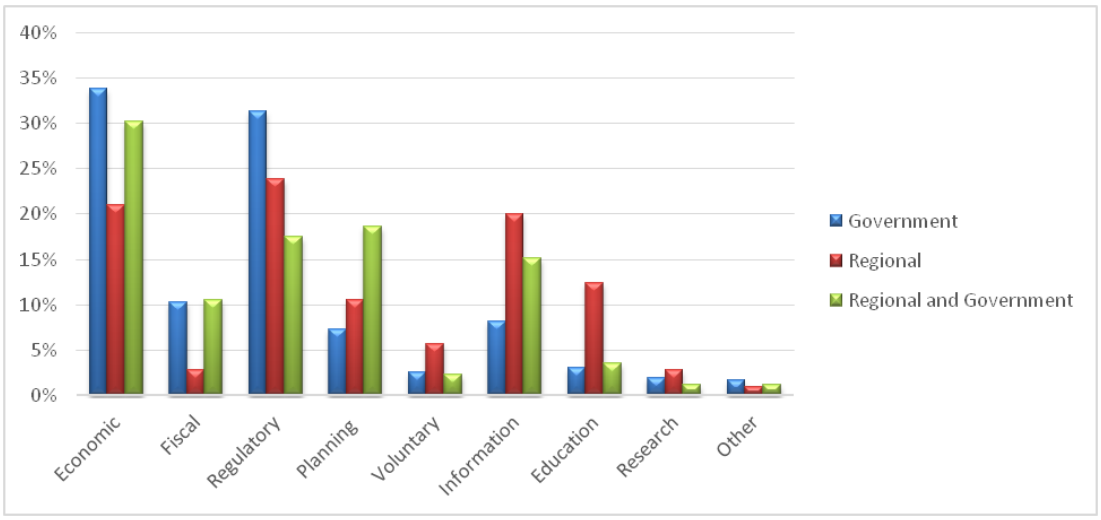
Source: Author based on data provided by EEA

In most other cases the regional level of governance acts in collaboration with other institutions responsible for implementation. The second most common method of implementation is by National and Regional government acting together, which accounts for the implementation of just over 7% of PaMs.

Figure 4.11 shows which PaM instrument types are used by the institutions or institutional combinations responsible for the majority of the PaMs. 82.5% of all PaMs are implemented by either national government alone, regional government alone or a combination of national and regional government. National Governments predominantly use economic and regulatory instruments to implement PaMs. Similarly, regional government use both economic and regulatory instruments but not as much as national government. In addition, regional government use information and education as ways of implementing PaMs. These less formal instruments may reflect the lack of competency that regional governments have in certain sectors and domains. Finally, it is interesting to see that when national and regional governments act in

combination to implement a PaM, planning instruments are used in proportionately more instances. This may be due to the planning systems of Member States, with strategic planning policy being determined at a national level and land use planning determined at a regional level.

Figure 4.11: Instrument type used to implement PaM by institution



Source: Author based on data provided by EEA

The role of EU Directives

As part of the reporting framework Member States are required to state whether a PaM is implemented as a result of EU-wide initiatives or Directives.

Table 4.4 lists the most significant EU policies identified by the 2015 EEA technical report on reported PaMs on climate change mitigation in Europe.

Table 4.4: Most significant EU policies in the development of national PaMs

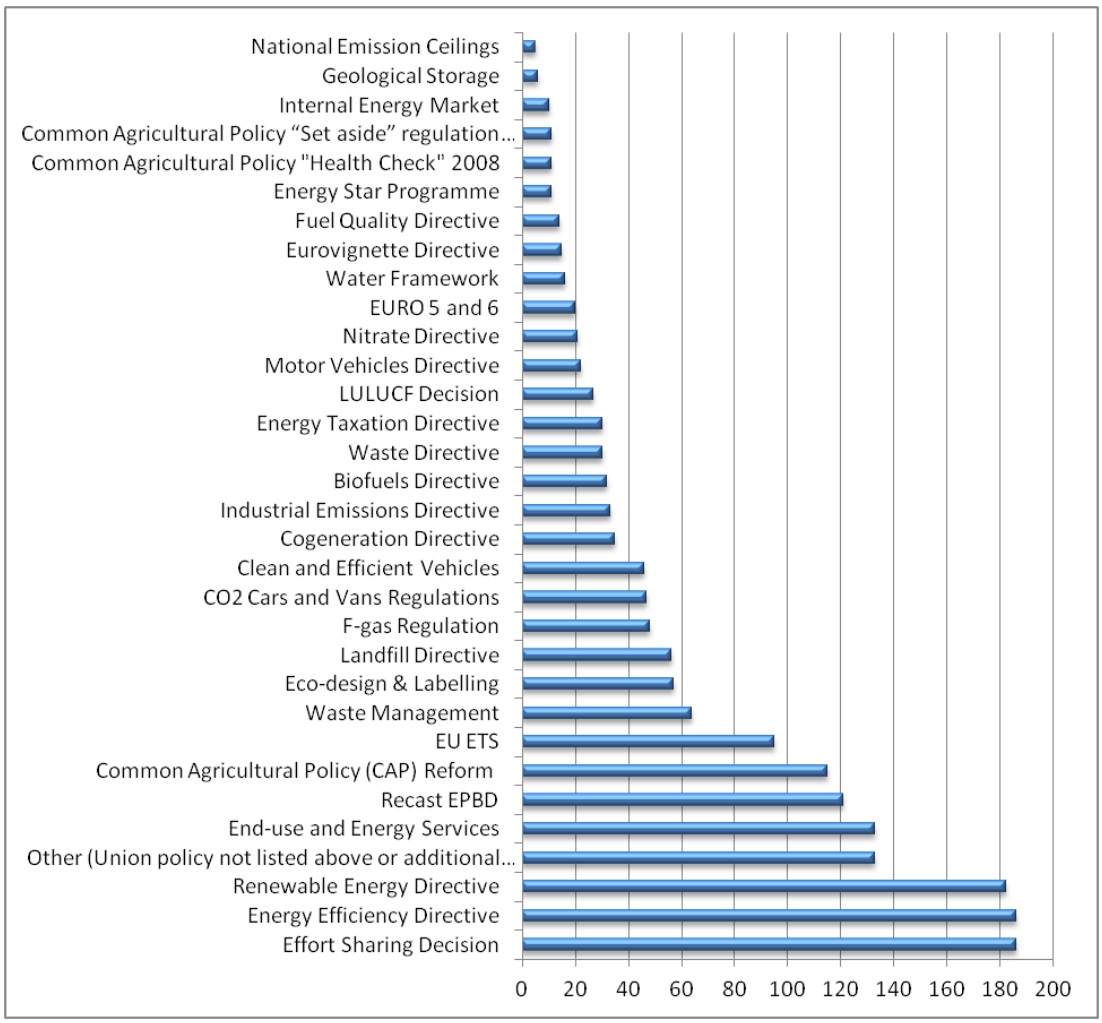
The Renewable Energy Directive (RED), which establishes an overall policy for the production and promotion of energy from renewable sources in the EU, to be achieved through the attainment of individual Member State national targets (Directive 2009/28/EC);
The Energy Efficiency Directive (EED), which establishes a set of binding PaMs to help the EU –and its Member States – reach its 20% energy efficiency target by 2020 (Directive 2012/27/EU)
The Energy End-use Efficiency and Energy Services Directive which sets a framework and conditions for the development of a market for energy savings and the delivery of energy-saving programmes and measures to end-users. Member States are expected to indicate their energy savings target via the preparation of national energy efficiency action plans (NEEAPs) (Directive 2006/32/EC)
The Energy Performance of Buildings Directive (EPBD) which aims to reduce the energy consumption of buildings through a number of measures; for example, the inclusion of energy performance certificates in all advertisements for the sale or rental of existing buildings, and minimum energy performance requirements for new buildings which must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018) (Directive 2010/31/EU)
The EU Emission Trading System (EU ETS) which establishes (improves and extends) a scheme for GHG emission allowance trading within the EU (Directive 2003/87/EC, amended by 2008/101/EC and 2009/29/EC)

Source: Author

The three most important EU-wide instruments that are linked to the implementation of PaMs are: the Effort Sharing Decision; Energy Efficiency Directive and the Renewable Energy Directive.

Figure 4.12 shows the distribution of EU-wide instruments. According to the data, only 22% of all PaMs (291 cases) have been implemented without any direct link to an EU-wide instrument; i.e. that particular PaM was a national initiative.

Figure 4.12: Number of PaMs implemented in response to the main Union policies



Source: Author based data provided by EEA

Summary of PaMs evidence

The evidence presented above shows a clear relationship between international policy initiatives and treaties on tackling climate, its impact on EU level policy and how this in turn is transmitted to national level policies and measures. There is also evidence that the EU principle of subsidiarity, based on which a decision is delegated to the lowest possible and most appropriate level, is working up to the level of national government. The differences at the national level in the type of instrument used and the sectors targeted seem to indicate that PaMs are tailored to fit a country’s particular regulatory and economic circumstances. However, based on the analysis of PaMs, it appears that there has been limited delegation of the implementation of PaMs to sub-national levels. The Member States report that 72% of all PaMs have been implemented by national government, with only 6.5% implemented by Regional Government alone.

National institutional structures, energy efficiency policies and trends

In order to provide a more detailed account and also to fill the gap with regard to the ESPON partner countries which are not included in PaM data base, we have undertaken a desk-based research to complement the analyses of PaMs. The desk-based search focused particularly on results in the English language, including results from policy, academic and grey literatures. The search also focused on reports published by key databases, such as the ODYSEE-MURE and IEA databases and on the EU's database of submitted national energy efficiency action plans. This was done to allow where appropriate, direct comparisons in performance between countries. On this basis, edited extracts from the ODYSEE-MURE and IEA databases are summarised in Table A.3, which presents a brief synopsis of the profiles on energy efficiency policies and trends and institutional set-ups of EU countries and ESPON partner states. The aim was to provide an initial understanding of energy efficiency policy trends in ESPON countries, which will then be used as a basis to inform more in-depth country reviews of the illustrative examples selected in stage 3 of task 4.

Sources: Key sources for the EU and ESPON partner states are included in table A.4 (appendix).

4.2 Stage 2: Development of regional typologies

The aim of Stage 2 was to create clusters of regions based on two factors: the extent to which a region has progressed to a low-carbon economy (Regional Performance), and the degree of regional governance authority (Regional Governance). These are further elaborated below.

Regional Governance

To understand regional autonomy we have used the Regional Authority Index (RAI)[54]. This allows a classification of regions as either having a high, medium or low degree of regional governance authority. RAI is one of the most frequently used tools for comparing and tracking, on an annual basis, the power of subnational level of government across 81 countries (including EU Member States) since 1950. Using two sets of criteria (each including multiple indicators), the index represents the synthesis of the administrative, fiscal and political power of the intermediate level of government. It should be noted that RAI is not a measure of "quality" of regional governance but a measure of the powers available/authorities endowed to the regional level of governance.

[54] 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

The Regional Authority Index (RAI)

It is a difficult task to produce a quantitative measurement of something that is inherently subjective and contingent on a number of socio-economic factors. The team behind the Regional Authority Index has attempted to do this in an open and transparent way. Not only is their underlying data available for analysis, but they have also produced a comprehensive discussion on the rationale of their method, and of the ontology and epistemology behind its construction. For the purposes of this project it therefore offers an important framework for the reliable differentiation of regions within the ESPON Space. In the next section, we will set out and define the terminology used in the RAI. The section then proceeds to provide an overview and analysis of the regions within the ESPON space and their relative autonomy.

What is a region?

This is not always a straight forward question to answer. In federal states such as Germany this is a relatively easy question to answer with the Länder being the regional tier of government. However, in many countries there is no recognised regional tier of government or at the opposite end of the scale more than one tier of sub-regional government. The RAI draws the boundary for regional government at an average population level of 150,000. Below this population level it is assumed that the government is local. There are some exceptions to this rule mainly in relation to autonomous islands such as Åland or Gran Canaria, which are included in the RAI for the sake of completeness.

The RAI is based on 10 dimensions which are divided into two elements: self-rule and shared rule. Table A.1 (appendix) sets out the 10 dimensions (n.b. Executive and Constitutional Reform have two sub-dimensions to them) and the methodology for giving a score for each dimension.

By scoring regions against the above framework it is possible for a region to have a score ranging from between 0 and 30. For the purposes of this project we broke this down into low (0-10), medium (11- 20) and high (21 – 30) regional authority scores. Table 4.5 sets out the scores for the various regions within the ESPON area. Where a country has a uniform set of regions, for example the German Lander, a single score is given for that country. For countries where there is a variety of regional institutional structures, for example in the UK and Belgium, the individual regions are shown in the table. The final column in the table gives the Regional Autonomy Cluster for each region. Cluster 1 includes regions with low autonomy, cluster 2 regions with medium autonomy and cluster 3 regions with high regional autonomy.

Table 4.5: RAI Scores and Regional Autonomy Clusters

	Country	Self-rule	Shared-rule	RAI score	RA Cluster
Mainland Finland	FI	1	0	1	1
HUNGARY	HU	1	0	1	1
SLOVENIJA	SI	1	0	1	1
BULGARIA	BG	2	0	2	1
Continente	PT	2	0	2	1

	Country	Self-rule	Shared-rule	RAI score	RA Cluster
GREECE	EL	2	0	2	1
IRELAND	IE	3	0	3	1
LITHUANIA	LT	3	0	3	1
LATVIJA	LV	3	0	3	1
Combined Authorities (ENGLAND)	UK	5	0	5	1
DANMARK	DK	7	0	7	1
POLSKA	PL	8	0	8	1
ROMANIA	RO	8	0	8	1
SLOVAKIA	SK	8	0	8	1
ČESKÁ REPUBLIKA	CZ	9	0	9	1
CROATIA	HR	9	0	9	1
FRANCE	FR	10	0	10	2
London	UK	10	0.5	10.5	2
NORGE	NO	12	0	12	2
SVERIGE	SE	12	0	12	2
Wales	UK	9	6.5	15.5	2
Este	ES	11	6	17	2
Nord-Est	IT	13	4	17	2
NEDERLAND	NL	10	7.5	17.5	2
Région De Bruxelles-Capitale	BE	13	5	18	2
Attikη (Attiki)	EL	16	2	18	2
Centro (It)	IT	15	3	18	2
Sud	IT	15	3	18	2
Northern Ireland	UK	12	6.5	18.5	2
Région Wallonne	BE	14	5	19	2
Isole	IT	15	4	19	2
Nord-Ovest	IT	15	4	19	2
Região Autónoma Da Madeira	PT	15	4.5	19.5	2
Região Autónoma Dos Açores	PT	15	4.5	19.5	2
Scotland	UK	14	6.5	20.5	3
ÖSTERREICH	AT	14	9	23	3
Canarias	ES	14	9.5	23.5	3
Centr	ES	14	9.5	23.5	3
Comunidad De Madrid	ES	14	9.5	23.5	3
Noreste	ES	14	9.5	23.5	3
Noroeste	ES	14	9.5	23.5	3
Vlaams Gewest	BE	14	10	24	3
Sur	ES	14	10	24	3
Åland	FI	17	8	25	3
SUISSE	CH	18	8.5	26.5	3
DEUTSCHLAND	DE	15	12	27	3
Luxemburg	LU				
Malta	MT				
Cyprus	CY				
Estonia	EE				

Sources: https://www.arjanschakel.nl/regauth_dat.html

The countries below the table do not have an RAI score as they do not have recognised regional divisions or institutions. They fall outside the clusters as they are dominated by national level government.

Regional Performance

We developed a categorisation of regions as being high, medium or low performing in relation to their transition to a low-carbon economy using the analyses carried out in Tasks 1 and 2.

To measure a region's transition to a low carbon economy a synthetic indicator was created using data from tasks 1 and 2. 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 of 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 to 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[55]

Table 4.6: Methodology for the selection of regional clusters

Reg Performance / Reg. Governance	High performance	Medium performance	Low performance
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

[55] 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.

4.3 Stage 3: Selection of illustrative examples

Using the two categories outlined above we assigned regions to the relevant clusters. Table 4.7 shows the methodology for the selection of the final 9 illustrative examples.

Table 4.7: Methodology for the selection of illustrative examples

PaM Instruments / Regional clusters	Financial		Regulatory		Informal			
	economic	fiscal	regulatory	planning	voluntary	information	research	education
Cluster 1 regions High performance & high authority	Region in a country with highest number of financial PaMs		Region in a country with highest number of regulatory PaMs		Region in a country with highest number of informal PaMs			
Cluster 3 regions Low performance &high authority	Region in a country with highest number of financial PaMs		Region in a country with highest number of regulatory PaMs		Region in a country with highest number of informal PaMs			
Cluster 7 regions High performance & low authority	Region in a country with highest number 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

Table A.5 (appendix) shows the full list of regions and their corresponding cluster. Using the data from Table A.5 it is possible to carry out some initial analysis on the distribution of regions across the nine clusters. Table 4.8 shows the distribution of regions across the nine clusters and the Chi-squared cross-tabulation of the matrix:

Table 4.8: Distribution of regions by cluster
*Green Score * RAI score Crosstabulation*

			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

(Pearson chi-square – 45.426; df 4; sig 0.00)

The highest number of regions fall in the Low Regional Autonomy/Low 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 some form of positive relationship 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 seem to make. What is not clear

from this data is the causal link between the two. The inference from our research is that higher regional autonomy results in a stronger progression to a low carbon economy but this cannot be said for certain using these results.

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.

4.4 Stage 4: In-depth study of illustrative examples

Table 4.9 shows the final selection of illustrative examples from the cluster matrix containing the long list of regions (see Table A.5). This was carried out using the matrix outlined in Table 4.8.

Using the synthetic indicator to show progress towards a low carbon economy and the RAI index for each region a long list of regions was assigned to each cluster. Data from Table 2: "PaM instrument types for each country", was then used to differentiate between regions that favoured a particular instrument type. There were some limitations to this method for linking a region to an instrument type, the main one being the PaM data is only provided at a national level with only limited information on its implementation at a regional level. This is problematic for countries such as the UK which have an asymmetric devolution system, with different regions being granted different levels of autonomy.

Table 4.9: Final Selection of regions for example regions

	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	Scotland	Antwerp
Cluster 3	**Switzerland**	**Finland**	***No regions***
High Regional Authority and poor Transition to low carbon economy	Nordwestschweiz	Åland	
Cluster 7	**Czech Republic**	**Greece**	**Republic of Ireland**
Low Regional Authority and strong Transition to low carbon economy	Moravian-Silesian	South Aegean	Southern Region

The final selection of the 8 illustrative examples was done in consultation with ESPON EGTC. We ensured 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 (for example 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 within Task 3 of the project were excluded from the selection of illustrative examples to avoid repetition.

By drilling down into individual illustrative regions within each cluster it will be possible 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. More specifically, for each illustrative example a two stage process was undertaken:

- Review relevant national, regional and sub-regional policies, programmes and initiatives focused on transition to low carbon economy.
- Conduct face-to-face or telephone interviews with a number of key informants representing sub-national government and voluntary and/or private sector depending on the role they play in the governance typology and in low carbon initiatives.

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.

4.5 Illustrative examples

4.5.1 Cluster 1 – Financial: Rheinland-Pfalz – Germany

Introduction

Germany is a federal, parliamentary, representative democratic republic with 16 federal states, also known as Länder or Laender. Each state has its own constitution and is autonomous in terms of its internal organisation. This case will particularly focus on the western state of Rheinland-Pfalz or Rhineland-Palatinate. It borders with the German states of North Rhine-Westphalia, Hesse, Baden-Württemberg and Saarland, and with Belgium, Luxembourg and France. Rhineland-Palatinate covers an area of 19,846 square kilometres with about four million inhabitants. Its state capital is Mainz, also known as the capital of the German wine industry. Other leading industries in the state include the chemical, the pharmaceutical and the auto-parts industries.

Table 4.10: Key Low Carbon Statistics for period 2002-2012, Rheinland-Pfalz

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Koblenz	+5%	107.69	11%	-9%
Trier	+6%	81.63	12%	-13%
Rheinhessen-Pfalz	+6%	237.86	5%	-10%
Av for Laender	+6%	142.39	9%	-11%

The 1949 German Constitution known as Basic Law distributes power between the federal government and the Länder, with each Länder having a minister-president (Ministerpräsident) and a parliament (the unicameral Landtag) complemented by a strong system of state courts.

As stated by art. 28 of the Basic Law, federal state governments must “conform to the principles of republican, democratic, and social government, based on the rule of law”. As such, the relationship between the legislative and executive branches of the state parliamentary republics mirrors that of the federal system.

Legal and Policy context

Germany is often cited as an illustrative example for effective environmental governance, and for renewable energy generation and energy efficiency governance (Kuzemko, 2016; Ohlhorst, 2015; Toke and Lauber, 2007). It is also known for its efforts in leading the global transition to a renewable energy future and low carbon economy, with its flagship energy transition programme (Energiewende) considered “an evolving effort that engages government, private industry and civil society”, inspiring the ambitions of other countries (IRENA, 2015; Moss et al., 2015). The Energiewende represents a process of structural and societal transition, which envisages a strategy for phasing out nuclear power by 2022 and a shift in electricity and heating generation from fossil fuels to renewable sources, with renewables expecting to provide 60% of final gross energy by 2050 (Moss et al., 2015). The International Renewable Energy Agency terms Germany’s Energiewende as unique in its approach, as it aims to maintain economic growth and prosperity whilst transforming the country’s energy system, through technological changes, smarter energy use, better consumer participation, and energy efficiency implementation measures (IRENA, 2015). Developed on wide political consensus, the Energiewende is an evolving process, building on earlier efforts and policy initiatives. Policy initiatives flowing from the Energiewende are the 2010 Energy Concept, which sets the target of Germany’s long term (to 2050) strategy for energy and climate policy; and the 2011 action plan, a portfolio of legislation for transforming the energy system (including the phasing out of nuclear energy by 2022).

Since 2011, the Energiewende has been setting medium and long-term targets, which are to be achieved through strategies and policies developed at both, the federal and Laender level, involving a range of public and private sector groups working in coordination. This is a good example of multi-level governance with National and Federal governments working together to implement PaMs.

The energy transition is a process which is to be agreed between the federal government and the federal states or Länders, which have their own government and regulators. In this multi-level framework, Länders can influence the energy transition in several ways. They can supplement federal government’s legal requirements with their own laws and regulations. They can also set their own targets, for example increasing the share of renewables in electricity supply. Some Länders, such as Rhineland-Palatinate, also use strategic planning processes and have specified a certain percentage area of their spatial development plan to be dedicated for wind power development.

The political and technical coordination of the activities undertaken by the government and states is managed at a number of levels, including the Federal Assembly, the Joint Commit-

tees of the Ministers for Economic Affairs and the Ministers for the Environment and the Conference of Ministers for Spatial Planning.

Regions and local authorities can also set their own energy strategies and goals. As stated by Ohlhorst, “they prefer to control their energy supply in order to enjoy the co-benefits like ownership of renewable energy generation facilities, positive returns on investments, jobs, security of supply, increased independence from rising energy prices, reduced health and environment impacts, as well as citizen’s participation and engagement in community issues (2015, p.312). Further, each Länder also has its own Kartellamt and infrastructure regulator (Kuzemko, 2016).

Review of financial Policy and Measures (PaMs)

This section will use the EEA database of PaMs as a reference, and will focus on financial PaMs. The EEA database lists a total of 42 PaMs for Germany, of which more than half are financial, emphasising therefore the reliance on this type of instrument for enabling the energy transition in comparison to regulatory or informal instruments (see Table 4.2). The dominance of financial PaMs is not too surprising, as Germany supported renewable power generation through financial instruments for many years, at first through feed-in tariffs and more recently moving onto feed-in premium payments and an auctioning system (IRENA, 2015).

Rhineland-Palatinate’s goal is to cover electricity consumption with renewables completely by 2030, with contributions mainly from wind power (about two thirds) and photovoltaic energy (about a quarter). Hydropower will cover around 5% of the state’s power demand, while biomass will provide a balancing role (Ministry for Economic Affairs, Climate Protection, Energy and Regional Planning Rhineland-Palatinate, 2014). The development of smart or intelligent grids and storage systems is also a key goal of Rhineland-Palatinate’s energy policy. Through the “Smart Grids Future Initiative”, in cooperation with the industry and local authorities, the state is supporting the development of smart grids and smart grid management systems (Ministry for Economic Affairs, Climate Protection, Energy and Regional Planning Rhineland-Palatinate, 2014). Another policy includes the development of renewable energies for electricity generation by ensuring favourable conditions for their development and by promoting renewable energy technology. Following the amended Renewable Energy Act (2014), this should be done by continuing to prioritise feed-in for electricity from renewables for which remuneration can be reliably planned for plant operators and investors (ibid).

The importance of authority power in the development and delivery of financial PaMs

The state Rheinland-Pfalz has recognized sustainable energy transition as one of their main priorities. In order to achieve their ambitious goals, the Laender sought to involve actors from various backgrounds such as municipalities, private sector, civil society, research as well as clusters, networks and initiatives, which is set out in the strategy – “Energiewende in Rheinland-Pfalz” (“Energy transition in Rheinland-Pfalz”).The four aims of this strategy are the development of renewable energy, increasing energy efficiency, development of energy con-

sulting as well as of intelligent electricity network management systems and storage systems. Responsible ministry is the Ministry for Environment, Energy, Nutrition and Forests (Ministerium für Umwelt, Energie, Ernährung und Forsten- MUEEF).

Energiewende in Rheinland-Pfalz must be initiated at the federal and state level, but implemented at the local level, with local authorities and companies working together in a technical network. To assist this network, the Rhineland-Palatinate Energy Agency is responsible for providing information on energy issues (relating to the energy sector as a whole, energy efficiency, including energy efficient buildings, renewable energy generation), raising awareness and for offering an advice service to private households. The state is also committed to a citizen supported energy transition, with local citizens actively involved in shaping the state's energy future, acting not only as investors, but as "co-owners with the right to co-determine" (ibid., p.23). Citizen-organised energy cooperatives are one of the ways through which this can occur, with 22 cooperatives established in this state between 2009 and 2012. To assist the development of cooperatives, the state network for citizen energy cooperatives (Landesnetzwerk Bürgerenergiegenossenschaften Rheinland-Pfalz e.V-LaNEG) was established in 2012 with the support of the state government.

Findings from Stakeholder Interviews

There are various programmes coordinated by the MUEEF which are financed in different ways: either financed on the regional level, or are financed or co-financed by the national and EU-levels. Measures from the Laender include PaMs which seek to tackle energy efficiency, information platforms to share knowledge, and initiative to support engagement of citizens and offer common energy systems for citizens and associations.

MUEEF also coordinates a number of financial support programmes to improve the use of renewable energy and to improve energy efficiency; to support investment focusing on biomass, geothermic and solar energy, industrial waste heat and wastewater as energy supply; and to support retrofitting of the street light system into highly efficient LED. This financial support is provided through both grants and loans. In general, the strategy of the state is to exhaust possibilities of financing which are offered and available from the federation and the EU, and use the available state resources to finance additional measures that are not covered at other levels.

Key findings and conclusions

For the state of Rhineland-Palatinate, the energy transition (Energiewende) can only be delivered if all actors (local authorities, industry, academia and citizens) are involved in "… creating and communicating connections, developing innovative technologies, processes and business models in order to strengthen the regional industry and realise specific measures to save energy, increase energy efficiency and generate and use renewable energies as well as enable participation" (Ministry for Economic Affairs, Climate Protection, Energy and Regional Planning Rhineland-Palatinate, 2014, p.27). This ethos of working together through a combi-

nation of top-down and bottom-up efforts to succeed in the energy transition is also echoed at the federal level, with the Federal Ministry for Economic Affairs and Energy (2017) describing it as a "joint task" which should be discussed at "one table".

4.5.2 Cluster 1 – Regulatory: Scotland – UK

Introduction to the region

Scotland is one of the four nations comprising the United Kingdom (UK). As a result of devolution processes, Scotland has achieved a degree of autonomy with the Scottish Parliament dealing with matters that concern the country of Scotland; these include agriculture, education, the environment, health, local government, and justice. By contrast, the UK Parliament and British Government deal with reserved matters, meaning that the UK Parliament retains powers to legislate in Scotland in certain areas of government policy, such as areas of socio-economic policy, including energy.

Legal and Policy Context

Despite the lack of devolved powers in relation to energy, Scotland has been able to develop its own policy strategy in this area more broadly. For example Scotland opposes the development of new nuclear power stations and can implement this through their planning powers. Scottish Government aims to achieve 100% of electricity and 11% of heat from renewables by 2020 (Scottish Government, 2017a) a much higher target then the UK.

Table 4.11: Key Low Carbon Statistics for period 2002-2012, Scotland

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Eastern Scotland	+7%	+4.35	+3%	-8%
South Western Scotland	+7%	+5.91	+9%	-7%
North Eastern Scotland	+4%	+1.67	+2%	-15%
Highlands and Islands	+25%	+1.52	+2%	2%
Av for Scotland	+11%	+3.36	+4%	-8%

It is often stated that Scotland is either outperforming or leading the UK in terms of renewable generation capacity and in cutting greenhouse gas emissions (BBC, 2016). According to Hamilton (2002), Scotland's leadership is due to the political resources invested by the Scottish National Party (SNP), which has made energy development crucial for the economic future of an independent Scotland, with investments in renewables gaining support from all parties (Cowell et al., 2017; Thomas and Ellis, 2017). Further, the existence of major energy development actors in Scotland, such as energy businesses (Scottish Power and Scottish and Southern Energy), national and regional development agencies (Scottish Enterprise and Highlands and Islands Enterprise) and trade associations for renewables (Scottish Renewables), helped create a policy community of consensus around renewable energy which further consolidated Scotland's leadership position (ibid.). It also enhanced the Scottish Gov-

ernment's credibility with the energy sector, and legitimise the powers made available through the devolution settlement (Thomas and Ellis, 2017).

To assist the Scottish Government in the achievement of its targets, in 2009 the First Minister set up the Scottish Energy Advisory Board (SEAB) "for high-level, effective, open and informed engagement between ministers, the energy industry and other relevant bodies on the main challenges facing the energy sector in Scotland". It brings together industry experts, academics, public sector bodies and consumer representatives to work collectively to deliver Scotland's energy potential and secure Scotland's energy future, by focussing on five themes subgroups.

The subgroups have clear terms of reference; are accountable to the Scottish Energy Advisory Board; and, like the Board, they provide advice to ministers and to enterprise bodies on the challenges and opportunities in their particular sector. The five themed subgroups are: (1) Renewables Industry; (2) Oil and Gas Industry; (3) Thermal Generation and Carbon Capture and Storage Industry; (4) Skills Industry; and (5) the Economics and Grid Industry (The Scottish Government, 2011; Scottish Government, 2017a).

Overall, as reflected in Government policy, Scotland's approach to energy and efficiency and renewable and low carbon ambitions is characterised by three main themes. First, it takes "a whole-system view" by prioritising in an equal manner both energy supply and consumption through an integrated approach to power, transport and heat. Second, it is adopting a "stable, managed energy transition", by ensuring that whilst decarbonising the energy system Scotland has secure and affordable energy supplies. This is ensured by continuously supporting innovation and research in renewable energy technologies and in innovative and low-cost ways of producing, storing and transmitting energy. Finally, it takes a "smarter model of local energy provision" by promoting local energy, planned with community involvement and offering community ownership of energy generation (Scottish Government, 2017c).

Overview of PaMs affecting the region

This section will use the EEA database of PaMs as a reference, and will focus on regulatory PaMs. As stated in the methodology, regulatory PaMs include both regulatory measures (i.e. that set binding standards and regulation such as building regulations or eco-design standards) and planning measures (such as waste management plans, transport plans, urban planning). The EEA database lists a total of 58 PaMs for the UK, of which 33 are classed as regulatory, emphasising therefore the reliance on this type of instrument.

With most of Scotland's energy policy being a reserved matter, regulations and the setting of an appropriate regulatory framework are instrumental for creating an energy system that works for Scotland and for the Scottish Government's objectives, targets and high ambitions, whilst continuing to work with the UK Government, the GB energy regulator (Ofgem) and System Operator (National Grid). Though the GB energy market is a single one, regulations can allow the Scottish Government to identify and explore existing and emerging opportuni-

ties within the single GB energy market. Following the results of the Scottish Independence referendum, new devolved powers granted in the 2016 amendment to the Scotland Act will in effect allow the Scottish Government and the Scottish Parliament to take on additional responsibilities and adopt measures for regulating and reshaping the Scottish energy system in a way that suits Scotland's vision.

Land use planning including consenting to energy developments, are almost entirely devolved, granting therefore opportunities for autonomous policy development. Housing is also a devolved matter. This means that as a devolved administration, Scotland has been able to use its powers to relax planning restrictions, resulting in an increased distribution and expansion of renewables and reinforcement of electricity grids (including the expansion of wind energy and blocking of further nuclear power stations), and use its housing powers to increase domestic energy efficiency (Thomas and Ellis, 2017). As stated in Scotland's Energy Efficiency Programme (SEEP), the government's commitment to the Energy Strategy and Climate Change Plan requires ambitious and challenging targets for the decarbonisation of heat supply and reduction of energy demand across the built environment so that it is both, economically and socially sustainable (Scottish Government, 2017d). One of the instruments relied on to achieve this aim are regulations. Over time, their use has increased and resulted in improved efficiency and heat decarbonisation standards of Scotland's building stock. They are said to be favoured by stakeholders as well, as they provide clarity on expectations making investments in energy efficiency and heat, the norm (ibid.).

Another aspect that contributes to explaining the dominance of regulatory instruments is the privatisation of the electricity sector in Great Britain initiated in the 1990s. It created different roles for suppliers, generators, bulk transmission networks, national balancing system and for the regional distribution networks; a regulator (Ofgem) was also created (Shaw et al., 2010). As noted by Cowell et al. (2013), Ofgem oversees the regulation of prices and capital spend by the distribution and transmission companied across the UK, as well as rules for grid access and provision for grid transmission charging. This means that a rich regulatory framework which defines roles, duties, obligations and policy objectives has existed prior to, or during, the development of renewable energy in the UK, and prior to unreserved matters being devolved to Northern Ireland, Scotland and Wales.

Example of a regulatory instrument and its adoption

Renewable Obligations (RO) are the main market support mechanism for trading Renewable Obligation Certificates (ROC). They require electricity suppliers to assume an "obligation", thus to achieve increasing targets of renewable energy, by purchasing ROCs (Ofgem, 2017). As noted by Cowell et al. (2015), a RO has two spatial dimensions. The first is at the UK level, as national government has responsibility for designing market support systems, meaning that ROCs can be transferred within the countries forming the UK, making ROs operate effectively within a single market. The second dimension is that in operation terms, ROs have been broken into separate mechanisms for the devolved nations. This has given the Scottish Gov-

ernment powers to vary the levels of ROC support for different renewable energy technologies (ibid.), whilst tapping into a UK-wide pool of market support (Cowell et al. 2017).

The Renewables Obligation Scotland, known as the ROS, is therefore the Scottish Government's main means of increasing renewable electricity generation in Scotland. Though they work in tandem with identical legislation covering the rest of the UK, in comparison to the UK, the Scottish Government exploited its operational powers and set bands that awarded more ROCs per megawatt to wave and tidal stream power (Scottish Government, 2016). This was done to incentivise the extra costs of these emerging technologies that the Scottish Government was aiming to encourage (Cowell et al, 2015).

The importance of authority power in the development and delivery of regulatory PaMs

According to research conducted by Cowell et al. (2013), Scotland has been quite successful in advancing and leading renewable energy in the UK partly because it has been able to create a policy community arena informed by a certain degree of consensus around the need and benefits for renewable energy generation and energy efficiency, which have facilitated a high degree of territorial cohesion around energy. The Scottish Government, Scottish development agencies, local authorities and major Scottish industries are all part of this arena. The privatisation process of the electricity sector in effect left Scotland with major Scotland-based businesses, including ScottishPower and Scottish and Southern Energy, which contributed to creating a structure in which major corporate players could contribute to the policy process (ibid). Moreover, as noted by Thomas and Ellis (2017), Scotland's ability to exercise its devolved powers and implement change and/or pursue its own vision and energy strategy, has been achieved through alternative modes of governance (e.g. through planning and developing business confidence); and by proactively exercising its legal powers to adjust and set its own goals and targets, though within the framework provided by the UK government (e.g. Scotland's own version of the Climate Change Act passed in 2009, within the framework set by the UK 2008 Climate Change Act).

Findings from stakeholder Interview

Scotland has had to adapt its strategy on implementing PaMs as the regional government's devolved powers did not allow it to deal with energy as a national issue but did allow it to promote energy efficiency and the development of renewable energy development. The Scottish government has been able to develop a coherent narrative around the economic, environmental and social benefits of a transition to a low-carbon economy, in particular around the idea of national self-sufficiency and the circular economy. This narrative has also found resonance in the ongoing debate about greater Scottish autonomy and independence as a sovereign state.

The setting of ambitious targets for renewable energy and energy efficiency also had an important political message both in Scotland and in the wider UK context. Internally the higher targets signalled the importance being placed on this policy domain. It helps concentrate people's minds on the challenges ahead. They also feel they are getting beyond the easy to

reach targets. Now PaMs focus on the more complex and harder to achieve aspects of the transition to a low-carbon economy. These need more political and financial capital from the region and from the wider UK and EU.

Stakeholders confirm that at the moment the region has sufficient autonomy to implement PaMs to transition to a low carbon economy.

Key findings and conclusions

The benefits to Scotland of setting ambitious climate change targets and using Policies and Measures to achieve those targets extend beyond the political to the social and economic. Setting what are often seen as unachievable targets raises the region's ambitions and creates a common framing of the problem. This is particularly valuable once the first stages of the process have been completed and the easy targets achieved. To continue to reach the more challenges targets with the harder PaMs requires political capital that has been developed during the early phases.

4.5.3 Cluster 1 – Informal Instrument: Antwerp – Belgium

Introduction to the region

Antwerp province is one of five provinces that form the Flemish Region of Belgium. In turn, the Flemish region is one of 3 federal regions within Belgium. Belgium has a somewhat unique federal system which devolves significant power and autonomy to the three federal governments. This division of governance reflects the separation between the Flemish and French speaking areas of the country. The regions have competency for environmental matters and are the key institutions determining policy on climate change. The Belgium system is funded on a concept of duel federalism which means that competencies are divided so that each level has a distinct level of control and each can operate independently from each other (Happaerts, 2015). This can be a benefit, as it allows polices and measures to be developed and designed for the specific circumstances of the region. It can also be a barrier to effective action, for example where regions seek to transfer the responsibility for action to another region or where the issue involves complex cross-border activity. An example of this was the delay in driving the Belgium non-Emissions Trading Scheme targets between the federal governments and the Flanders, who developed their own carbon reduction strategy ahead of achieving a national agreement on the matter (Flemish Government, undated).

Antwerp falls within cluster 1 as it is within a region with high regional autonomy and has exhibited significant progress towards a low carbon economy. The low carbon economy scores for Antwerp whilst not in the highest quartile for any of the scores, overall Antwerp scored highly because of its consistency. It was in the 3 quartiles for all measures.

Table 4.12: Key Low Carbon Statistics for period 2002-2012, Antwerp

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Antwerp	+ 0.096	+ 69.55	0.03	-15%

It has also been chosen to illustrate the use of informal measures as Belgium as a whole had the highest level of informal, specifically information, policies and measures.

Legal and Policy Context

As mentioned above the province of Antwerp sits within a three tier governance framework. At the highest level is the national government. Below this sits a regional tier, consisting of three regions: Flanders, Walloon and the Brussels Capital Region. Alongside the regional structure sits a community structure which reflects the social and cultural differences within Belgium. There are three "cultural communities": Communauté Française; Vlaamse Gemeenschap; and Deutsche Gemeinschaft representing the France, Flemish and German cultures within the country. In the case of the Flemish region the community and the regional institutions were merged in 1980. The regional tier of government has exclusive competence in a number of policy areas: provincial and local government; economic development (including the environment); tourism; external trade; infrastructure; energy policy; and agriculture. The national parliament does not have the power of veto over the regional authority (Hooghe at al., 2016).

The Flemish government adopted a Climate Change Policy Plan in 2013. There is a clear link between the regional climate change policies and international climate change treaties with each of the policy plan making explicit reference to the international and EU targets for climate mitigation measures (Flemish Government, undated). Flemish environmental policy is informed by the Milieurapport, an annual State of the Environment report produced for the regional government by a team of scientific researchers. With the exception of the Brussels regions, each region is divided into five provinces with Antwerp Province being one of the five provinces in the Flemish Region.

Overview of PaMs affecting the region

Overall 39% of Belgium PaMs fall within the Informal category with 32% of PaMs being fiscal and 28% regulatory. This is one the largest proportion of informal PaMs across the reporting countries.

The majority of informal PaMs are of the information type with education a close second and research only providing 1 example. It is also interesting to note that only 2 PaMs were bottom-up initiatives developed by the regional authority. All other PaMs reported were implemented as a result of a higher level policy.

Findings from Interviews

Speaking to representatives of the Province of Antwerp, they used an interesting phrase to describe their situation: "lots of autonomy, but no power!" This was a reflection on the lack of

power to instigate regulatory or financial PaMs at the local level. What they do have power to do is take control over their own projects and ensure they become exemplars of sustainability. The example they proposed as an informal PaM is a project called Kamp- C[56]. This a centre for "sustainable building and living". It was developed in an old WWII army camp. It seeks to be an exemplar both through the design and construction of its own buildings and through training others in the methods needed to develop sustainable buildings. There is also an incubator space to help develop capacity in this area of practice and generate an entrepreneurial approach to a low carbon economy. The aim is to reach a wide range of stakeholders from individuals and businesses to local authorities and schools. Education plays a big role in the aims of Kamp-C. This is both for students and individuals as they contemplate building projects.

Informal PaMs of this type aim to bring about a low carbon economy through softer policy structures. Kamp-C operates as both a node in a network and as a network creator, bringing stakeholders together to collaborate on low carbon projects.

The Province of Antwerp has also pursued other informal PaMs. One major initiative is to develop a bulk buying programme for low carbon technology such as solar panels and pass on the lower prices to citizens and businesses in the Province.

Key findings and conclusions

Lacking formal power to develop financial and regulatory PaMs, the Province of Antwerp has looked to more informal measures to ensure a transition to a low carbon economy. Kamp C is a good example of a municipality led initiative which catalyzes a range of stakeholders to tackle a complex issue. The Province has been able to use its own development powers and estate to start a larger project that brings in a wider range of stakeholders. The aim of projects such as Kamp C is to create a critical mass of activity around a particular issue, in this case sustainable development. By acting as a node in a network, the Provincial Government can create an ecosystem of knowledge that fosters the supply of those individuals and businesses capable of delivering sustainable development. Further, by improving the flow of knowledge between the various stakeholders with responsibility for the transition to a low carbon economy, it creates the demand for such sustainable development products and services. Through this process the region can develop and strengthen a more circular economy.

[56] https://www.kampc.be/

4.5.4 Cluster 3 – Financial: Nordwestschweiz- Switzerland

Introduction to the region

The North-Western Region of Switzerland is formed by three Cantons: Aargau, Basel-Stadt and Basel-Landschaft. It borders France and Germany to the north with its main city, Basel being the commercial hub of the region.

Table 4.13: Key Low Carbon Statistics for period 2002-2012, Nordwestschweiz

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Nordwestschweiz	+ 1.85%	+21.54	No data	-14.99%

Legal and Policy Context

Switzerland is a federal state, comprising 26 Cantons, as set out in the Federal Constitution with the Cantons having significant levels of autonomy. The Swiss government, parliament and court systems operate on three levels: federal; cantonal (based on 26 cantonal constitutions); and communal.

One of the departments of the Federal government is the Federal Department of the Environment, Transport, Energy and Communications (DETEC). This includes the Swiss Federal Office of Energy (SFOE) which has responsibility for policy for improving energy efficiency, promoting renewable energy sources, developing the electricity grid, and increasing energy research and international cooperation. It supports delivery of these by producing regulations, for example, on energy consumption of electric appliances. The aim is to ensure that Switzerland will still have sufficient, safe, affordable and environmentally friendly energy supplies in the future (SFOE, 2017a).

Energy policy and implementation is the responsibility of both federal and cantonal governments. In 1990 for the first-time Swiss voters assigned responsibility for efficient use of energy to the Federal government, by supporting the “Energy Article” in the Federal constitution. The Federal government, therefore, develops framework laws and supporting programmes and sets requirements for energy efficient use of appliances and the Cantons are then responsible for policy implementation (Sager et al, 2014). Often the Cantons have to work together to harmonise energy laws and regulations and then transpose these into their own cantonal laws. (ibid.)

Overview of PaMs affecting the region

Of the 19 PaMs identified by the IEA for Switzerland, three are Economic Instruments, two are Research, Development and Deployment PaMs, one is a Policy Support PaM, one is a Regulatory Instrument PaM, eight are a combination of instrument types and there is no information on four of the PaMs (IEA, 2017).

Switzerland was a signatory to the Kyoto Protocol, committing to reducing its GHG emissions by 8% below the 1990 level between 2008 and 2012 (Gerigk et al., 2012). In 2000, a CO_2 Law was enacted that set a joint CO_2 emission reduction target for heating and process fuels and transport fuels of 10% below 1990 levels in the period 2008-2012. Historically energy regulation in Switzerland has given priority to voluntary private-sector schemes, reflected in the number of the energy PaMs adopted in Switzerland before the turn of the last century and in the early 2000s (IEA, 2012). The introduction of "Effective and voluntary" measures, such as the CO_2 tax on fossil fuels in 2008 was a recognition that such voluntary measures have proved ineffective and did not sufficiently contribute to the attainment of energy and climate policy goals (Gerigk et al. 2012; Sager et al 2014). Subsequent to the adoption of the PaMs identified above, the Federal Council prepared an Energy Strategy 2050 following the Council and Federal Parliament's decision to withdraw from nuclear energy production in the wake of the Fukushima nuclear reactor disaster in 2011. The production of the Energy Strategy 2050 was necessary to enable an upgrade of the Swiss energy system SFOE (2017b). The Energy Strategy 2050 is complemented by an initiative, SwissEnergy. SwissEnergy aims to stimulate debate on climate change, to create projects to support the transition to a low carbon economy, the creation of low carbon standards to guide future investment and implement financial support programmes. It is an ambitious programme of initiatives that aim to combine bottom-up activity with top-down resources and knowledge.

Example of an informal instrument and its adoption

Both Basel-Stadt and Basel-Landschaft undertake various measures on the regional level to improve energy efficiency. Whilst the Cantons participate in international programmes such as in Interreg A and B programmes, it is the internal multi-level governance arrangements that are more important in supporting cantons to becoming more energy efficient and using more renewable resources. For example, the platform Energie Schweiz, created by Federal Office for Energy, is an initiator of many projects. One of these is "The 2000-Watt Society" ("die 2000-Watt Gesellschaft") which among others is a label for cities or municipalities who have reached or are on the way to reach the 2000-Watt Society. The goal is to support households to reach a continuous output of 2000 Watt, which would reduce the amount of CO_2 pro household to 1 tonne/year. The city of Basel is participating in the project and earned the label of "Energy city on the way to 2000-Watt Society".

Another label created on the national level in Switzerland, and awarded internationally, is the European Energy Award that supports "Energy cities" which stand out due to their efforts and commitment in regards to energy policies. One of such commitments of Basel-Stadt is reduction of CO_2 emissions in public buildings. In years 2009-2016, Basel-Stadt has implemented 34 projects to reduce and save energy in public buildings. The Federal Office for energy also supports an umbrella organisation called AEE SUISSE which represents 22 trade associations and 15000 enterprises and energy suppliers from areas of renewable resources and

energy efficiency in order to help educate the public and decisions makers towards more sustainable energy.

Basel-Stadt implements further PaMs in order to reach its energy efficiency objectives. In 1999 Basel-Stadt has introduced a steering tax on electricity with the aim to motivate efficient energy use. The collected money returns to the consumers, however, households and companies that use little electricity pay a lower tax, receive the same amount of money back as households or companies using more energy. Incentivized are also enterprises that offer many working places and use electricity in an efficient manner.

Basel-Stadt offers financial contributions for renovations that improve energy efficiency, efficient new constructions as well as renewable energy use. The canton offers guidelines in relation to buildings and renovations to share best practice for energy efficiency, renewable energy and construction standards.

Both Basel-Stadt and Basel-Landschaft cooperate in terms of energy efficiency. For example, together with the Institute for Energy in Building of the University of Applied Sciences of the North-West Switzerland, they organize a free event called Energieapéro with various kinds of information and topics on energy efficiency. In addition to public efforts and cooperation on the regional and national level, there are also many private actors and associations that offer support, as well as information on private financial support for energy efficiency in every canton.

Findings from stakeholder interviews

Whilst the regions are bound by national lows concerning the transition to a low-carbon economy, they are usually formulated in such a way to allow the region to adapt them to their particular circumstances. However, control over financial resources still rests with the Federal Government which can act as a barrier to the regions when seeking to implement PaMs.

Financial PaMs were felt to be the most appropriate option in this region as the research identified building efficiency as being the most important area for intervention. The financial PaMs could be targeted at building improvements and renovation of existing building stock. These measures do seem to have been successful though there has been no formal evaluation of the programme.

The balance between the national laws and their implementation at the regional level was felt to be working well and the stakeholders did not feel any further devolved powers were needed at the present time.

Key findings and conclusions

As with the German illustrative example, the federal nature of Switzerland's constitution means there is a framework which allows multi-level governance to operate. Whilst EU PaMs do not apply to Switzerland they have their own nationally derived PaMs which seek to satisfy their obligations under the Kyoto Protocol. The financial PaMs outlined in this example balance the top-down national laws and regional initiatives that are specific to the region. There

is also an acknowledgement that financial PaMs on their own may not be sufficient. In parallel information PaMs have been implemented to ensure the maximum benefit is derived from the financial PaMs. As with other illustrative examples there is evidence that these PaMs are designed through a collaborative process which extends well beyond the regional authority.

4.5.5 Cluster 3 – Regulatory: Åland – Finland

Introduction to the region

Åland is an archipelago of Islands off the south coast of Finland. Although part of Finland, it has strong cultural ties to Sweden. In terms of governance, Åland is a "special autonomous region" (Hooge et al., 2016) which was granted autonomy in 1920. The region covers 60 inhabited islands with a total land area of 13,325 km^2 (ÅSUB, 2016). Åland has a population of 28,983 with the majority of the population living in the main town of Åland, Mariehamn. The population of Åland is very stable with 65% of residents having been born in Åland.

Employment within the region is dominated by the public sector, which accounts for 34% of overall employment. Tourism and Transport are also significant employment sectors.

The presence of a major business in the region also has a significant impact of the economy of Åland. Viking Line, the passenger transport company based in Åland is a significant employer and contributor to the GDP of the region. Shipping in general is a very important component of Åland's economy, as it benefits from being able to sell products tax-free on its ships (Kinnunen & Lindström, 2010).

In terms of its transition to a low carbon economy, Table 4.14 shows Åland has made only limited progress on the key measures used in this report. This is partly due to the fact that Åland imports a significant proportion of its electricity from Sweden and to a lesser extent Finland. With regard to its domestically generated energy, until the millennium generation, using oil made up nearly 2/3rds of the supply. This has now been phased out with wind being the dominant generator of electricity. This transition took place prior to 2002 and therefore does not appear within our data.

Table 4.14: Key Low Carbon Statistics for period 2002-2012, Åland

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Åland	0	+0.22	0	-11%

Legal and Policy Context

Åland is a semi-autonomous region in Finland. Its status within the Finish national structure is due to its close cultural relationship to Sweden and a history of political conflict between Sweden and Finland over control of the Islands that make up Åland. They gained their autonomy in 1920 and have remained self-governing ever since.

Åland has extensive competency over a range of policy areas including over taxation, education, environment and industrial matters. The island has its own legislature, the *lagtinget*, which is directly elected by the population of Åland every 4 years. Within the Finish constitutional system, Åland stands out as having a significant level of autonomy. Whilst Åland joined the EU at the same time as Finland's accession, it did not join the Tax-Union and therefore enjoys certain tax benefits over neighbouring Finland and Sweden. There are some tensions between Åland's interests and the national Finish interest when it comes to EU policy. The dominance of Åland as a shipping cluster is not matched by any national interest in this sector. This can cause conflict in relation to the response to EU PaMs around the low carbon economy as they apply to shipping and maritime transport (Lindström, 2005).

At a national level climate change policy is shared between the Ministry of Economic Affairs and Employment and the Ministry of the Environment. In 2015 Finland passed the Climate Change Act which enshrined the commitments made under the Kyoto Protocol, to reduce its greenhouse gas emission by 80% of the 1990 level by 2050. The long-term goal of Finland is to become a carbon neutral society.

The national Government has produced a number of strategies to deliver these long-term ambitions. In 2013 a National Energy and Climate Strategy was presented to parliament. Following this, in October 2014 a "Energy and Climate Roadmap 2050" was produced by the parliament. This set out the broad goals of policy and a framework within which they could be achieved.

Overview of PaMs affecting the region

The majority of financial PaMs implemented by the Finish national government were derived from EU legislation. These were implemented through the national tax system and other financial measures such as support programmes for energy efficiency and feed-in-tarrifs to support renewable energy.

At a local level, Åland has sought to develop a vision for the sustainable development of the Island. This was initiated in 2014 when the Parliament of Åland adopted the Åland in Transition – Strategic Planning for a Sustainable Future 2013-2051. Building on this initiative, in 2016 a Forum for Social Development was convened by the network bärkraft.ax. This network had the ambitious goal of bringing together everyone one living and working in Åland to develop a vision and set of strategic development goals for the Island. In all seven goals were identified for Åland: Happy people who use their resources sustainably; High levels of trust and equal opportunities to participate in society; All water is of good quality; Ecosystems in balance and biological diversity; Åland is attractive for visitors, residents and businesses; Significantly higher proportion of energy from renewable sources, plus increased energy efficiency; and Sustainable and mindful patterns of consumption and production.

These seven goals are then monitored though a series of indicators and are overseen by a steering group made up of stakeholders from the parliament of Åland, businesses based on

the island, representatives from tourism and the cultural sector. This group of stakeholders forms the Development and Sustainability Council which meets every year to monitor progress.

Example of a regulatory instrument and its adoption

There does seem to be a degree of tension between the parliament in Åland and the Finish Government which can see Åland left out of certain low carbon initiatives. A recent example of this is the national support programme for wind energy in Finland. Åland's wind energy companies have been left out of the support programme for renewable energy[57]. This has caused some concern that wind energy companies will leave the region and put in doubt their aim to have 70% of their electricity supply from wind. To counter this and fill the gap, Åland's parliament has stepped in to provide their own support package. This example shows both the positive and negative aspects of a high degree of autonomy. There is a risk the region will be left to go it alone in certain matters if the national government decides to exclude the region. This can place a heavy financial burden on the region. On the positive side, it can allow the region to tailor their support to their circumstances and to be a bit more innovative in their approach. In this case Åland has chosen to adopt a "price floor" mechanism to support wind energy.

It was pointed out by a Senior Sustainable Development Policy officer from the *lagtinget* that the Åland in Transition vision derived from the original work carried out under the Agenda 21 initiative. There was a 3 – 5-year process leading up to the strategy to build the necessary understanding between the stakeholders and the citizens of Åland. This cooperation probably would not have happened if Åland was not so isolated.

Key findings and conclusions

Åland has used its remoteness and community spirit to bring together a coalition of stakeholders to develop a clear vision for a sustainable future for the Island. The need to create a strong vision for the transition to a low carbon economy came from a mix of bottom-up pressures and top-down international initiatives. The bottom-up pressures are located in the peripheral nature of Åland and its society. It has a strong history of independence and a political autonomy. This resonates with ideas of self-sufficiency that are found within the discourses of a low carbon economy. Being able to produce energy from its own resources strengthens Åland's position as an autonomous community. At the same time there is a strong acknowledgement that this approach does not mean social and political isolation. Åland recognises its place in the wider world and the contribution it can make to a global transition. This is reflected in the adoption of the Agenda 21 goals and through its participation in other international participatory programmes, particularly with other similar regions.

[57] https://svenska.yle.fi/artikel/2016/04/20/aland-satsar-pa-eget-vindkraftsstod

4.5.6 Cluster 7 – Financial: Moravian Silesian – Czech Republic

Introduction to the region

The Moravian Silesian region sits in at the eastern edge of the Czech Republic. It is one of 14 administrative regions within the country. It has a heritage of heavy industry but also contains some more rural areas of the region.

Table 4.15: Key Low Carbon Statistics for period 2002-2012, Moravian Silesian

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Střední Morava	+29.5%	+28	+14.6%	-4%

Legal and Policy Context

The Czech Republic is one of the successor states to the former Czechoslovakia. It gained its independence in 1993. As part of Czechoslovakia it was also one of the former Soviet Republics finally regaining its independence in 1990 during what was termed the "Prague Spring"

The regions or *kraje*, were devised in 1997 but only became effective regions in 2000. There are 14 kraje within the Czech Republic. The regions have only limited autonomy, having competence in development, transport and tourism (Hooghe, 2016). Regions do have some delegated powers in the areas of education, health and environmental protection. The regions have elected assemblies but have only limited borrowing autonomy and their funding is derived mainly from the national government.

The Moravian Silesian region is home to the largest coal mine in the Czech Republic. The OKD mine is one of the largest employers in the region and has a significant impact on the regional economy.

Since independence, the country has adopted a number of strategies and polices to tackle the issues of climate change and take steps towards a low carbon economy. In 2010 a Strategy for Sustainable Development was published which broadly followed the Bruntland aim for a balanced sustainable development (Jirous, 2013). This was followed in 2012 by the Czech National Renewable Energy Action Plan. The latest policy on Climate Change to be adopted was the Climate Protection Policy of the Czech Republic which was adopted in March 2017 which replaced the previous National Programme on Climate Change which had been in force since 2004.

So far the Czech Republic has been able to meet its commitments under the Kyoto Protocol due to its transition away from heavy manufacturing and a shift towards gas as the major source of energy for domestic and business users.

The Czech Republic is facing a number of challenges as it seeks to transition to a low carbon economy. It has the second highest level of energy intensity within the EU[58]. It has also chosen to pursue a policy of switching to nuclear power rather than renewable energy to decarbonise its economy.

Overview of PaMs affecting the region

As stated in the official summary of Environment Policy[59], pollution is the biggest environmental issue facing the region. This seems to be a significant driver in the shift to a low carbon economy.

Example of a regulatory instrument and its adoption

It has not been possible to find a suitable example within the Střední Morava nor to make contact with suitable informants to conduct interviews with those involved in the development of policy for a transition to a low carbon economy. Efforts were made to contact individuals from the Střední Morava Regional Government.

4.5.7 Cluster 7 – Regulatory: South Aegean – Greece

Introduction to the region

Greece is a diverse country with a population of approx. 11 million people. The country consists of a mainland area and a series of islands and archipelagos of islands (approx. 10,000 in all) of a variety of size. The OECD regional outlook (OECD, 2016) highlights that Greece is one of the most centralised of all OECD states when it comes to government spending. Politically however, Greece has had a varying degree of regional governance with first regional representatives of national government and later more devolved administrations.

In recent years Greece has been dominated by the financial crisis, although as we will investigate later this has presented opportunities as well as threats for the country in terms of its transition to a low carbon economy. Greece suffers a low GDP and employment rates than the rest of the European Union and OECD but has lower levels of inter-regional variation than other countries. Recently there has been moves to strengthen the power and responsibilities of the regional management authorities (OECD, 2016). This is complemented by moves to adopt more bottom-up sustainable development measures through the Rural Development Programme and LEADER initiatives.

The South Aegean region is one of 13 regions within Greece and is comprised of many islands to the south east of mainland Greece. There are three main clusters of islands: The

[58] Using the latest figures available as per 2012

[59] https://wtd.kr-moravskoslezsky.cz/assets/zivotni_prostredi/environmental-policy-of-the-moravian-silesian-region.pdf

Cyclades which consists of around 220 island in the south east of the region; the Dodecanese with 12 major and 150 small islands in the south-eastern part of the Aegean Sea and the remaining area in the north of region. In administrative terms the region is divided into 13 smaller municipal units.

As with other Island regions, the South Aegean region faces significant barriers in its path to a low carbon economy. The lack of good grid connections means the connection of renewable energy into the system can be difficult. There is also a tension between low carbon development such as renewable energy with their significant impact on the physical environment and the main economic activity in the area, tourism. According to a review of renewable energy and sustainable development in the Aegean Region (Mondol & Koumpetsos, 2013) there is a significant opportunity to transition to a low carbon economy both through renewable energy, particularly wind and solar power, and through energy efficiency measure in the building stock.

Table 4.16: Key Low Carbon Statistics for period 2002-2012, South Aegean

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Νότιο Αιγαίο (Notio Aigaio)	+10%	12.7	+4.7%	-11%

Legal and Policy Context

Greece has two levels of governance: the Peripheries and the Nomoi (Prefectures). Nomoi were created in 1950 and were originally led by a centrally appointed prefect with a council of representatives. In 1994 Nomoi were decentralised and given greater autonomy with control over issues such as regional development, education, transport and health (Hooge et al., 2016). The Peripheries were created in 1986 as a way of managing EU development programmes and sit between the state level and the Prefecture level.

The Kallikratis Programme, more precisely the New Architecture of Local Government and Decentralized Administration of Greece (Greek law 3852/2010), reformed the administrative division of Greece in 2011 and redefined the limits of the Local Government units, the way they elect their Bodies, and their responsibilities. Key aspects of the Kallikratis Programme are: the reduction of the number of Municipalities and their legal entities by about 2/3; the replacement of the 57 Prefectures as secondary level Local Government Organisations by the 13 Regions; the establishment of decentralized regional administrations; changes in the way of financing the Local Government Organisations; the increase of the duration of the mandate of the Local Government Bodies from four to five years; and the redistribution of the responsibilities of each level."

The move to a low carbon economy is a key element in the response to climate change. Greece has created a National Climate Change Adaption Strategy (Ministry of Environment and Energy, 2016) which highlights the need not just for practical action but also governance

changes. The comprehensive strategy looks at all sectors of the economy and highlights the particular problems and opportunities for the island regions within the country. Greece also has a number of Frameworks of Spatial Planning and Sustainable Development which relate to both the national situation and regional level. Unfortunately many are only available in Greek and therefore it has not been possible to analyse these further.

Overview of PaMs affecting the region

Interestingly all but one of Greece's PaMs reported in 2016 contained some form of regulatory element. It was for this reason the Southern Aegean region of Greece was chosen to illustrate an example of regulatory PaMs in the transition to a low carbon economy. What is not clear from this to what extent other types of PaMs are under reported. Based on a review of the international initiatives such as the "Small Islands Initiative" or DAFNI Network of Sustainable Greek Islands, there seems to be a number of more bottom-up initiatives. This is particularly true in relation to renewable energy PaMs, which aim at creating smart grids to manage low carbon energy on isolated islands. In 2008 the Aegean Energy & Environment Agency was formed to act as an advisor to the Aegean Islands as they embarked on the transition to a low carbon economy. A number of studies have highlighted the challenges and opportunities facing the Greek Islands in general and the South Aegean region in particular. The National Climate Aciton Plan highlights climatic changes, lower rainfall and extreme weather events, coupled with sea-level rise as being the most significant challenge facing the South Aegean. Aspects of this can be mitigated locally through adaption of the building stock and measures to protect against sea-level rise. However, wider climatic change can only be tackled through participation in international climate change action. This means reducing GHG emissions in accordance with the various international climate change agreements.

Within the island regions of Greece, housing and energy seem to offer the best prospects for achieving these goals (Mondol & Koumpetsos, 2013) As the data from Task 1 shows, the island regions of Greece have a high renewable energy potential in both wind and solar. Oikonomou et al. (2009) highlight some of the barriers to achieving this potential in relation to wind. One of these barriers is grid connectivity, with many islands having no external grid connectivity. The other barrier is energy storage. Many renewable sources are intermittent and therefore require back-up capacity or storage. Only recently has the electricity storage technology been sufficiently advanced to offer opportunities to complement renewable energy generation. Technology such as hydrogen fuel cells and lithium ion batteries now offer realistic opportunities to smart island grids based on renewable energy.

In addition to the barriers outlined above in relation to low carbon economies there is often a tension between the primary income source for the region, tourism and the deployment of the low carbon economy. Renewable energy can have a significant impact on the landscape and cultural setting of the places where they are deployed. The Framework of Spatial Planning and Sustainable Development for Tourism acknowledges this tension and seeks to balance the two elements.

Example of an regulatory instrument and its adoption

It has not been possible to find a suitable example within the South Aegean Region nor to make contact with suitable informants to conduct interviews with those involved in the development of policy for a transition to a low carbon economy. Efforts were made to contact individuals from the University of the Aegean, the South Aegean Prefecture and through the ESPON Monitoring Committee.

Key findings and conclusions

From a review of the literature examining Greek policy in relation to sustainable development and the transition to the low carbon economy, at both the national and regional level, a number of themes emerge. The first is the relatively low importance placed on these issues in national politics in the period prior the financial crisis. The translation of EU regulations and Directives into national PaMs seems to have been undertaken by way of regulations and national laws. It has not been possible to establish whether the lack of informal PaMs in the data is due to their absence or because there is not a robust methodology of capturing the data and transmitting it to the EU.

In the immediate aftermath of the financial crisis there was a hope that a shift to a low carbon economy could be a partial solution to the financial problems that the country found itself in. Siamanta (2017) highlights how a "green growth" paradigm emerged within Greek sustainable development thinking. This is perhaps logical given the significant potential for renewable energy, both wind and solar, across much of Greece. As with other illustrative examples, peer-to-peer learning seems to have played an important role in the development of sustainable and low carbon strategies for the region. As well as the general regional networks such as the Covenant of Mayors, the region has also participated in more specific learning and support networks for regions facing similar practical issues. In this case it is the geography of the region with the patchwork of islands that is an important factor limiting the region's ability to shift to a lower carbon economy. Networks such as the "Smart Islands Initiative" help develop a shared understanding of the specific problems facing similar regions. These networks also help in making the case for support at a National and EU level for policies and measures that support a low carbon economy.

There is evidence from our illustrative example of more informal PaMs being undertaken at the regional level, for example attempts to create a renewable energy hub on the island of Syros following its connection to the main electricity grid (Zafeiratou & Spataru, 2015). However as can be seen from this project the more informal measures, such as educational initiatives, need to have more formal enabling works, i.e. grid connectivity, to be undertaken beforehand.

4.5.8 Cluster 7 – Informal: Southern Region – Republic of Ireland

Introduction to the region

The Republic of Ireland sits on the western most extent of the European Union. The Republic of Ireland forms the majority of the island of Ireland with Northern Ireland (part of the United Kingdom) being the remaining territory. The Republic of Ireland had no regional tier of government up until relatively recently. Its sub-national government structure was inherited from the UK when the country gained its independence in 1921. The main local governance unit is the county council, and in the urban regions, city councils.

Having been seen as a beacon of growth and development prior to the 2008 financial crisis, Ireland suffered significantly as a result of the crisis. In particular its housing and property market suffered a significant crash which has affected the country's economy. Post-crash Ireland has recovered well with a recent OECD report highlighting the strong progress the country has made on the path to recovery (OECD, 2016)

The example region is the Southern Regional Assembly and Tipparary County Council. The Southern Region contains 9 County Councils[60] which includes Tipperary County Council.

Table 4.17: Key Low Carbon Statistics for period 2002-2012, Southern Region

NUTS LABEL	Exploitation rate PV change 2002-2012	Generation change PV 2002-2012 [MWh/km^2]	Exploitation Rate Change wind 2002-2012	% change Building Energy consumption
Southern and Eastern	0%	+2%	+2%	-23%

Legal and Policy Context

There are three tiers of government within the Republic of Ireland. Below the national government sit 3 Regional Assemblies and below them 31 local administrations. The regional assemblies were created following the reform of local government in 2014. The main responsibilities are in relation to European funding and promoting effective local governance, but have recently been given new powers in relation to regional spatial and economic strategies (RSES). Members of the Assembly are appointed from the constituent local authorities. The RSESs "will provide a long-term regional level strategic planning and economic framework in support of the implementation of the National Planning Framework."

The lowest level of governance are the county councils and city councils. There are 26 county councils, 3 city councils and two combined city and county councils. The regional tier of governance was introduced mainly to administer EU structural policy measures. The regional

[60] The Southern Regional Assembly is made up of the following local authorities: Carlow, Tipperary, Waterford City & County, Wexford, Kilkenny, Cork City & County, Kerry, Clare and Limerick City & County

assemblies are institutions which aim to coordinate the activity of their constituent county and city councils. They have very limited autonomy and decision making powers.

At a national level the Climate Action and Low Carbon Development Act 2015 (The Climate Act) is the primary piece of legislation that determines the Republic of Ireland's strategy on climate change. Under the provisions of the Climate Act a Climate Change Advisory Council has been formed. This is predominately made up of leading academics in the field of climate change as well as senior policy officers from the national government. The Council's remit is "assessing and advising on how Ireland can achieve the transition to a low carbon, climate resilient and environmentally sustainable economy." The Council fulfils this remit by monitoring the activity of the national government, providing regular reports, advice and recommendations to government on the national response to the challenge of climate change. In November 2016, the council produced its first report[61]. The report highlighted three cross-cutting areas it felt more immediate action was needed: reform to the EU-ETS, non-price interventions to tackle behavioural barrier to a transition to low carbon economy and the removal of fossil fuel subsidies. Four sector specific areas were identified for action: renewable energy, home heating and retrofits, transport and taxation and agriculture and land use.

Other agencies of national government are responsible for climate change policies: the Department of Communications, Climate Action and Environment (DCCA&E); Environmental Protection Agency; Sustainable Energy Authority of Ireland; and Teagasc (The Agriculture and Food Development Authority). Each of the institutions has responsibility for developing and implementing policies on climate change and the low carbon economy.

At the lowest level of governance in the Republic of Ireland sits the County and City Councils. These are directly elected bodies with competency over a number of areas of public service. In terms of planning, they operate within a national and regional framework with a hierarchy of plans that the Councils must follow. In the case of housing and development for example, whilst polices on the construction type and energy efficiency of buildings are determined at the national level, they are implemented at the level of the County and City Council. These Councils are therefore integral to the successful implementation of the policies and measures ultimately originating at an EU level.

Overview of Informal PaMs affecting the region

The Republic of Ireland has adopted a series of climate change and low carbon economy strategies and national action plans. Implementation of the policies is done through a top down approach directly through the taxation system and through national policy initiatives such as Feed-in tariffs and indirectly through the planning system. National action plans are

[61] http://www.climatecouncil.ie/media/CCAC_FIRSTREPORT.pdf

cascaded down to the local level via Regional Economic and Spatial strategies and through initiatives implemented by the Sustainable Energy Authority of Ireland and Teagasc.

Most of the informal PaMs implemented in the Republic of Ireland are derived from EU Policy measures. The important of EU level policy measures is also highlighted in the various strategy documents such as the DCCA&E's "Statement of Strategy 2016-2019" and the CCAD's First Report. There is clearly a strong link between international and EU level policy initiatives and national climate change policy development at a national level in Ireland.

Example of an informal instrument and its adoption

For the illustrative example in this cluster we have selected the Tipperary Sustainable Energy Action Plan 2017-2020 (TSAAP)[62]. This is an example of an informal Policy and Measure implemented at the local level, but with strong regard to national and supra-national policy initiatives. The driving force behind TSAAP was the decision by Tipperary County Council to join the Covenant of Mayors 2015. The Covenant of Mayors is a network of local and regional authorities who are committed to voluntarily meeting the EU's targets for climate change and decarbonising their economies. It works on a peer-to-peer basis with opportunities to share best practice, monitoring and benchmarking progress against similar local authorities and the opportunity to influence national and supra-national policy on climate change and the transition to a low carbon economy.

The overall aim of TSAAP is to reduce emissions by 30% from the 2005 baseline year. A wide group of stakeholders, both local and national institutions as well as public and private sector, have been assembled to work together to deliver this aim: Teagasc; North Tipperary LEADER Partnership; South Tipperary Development Company; Local Enterprise Office Tipperary; Limerick Institute of Technology; Public Participation Network; Tipperary County Council and Tipperary Energy Agency.

The Action Plan sets out 32 detailed actions across eight sectors: Planning; Agriculture; Residential Buildings; Commercial and Business; Renewable Energy; Education; Transport; and the Local Authority. Each action is costed and an estimate of its contribution to the emissions target made. The actions range from single education and capacity building events to longer term support and research projects.

Findings from Stakeholder Interviews

Ireland has a weak regional governance structure. This is partly a legacy of the failure of previous attempts to devolve power to the regional level. The national stakeholder interviewed was of the firm opinion that the implementation of PaMs to facilitate the transition to a low carbon economy was a national policy matter. This was justified on the basis that Ireland is a

[62] https://www.tipperarycoco.ie/sites/default/files/Publications/Tipperary%20Sustainable%20Energy%20Action%20Plan%202017-2020.pdf

small geographical space and there is little need to differentiate between its regions in terms of climate policy.

The regional stakeholder interviewed took a positive attitude to the regions' role in implementing PaMs. They argued that the benefits of taking a regional approach was the ability to create a partnership which included the private sector, public sector and the citizens. Through this partnership approach it was also possible to engage with regional academic institutions to benefit from their knowledge and expertise.

The local partnership approach was complemented by an international peer learning approach. Through membership of international networks such as the Covenant of Mayors and C40 Cities, the region was able to share best practice and gain know-how from their international peers. Through this combination of partnership working and peer-to-peer learning Tipperary has been able to develop sufficient capacity to develop its own PaMs to drive forward the transition to a low-carbon economy.

Key findings and conclusions

The Republic of Ireland example highlights the difficulties smaller countries have with devolving policies and measures aimed at creating a low carbon economy down to the sub-national level. It is clear that certain aspects of a low carbon transition, due to their nature, require a uniform approach across the whole country. This is perhaps more relevant for financial and regulatory policies and measures, than it is for informal policies and measures. In the case of the Republic of Ireland the history of sub-national governance seems to still impact the feeling at a national level that the sub-national level is not capable to taking on a strong role. The housing boom highlighted the failure of local government to take a strong regulatory role in governing the physical development of the country (Murphy & Scott, 2013) and as outlined in the interviews a much longer distrust of local governance to implement the necessary policies and measures.

However, despite these misgivings at a national level there is evidence of progress at a local and regional level. The Tipperary example shows that strong sub-national initiatives can be generated from the bottom-up. Given the uneasy relationship between the national and sub-national levels of governance, it is not surprising perhaps that Tipperary looked beyond the Republic of Ireland for the support it needed for its own low carbon strategy. Through the support of the Covenant of Mayors, Tipperary has been able to develop a locally specific and appropriate low carbon strategy. The true test will of course be in implementing the strategy, but the process of bringing together the relevant stakeholders and gaining the political will to tackle the challenge in the first place is a good start.

4.6 Conclusions

This work package has 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. Above we showed how the strong link between global initiatives, such as the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC), are translated into EU legislation and in-turn are adopted at a national level by Member States. The analysis of the EEA's annual returns also shows how this contains a degree of subsidiarity within the process. Member States tailor the Policies and Measures they adopt to their national circumstances.

Using this data on national implementation of EU policies and measures (PaMs) we have selected a number of illustrative example regions to investigate in more detail whether the degree of autonomy a region has can have an impact on its ability to progress to a low carbon economy. The initial finding indicate there is a strong statistical relationship between the level of regional autonomy and progress to a low carbon economy. Table 4.8 showed how there was an 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 elements we are interested in.

To understand the relationship in greater detail, a number of illustrative regions were selected for more in-depth study. These were chosen so as to understand the relationship between regional autonomy and the transition to a low carbon economy and the dominant type of instrument used to implement the PaMs in that particular country.

The illustrative examples have highlighted that the influence of international initiatives extend 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, in the case of Republic of Irelands it came through the Covenant of Mayors. It seems that regions are therefore seeking to look above their National Government for inspiration for their initiatives on the low carbon economy. They are engaging in both the top down, major 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 relationship between the regional and local level and the national level of governance have played an important role in determining the regional response to the transition to a low carbon economy.

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. 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. There is also an interesting link between initiatives to 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 discourse of political autonomy linked to the idea of energy self-sufficiency.

In most, if not all 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.

Provide resources to regions to allow them to develop a framing of the problem in a way that 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. The second theme to emerge from the illustrative examples is the issue of institutional capacity. In this instance capacity refers not just to governance and regional autonomy but also to a wider network of actions through partnership working. The illustrative examples which identify good progress towards a low carbon all show high levels of institutional capacity. This spans regions with and without devolved powers. Future research is needed to investigate the link between institutional capacity and regional autonomy but this research seems to suggest that institutional capacity is as important as regional authority to enable the transition to a low carbon economy.

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 measure to their regions specific situation. This relates no 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 had 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. Building capacity with regional stakeholders takes time to build trust and understanding. This requires a commitment of resources with no immediate impact.

5 Potential support by EU Cohesion Policy

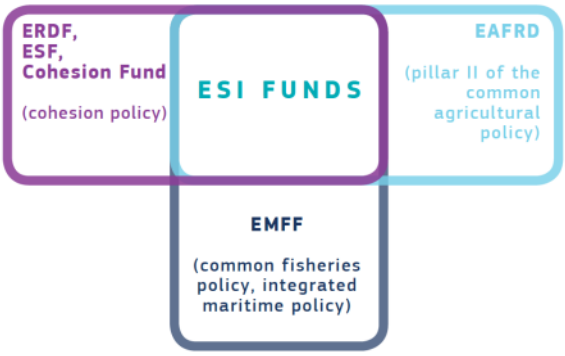
5.1 Identifying experience from programme evaluation, case study results and expert knowledge

5.1.1 Context

A framework strategy for a resilient Energy Union with a forward-looking climate change policy was adopted by the European Commission on 25/02/2015. The strategy aims 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) invest in a range of investment priorities and union priorities to support the shift towards a low-carbon economy in all sectors. Overall, ESI Funds shall contribute to an estimated annual greenhouse gas emissions decrease of around 30 million tonnes of CO_2eq, which equals around 50% of the emissions of either Sweden or Hungary. At the same time, they will also contribute to regional development, local jobs, and more competitive businesses.

Figure 5.1: Cohesion Policy as contribution of the European Structural and Investment Funds to the Commission Priority of Energy Union and Climate



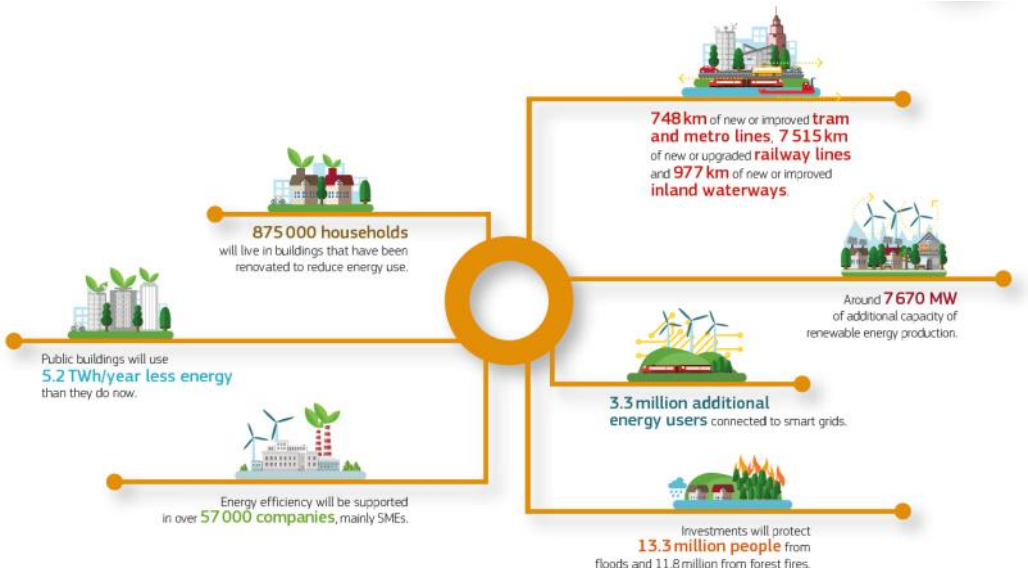
Source: How EU Cohesion Policy is helping to tackle the challenges of CLIMATE CHANGE and ENERGY SECURITY, A paper by the European Commission's Directorate-General for Regional and Urban Policy, September 2014.

ESI Funds represent the largest allocation of the EU budget to be channelled into low-carbon investments, by doubling the funds available to € 45 billion for the 2014-2020 programming period compared to the previous period. Most important shares of these investments come

from European Cohesion policy, through the Regional Development Fund (ERDF, 70%) and the Cohesion Fund (CF, 18%)[63]. These funds are to support Member States, regions, local governments and cities to implement investments in energy efficiency in buildings, renewable energy, smart grids or sustainable urban transport.

According to the requirements of the European Commission, ESI Fund programmes mainly focus on energy efficiency investments, particularly on the energy efficiency of buildings and small and medium-sized enterprises (SMEs). Additionally, they will also be used for investments in the production of renewable energy and smart distribution grids, as well as for smart energy transmission and storage infrastructure and for energy-efficient, decarbonised transport.

Figure 5.2: Contribution of the European Structural and Investment Funds to the Commission Priority of Energy Union and Climate



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

5.1.2 Conceptual framework task 5

According to the ToR, the emphasis of task 5 is put on cohesion policy which actively supports the transition to low-carbon economy in the current funding period 2014-2020. Striving for recommendations on how to bring (additional) added value to the regional implementation requires detailed information on already ongoing practices and activities at European level as well as the assessment of experiences with these instruments at the level of regions.

Therefore, task 5 will follow a three-step approach, with

(1) gaining knowledge on important experiences from previous cohesion policy implementation 2007-2013 as well as from the current programming period 2014-2020, which has just started with implementation in many countries; study results from the strategy

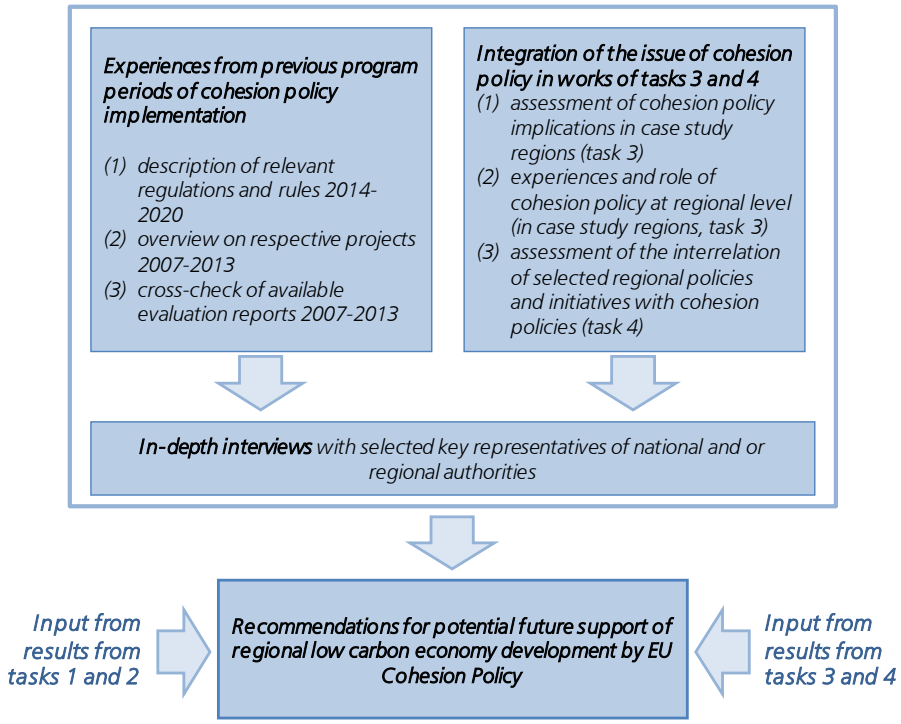
[63] European Structural and Investment Funds, Data, https://cohesiondata.ec.europa.eu/themes/4

development phase in preparation of the current period are also relevant in order to understand the context for the regional programmes in implementation.

(2) using the work in case study regions and interviews concerning policy assessment as a possibility to gain knowledge on the actual implementation and importance of cohesion policy at regional level and its interrelation with regional strategies (from task 3) and using the work in studies of illustrative examples and interviews concerning alignments of regional policies and strategies with objectives and implementation of cohesion policy at the regional level (from task 4)

(3) conducting 4-5 in-depth interviews with key experts, actually in charge of implementing cohesion policy in the programming period of 2014-2020

Figure 5.3: Conceptual framework of task 5



5.2 Experience from the 2007-2013 period of Cohesion Policy

5.2.1 The scale of Cohesion policy relating to GDP and government spending

In order to gain experience from the previous period 2007-2013 it is essential to look at the financial and spatial dimensions of EU Cohesion Policy, with focus on the 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, the system has been designed in a way to provide assistance money for development projects with predominantly in less developed regions. A number of indicators, with particular emphasis on GDP per capita, is forming the basis for the classification of EU regions in order to be eligible for ERDF or Cohesion Fund money. Since the Cohesion Fund has focused on less developed regions, providing assistance for infrastructure as well as for business development, administrative capacity building and research, the assistance contribution per capita by the EU is substantially higher as compared to the more developed regions and MS. As a result, most of

Cohesion Policy money in this period was spent in new MS and in southern regions in Greece, Spain, Portugal and Italy.

Table 5.1 below shows the impact of Cohesion Policy money relative to national GDPs and to the respective capital formation through governments:

- While Cohesion Policy contribution reached 0.3% of the GDP in the EU-27, for new MS this share reached 1.3 to 3.0% annually, while for the most developed countries this share was between 0.01 and 0.09%
- In relation to the governments' capital expenditure, for which most of Cohesion Policy money has been addressed, the share of EU contribution lies between 0.2 and 2.5%, while in the new MS this proportion reached from 25.1 to 57.1%.

As a conclusion, in the period 2007-2013 the contribution of Cohesion Policy in the new MS (EU-12) and in southern regions (Convergence Regions) reached significant levels, in some MS 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 addressing energy and low carbon-relevant projects and measures (see below).

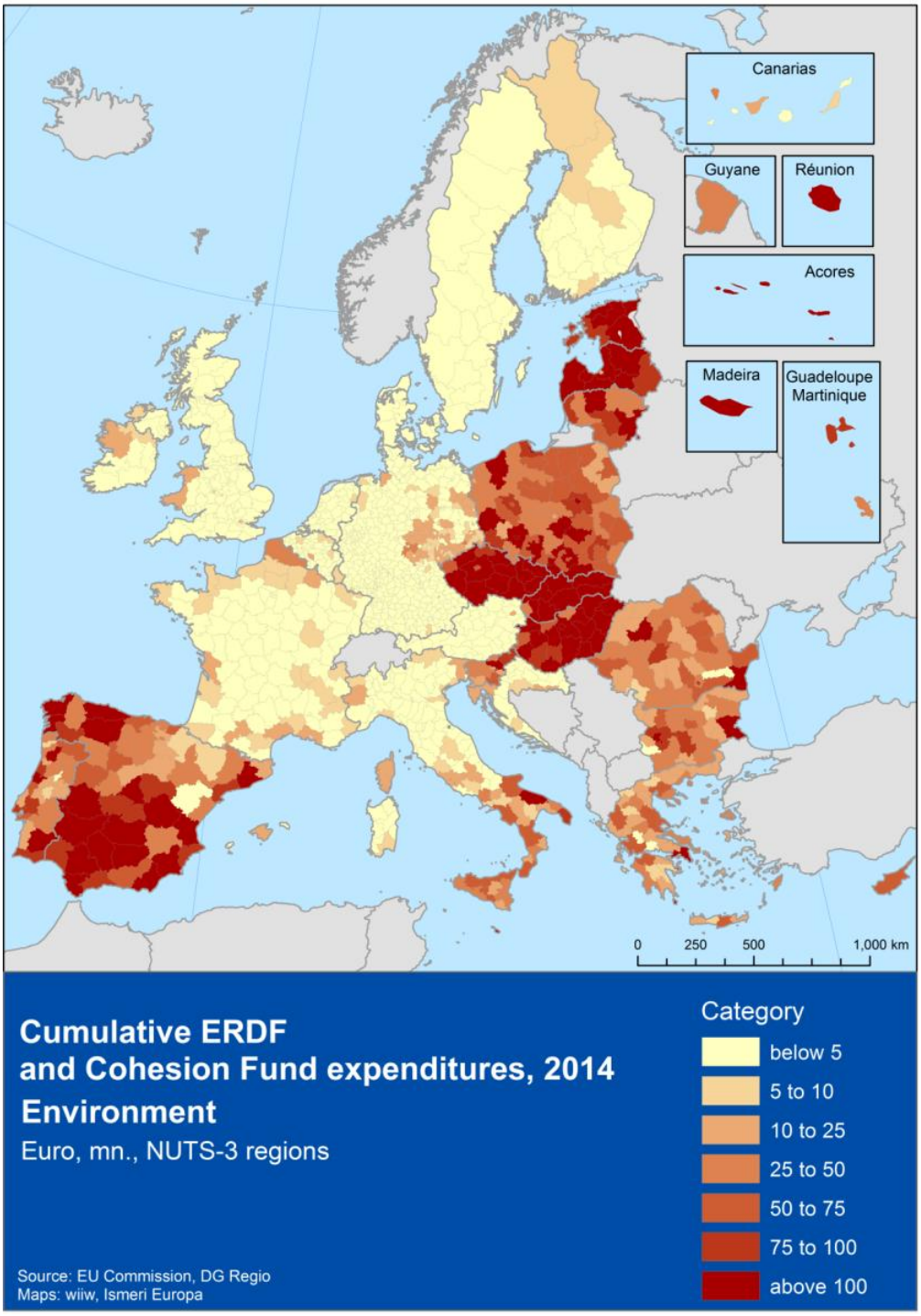
Table 5.1: ERDF and Cohesion Fund support relative to GDP and government capital expenditure, 2007-2013

	ERDF+ Cohesion Fund (EUR m)	% GDP	% Government capital expenditure
EU27	261 217	0.3	6.5
Hungary	21 281	3.0	57.1
Lithuania	5 747	2.7	52.1
Slovakia	9 999	2.1	52.1
Latvia	3 947	2.7	50.5
Malta	728	1.6	42.5
Poland	57 178	2.3	40.9
Estonia	3 012	2.6	39.4
Bulgaria	5 415	2.0	38.6
Czech Republic	22 146	2.0	34.3
Portugal	14 558	1.2	27.5
Romania	15 374	1.7	25.1
Slovenia	3 345	1.3	24.5
Greece	15 846	1.0	18.9
Cyprus	493	0.4	7.1
Spain	26 590	0.4	7.0
Italy	20 989	0.2	4.4
Germany	16 100	0.09	2.5
Finland	977	0.07	1.7
France	8 051	0.06	1.1
Belgium	987	0.04	1.1
UK	5 387	0.04	1.0
Sweden	935	0.04	0.8
Austria	646	0.03	0.7
Ireland	375	0.03	0.7
Netherlands	830	0.02	0.4
Denmark	255	0.01	0.4
Luxembourg	25	0.01	0.2
Croatia	*706*	*0.2*	*3.9*

Note: The first column shows the total decided amounts of funding for the 2007-2013 period as at 14/04/2016. This is then related to aggregate GDP and government capital expenditure over the years 2007-2013.
Government capital expenditure is the sum of General Government gross fixed capital formation plus capital transfers, the latter being adjusted approximately for abnormal transfers to banks and other companies during the crisis.
Source: DG Regional and Urban Policy (2016) WP1: Synthesis report, Ex post evaluation of Cohesion Policy programmes 2007-2013 (Eurostat, government statistics), August 2016.

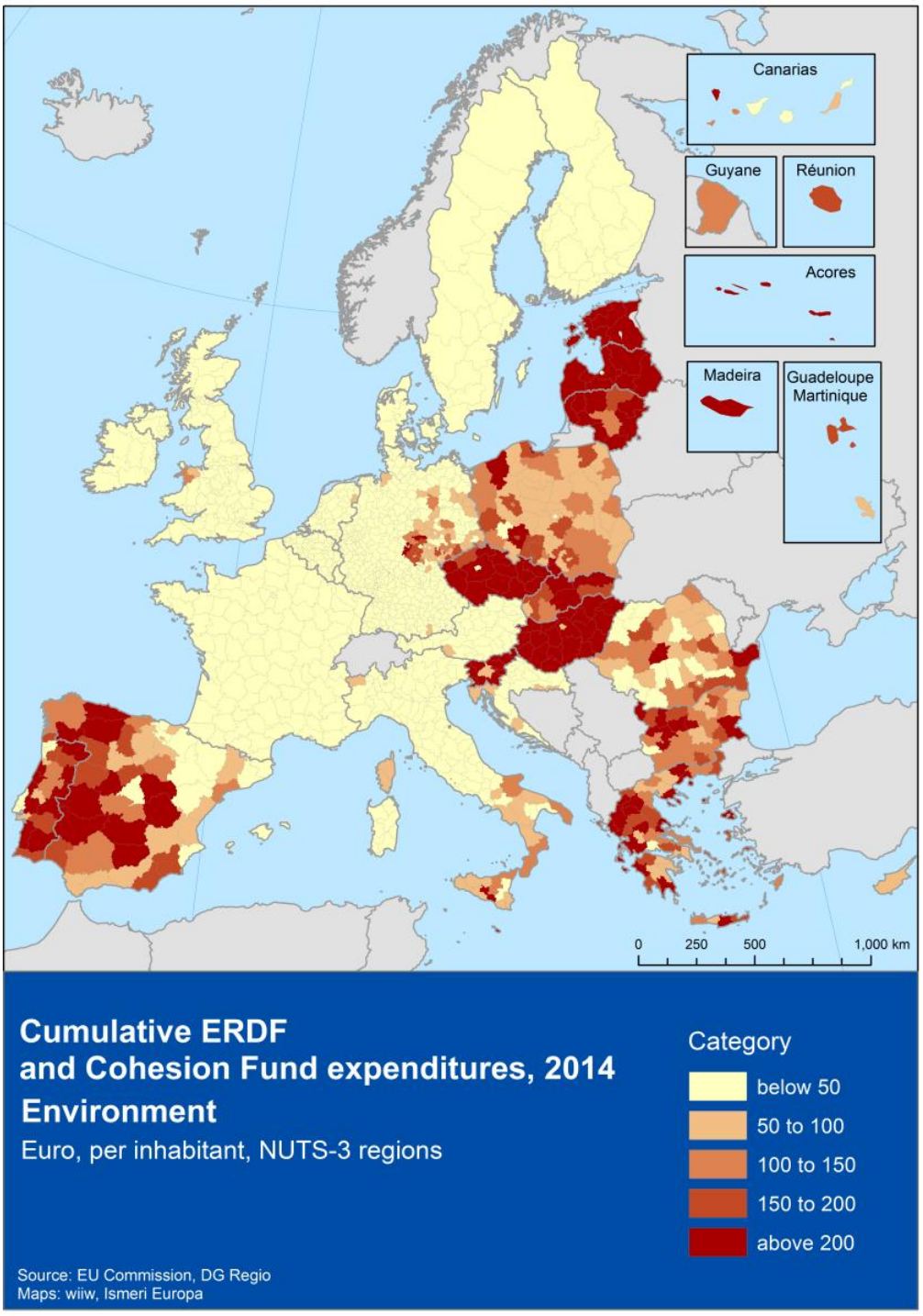
The following maps show the result of ERDF and Cohesion Fund spending across Europe at the level of NUTS-3-regions, in absolute terms (Map 5.1) and in relative terms, EU spending per capita (in € per inhabitant, Map 5.2). These data are drawn from the comprehensive ex-post-evaluation, where all EU co-funded projects have been identified and localized (such data, however, are not available for the current period 2014-2020).

Map 5.1: Cumulative ERDF and Cohesion Fund expenditures 2014, Mio. Euro, NUTS-3 regions



Source: DG Regional and Urban Policy: Ex post evaluation of Cohesion Policy programmes 2007-2013, Geography of Expenditure, Work Package 13 (Submitted by: WIIW, Ismeri Europa), 2015.

Map 5.2: Cumulative ERDF and Cohesion Fund expenditures 2014, € per inhabitant, NUTS-3 regions



Source: DG Regional and Urban Policy: Ex post evaluation of Cohesion Policy programmes 2007-2013, Geography of Expenditure, Work Package 13 (Submitted by: WIIW, Ismeri Europa), 2015.

5.2.2 Regional economic impact – the effects of Cohesion Policy over the period

Ex-post evaluation and economic modelling have tried to analyze and estimate the effect of Cohesion Policy with respect to the overarching objectives, particularly contributing to better economic cohesion by reducing economic disparities.

Overall, the effects shown by economic models[64] demonstrate that there actually was a reduction in regional disparities in GDP per head across the EU, in particular between Convergence regions and others.

The results of the econometric analysis undertaken suggest that Cohesion policy funding pushed up growth in the Convergence regions, even if by less over the years 2007-2011 than before. The macroeconomic models, which are the only way of assessing the full impact of Cohesion policy on growth, estimate that, in the EU12, the spending led to GDP in 2015 being increased by 4% above what it otherwise would have been, and in Hungary, by over 5%.

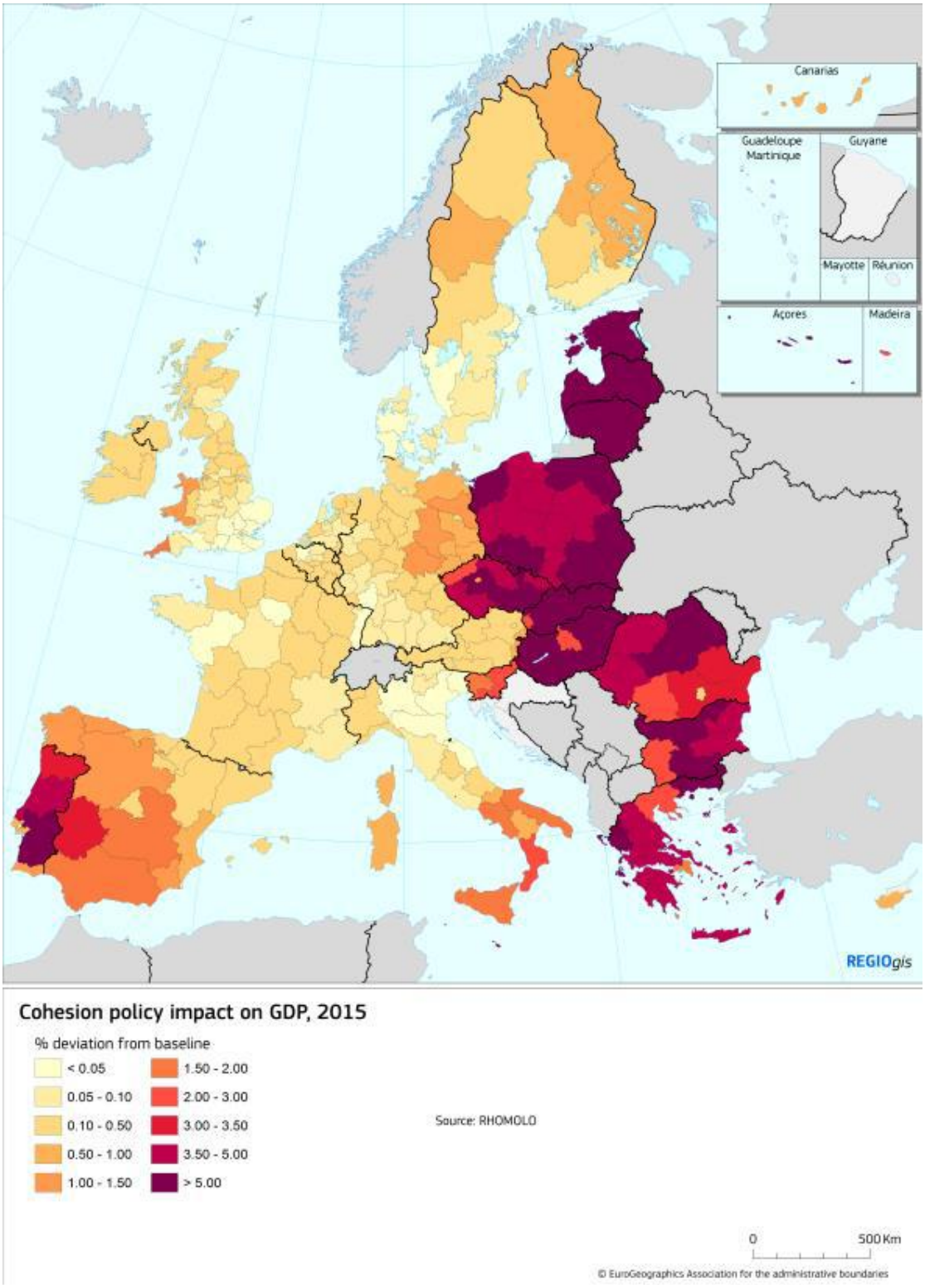
They also indicate that the investment carried out has a continuing effect long after the expenditure has ended (2015) because it increases productive potential and pushes up the growth rate that the economies can sustain in the long term. In Poland, for example, by 2023 GDP is estimated to be almost 6% above what it would be without Cohesion policy and rural development investment. The models show too that the policy was both effective and efficient, in that they indicate a return of over € 2.70 for each euro invested in Cohesion and rural development policy. All countries, moreover, gain, even the net contributors to the funding, as the income generated by the investment leads to increased imports into the countries supported. This reflects the closely integrated nature of the EU economies, in which spending in one part benefits all.

Both, short term and long-term impacts are shown in their regional dimension in the successive Map 5.3 and Map 5.4, illustrating the substantial impact in new MS and in some regions of the South (particularly Greece, Italy, Spain and Portugal).

From these data it can be concluded that EU Cohesion Policy successfully has addressed less developed regions and at a general level has contributing to reducing economic disparities by helping weaker regions to grow faster than without the support from the EU. It cannot be judged, however, if the monies were used effectively and to the best long-term, sustainable impact.

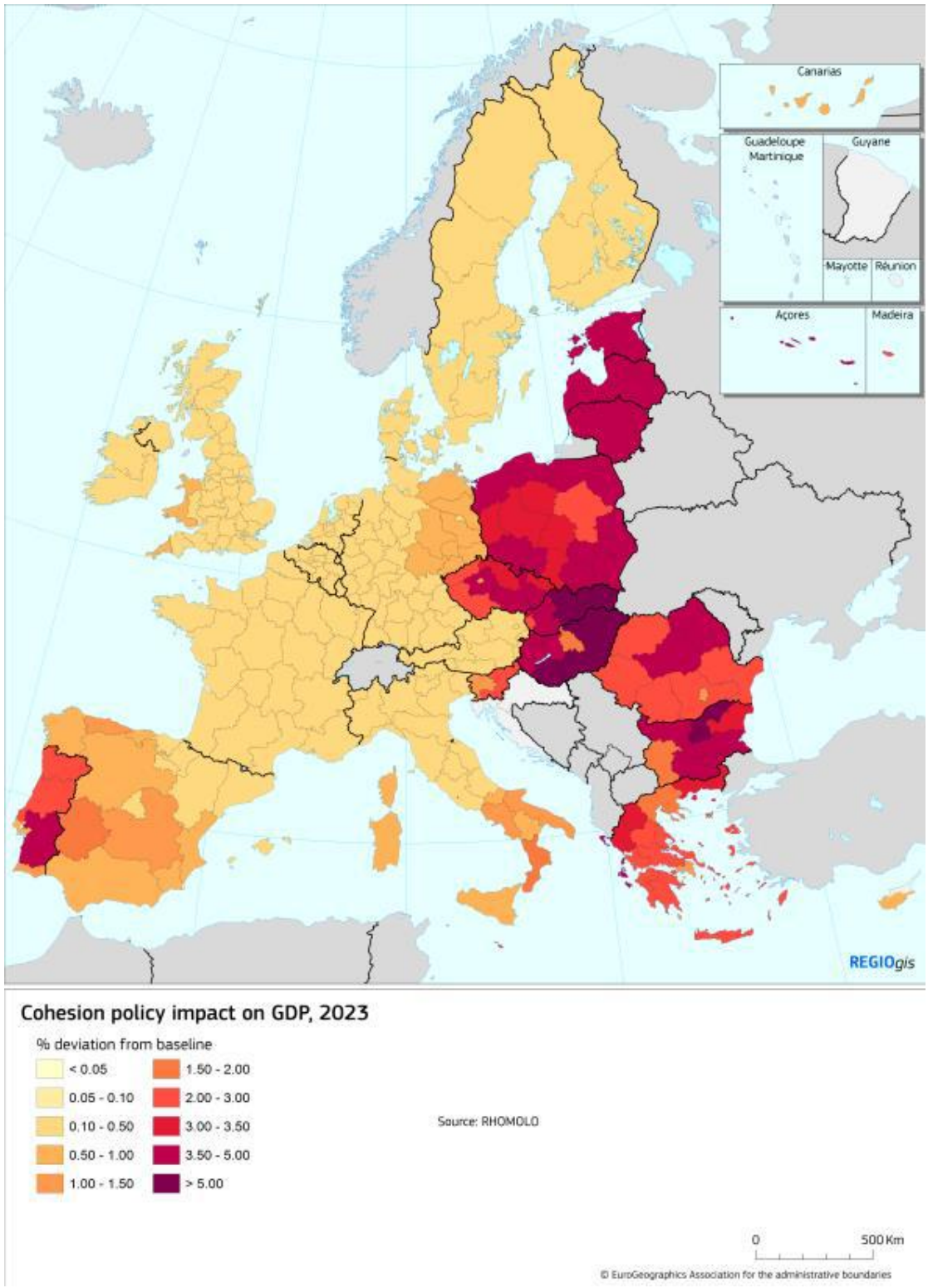
[64] WP 1: Synthesis Report – Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund (CF); Applica and Ismeri Europa, August 2016.

Map 5.3: Cohesion Policy, impact on GDP 2015 in regions, % deviation from baseline



Source: DG REGIO and Joint Research Centre Seville: The impact of cohesion policy 2007-2013: model simulations with RHOMOLO, May 2016.

Map 5.4: Cohesion Policy, impact on GDP 2023 in regions, % deviation from baseline



Source: DG REGIO and Joint Research Centre Seville: The impact of cohesion policy 2007-2013: model simulations with RHOMOLO, May 2016.

5.2.3 Ex-post evaluation of programme implementation 2007-2013 – conclusion

The evidence set out in the ex-post evaluation synthesis report[65] demonstrates that Cohesion policy, though operating in a very difficult environment in 2007-2013, worked effectively and produced tangible results. It has made a major contribution over the period 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. The evidence produced by evaluations on the ground point to this and it is complemented by the results of the macroeconomic models which indicate the added-value of the policy in terms of the additional GDP generated in all Member States.

The policy also contributed to the closer integration of the EU internal market through improving transport links as well as to the better implementation of EU legislation, notably in respect of the environment, and to a better quality of life.

In both EU12 countries and Convergence regions in the south of the EU, Cohesion policy funding represented the main, and in some cases, the only source of development expenditure over the period.

The evaluations carried out in different policy areas produced concrete evidence of achievements and highlighted the importance of Cohesion policy funding for the projects undertaken.

Interreg programmes financed under the European Territorial Cooperation (ETC) Objective generated a clear EU added-value and would not have taken place without the funding being available. The same is true of the support for transport and of investment in the TEN-T in particular.

The delivery system proved effective in implementing the policy over the period but there is the potential for gains in efficiency through increased administrative capacity as well as through further simplification and differentiation between programmes.

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

As said above, only a small part of Cohesion Fund money went to energy-related projects and measures. Table 5.2 shows the share of the priority theme energy as 4.5% in the EU-27, with more developed regions in the Competitiveness programmes having a higher share of 6.6%.

[65] 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.

Table 5.2: Division of ERDF+Cohesion Fund decided amounts by policy area and Objective, EU12, EU15 and EU27 (% of total in each case)

	EU12	EU15			EU27		
	Total	Conv.	Comp.	Total	Conv.	Comp.	Total
1.RTD and innovation	12.8	16.7	34.9	23.0	14.0	33.6	17.2
2.Entrepreneurship	1.5	2.3	5.8	3.2	1.8	5.5	2.2
3.Other investment in enterprises	4.4	8.3	9.2	8.4	5.8	9.2	6.1
4.ICT for citizens+business	4.1	3.7	6.3	4.5	3.6	6.1	4.3
5.Environment	17.6	16.2	9.2	13.8	17.2	9.1	16.0
6.Energy	4.5	3.9	7.0	4.4	4.4	6.6	4.5
7.Broadband	0.8	0.8	1.7	1.1	0.8	1.6	0.9
8.Roads	21.1	13.1	1.0	9.9	18.6	1.9	16.3
9.Rail	9.8	9.5	2.7	7.4	10.0	2.5	8.8
10.Other transport	6.5	5.7	5.2	5.3	6.3	5.3	6.0
11.Human capital	0.2	0.0	0.5	0.2	0.1	0.5	0.2
12.Labour market	0.1	0.1	1.0	0.3	0.1	0.9	0.2
13.Culture+social	9.5	10.7	4.1	9.0	9.7	5.2	9.3
14.Social inclusion	0	0.1	0.1	0.1	0.0	0.1	0.0
15.Territorial dimension	4	6.7	8.8	7.0	4.8	8.9	5.3
16.Capacity building	0.2	0.2	0.3	0.2	0.2	0.3	0.2
17.Technical assistance	2.9	2.1	2.3	2.2	2.6	2.4	2.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: "Social inclusion" includes measures to assist disadvantaged groups and migrants. "Territorial dimension" includes support for urban and rural regeneration, tourist services and measures to compensate for climate conditions.
Source: DG Regional and Urban Policy (2016) WP1: Synthesis report, Ex post evaluation of Cohesion Policy programmes 2007-2013 (Infoview database. Data as at 14 April 2016), August 2016.

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

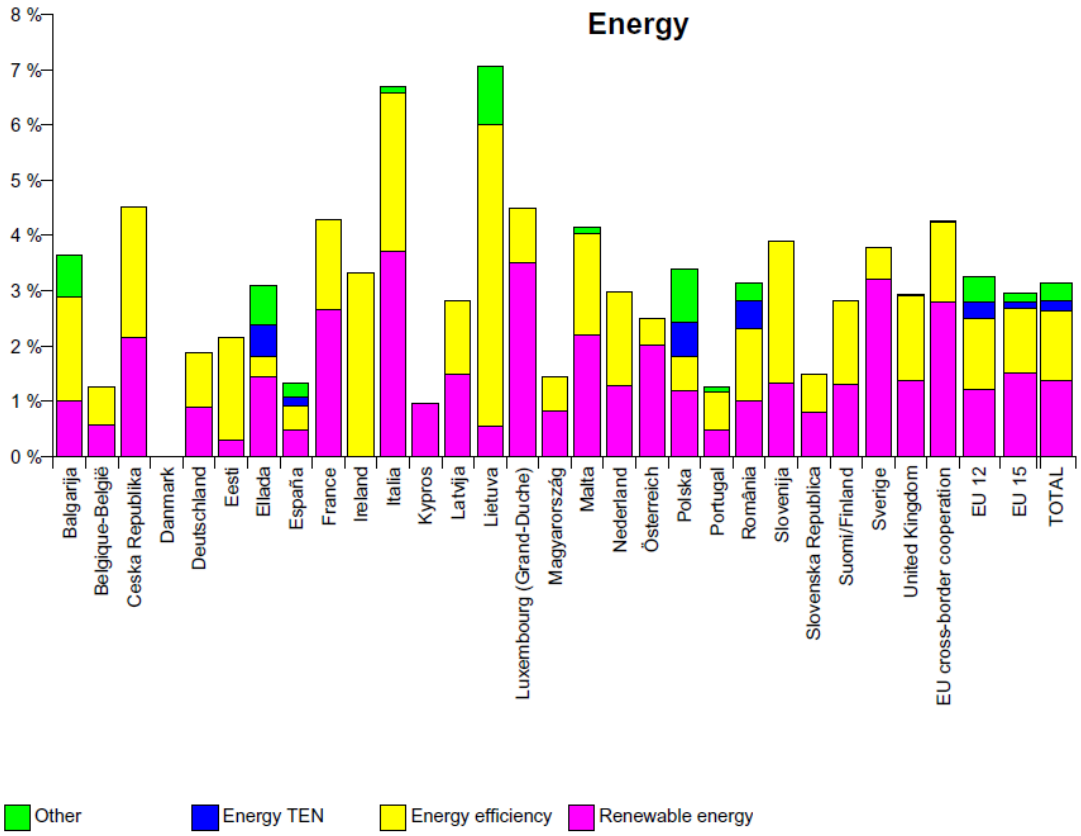
For both Convergence and the Regional Competitiveness and Employment objectives an important ERDF priority is to stimulate energy efficiency and renewable energy production and the development of efficient energy management systems.

Renewable energy activities have a large potential to foster the economic development in the EU regions, creating new jobs and giving new economic and social development impetus. This appears to be reflected in the fact that Cohesion policy allocations to renewable energies for the period 2007-2013 are five times higher under the Convergence objective and seven times higher under the Regional Competitiveness and Employment objective compared to the period 2000-2006.

In the framework programmes for 2007-2013, EU allocations of € 4.8 billion have been made for projects in renewable energies (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.

Figure 5.5 shows how great the variation in national (and regional) strategies towards a low-carbon energy future are, both, in terms of the priority given to the energy theme in the individual programmes (intensity of funding) and in terms of the focus given to RES and energy efficiency.

Figure 5.4: Intensity of funding allocated for the priority theme energy efficiency, co-generation and energy management in total allocation in EU 27



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

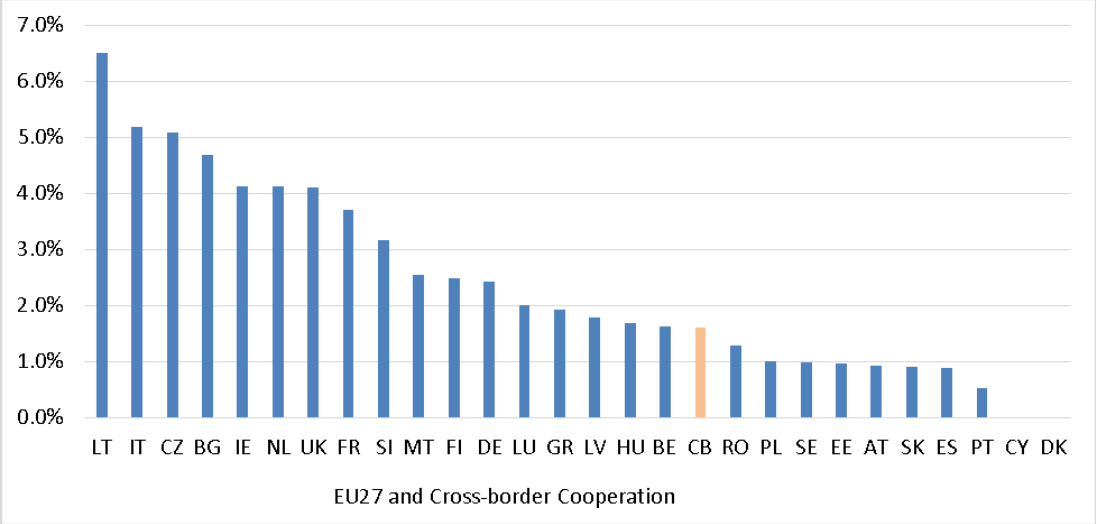
Figure 5.5: Categorisation Codes relating to Energy in the 2007-2013 period

Categorisation Codes : Energy					
Category Cd	Category	Renewable energy	Energy efficiency	TEN	Other
33	Electricity				Y
34	Electricity (TEN-E)			Y	
35	Natural gas				Y
36	Natural gas (TEN-E)			Y	
37	Petroleum products				Y
38	Petroleum products (TEN-E)			Y	
39	Renewable energy: wind	Y			
40	Renewable energy: solar	Y			
41	Renewable energy: biomass	Y			
42	Renewable energy: hydroelectric, geothermal and other	Y			
43	Energy efficiency, co-generation, energy management		Y		
Reference: Commission regulations implementing the Structural Funds No 1828/2006 (Annex II A) http://ec.europa.eu/regional_policy/sources/docoffic/official/reglem_en.htm					

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

Figure 5.6 below provides an overview of the intensity of funding allocated for *priority theme energy efficiency, co-generation and energy management,* which is calculated as the ratio of EU allocation for the priority theme and the total EU allocation per Member States. The highest share was in Lithuania and Italy, while there were no allocations for the priority theme in Cyprus and Denmark.

Figure 5.6: Intensity of funding allocated for the priority theme energy efficiency, co-generation and energy management, total allocation in EU 27



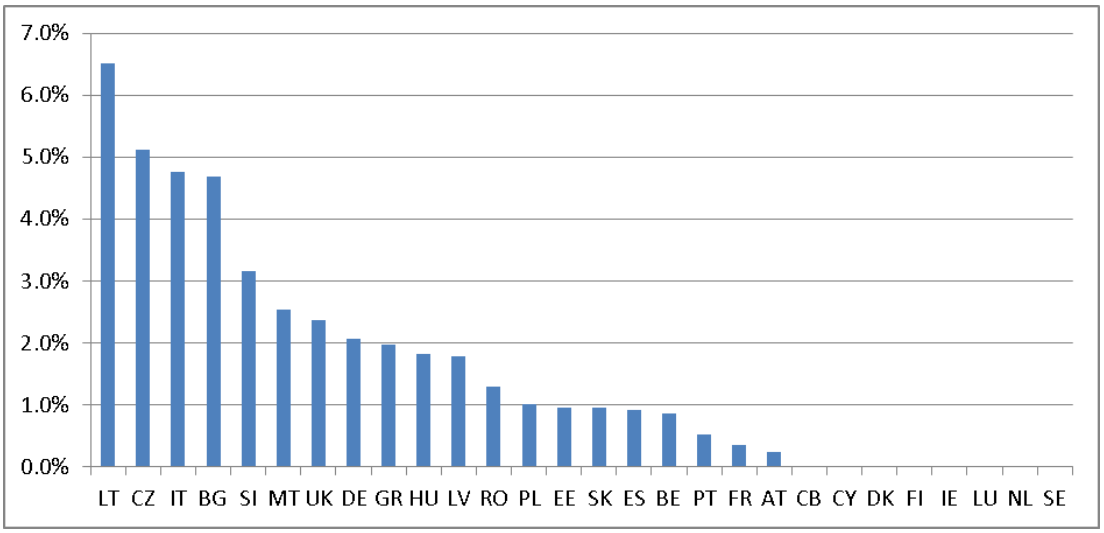
Source: DG Regional and Urban Policy: Ex post evaluation of Cohesion Policy programmes 2007-2013 – Energy efficiency in public and residential buildings, Work Package 8, 2015, Annex 1.

Different from the overall picture, Figure 5.6 provides a picture of the intensity of funding allocated to the priority theme to the *Convergence objective* of EU regional policy, representing the largest share of EU Cohesion funding. The highest intensity was achieved by Lithuania, while there were no allocations to the priority theme under this objective in Cyprus, Denmark, Finland, Ireland, Luxembourg, the Netherlands and Sweden.[66]

In contrast to the above figure, Figure 5.7 indicates the intensity of funding for the priority theme for the *Regional Competitiveness and Employment* objective of EU regional policy, representing regions in the most developed MS. Italy had the greatest intensity at 7.6%, while both France and the UK were at 5.0%. Only 15 Member States had allocations for the priority theme under this objective.

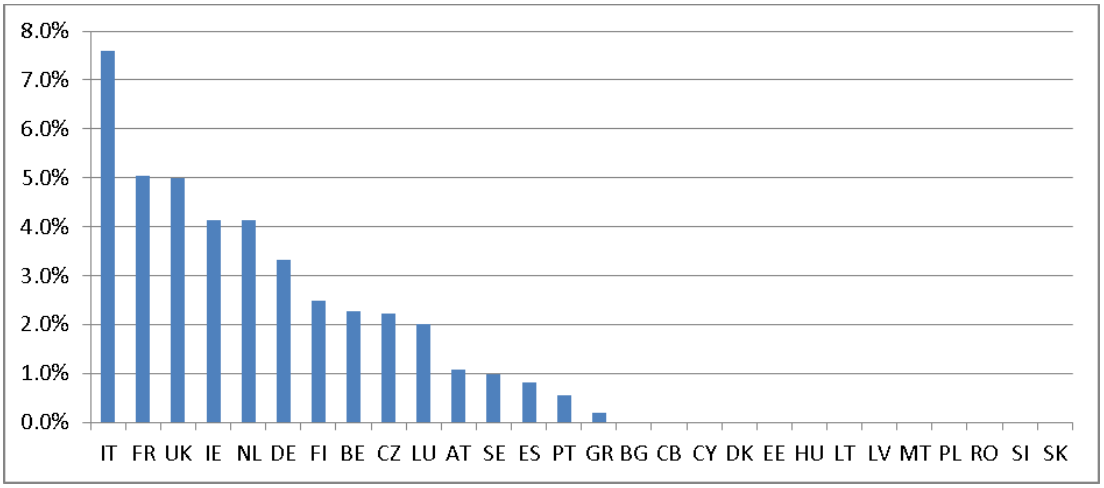
[66] Annex 1: Presentation of financial information on energy efficiency investments in public and residential buildings under ERDF/CF, Ex post evaluation of Cohesion Policy programmes 2007-2013, July 2015.

Figure 5.7: Intensity of funding allocated for the priority theme in total allocation in EU 27 under the Convergence objective of EU regional policy



Source: DG Regional and Urban Policy: Ex post evaluation of Cohesion Policy programmes 2007-2013 – Energy efficiency in public and residential buildings, Work Package 8, 2015, Annex 1.

Figure 5.8: Intensity of funding allocated for the priority theme and total allocation in EU 27 under the Regional Competitiveness and Employment objective of EU regional policy

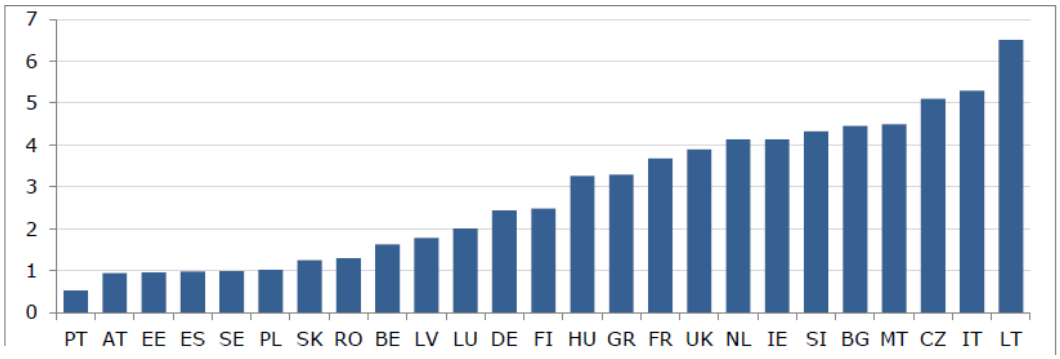


Source: DG Regional and Urban Policy: Ex post evaluation of Cohesion Policy programmes 2007-2013 – Energy efficiency in public and residential buildings, Work Package 8, 2015, Annex 1.

5.2.5 Focus evaluation on energy efficiency in public and private buildings

While the ex-post evaluation provided a good overview on 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, energy efficiency in public and residential buildings. As has been seen from the variation between MS in allocating funds to the priority theme energy, this also holds true for the energy efficiency segment – the variation between MS is high, with funds allocated to energy efficiency between 0.5% and 6.5% of total.

Figure 5.9: Decided amounts of ERDF going to energy efficiency (category 43) by Member State, 2007-2013 (% total decided amounts)



Source: DG Regional and Urban Policy (2016) WP1: Synthesis report, Ex post evaluation of Cohesion Policy programmes 2007-2013 (Inforegion database. 14 April 2016), August 2016.

Support for energy efficiency[67]

The measures for increasing energy efficiency in housing and public buildings (co-financed by about € 6.3 billion from ERDF) reduced energy use by 1,438 GWh a year by the end of 2013 in 27 OPs, a cut of 0.2% in total yearly energy consumption in the regions concerned − not large, but significant given the small amount of funding involved (only around 2% of the total). Reflecting its high level of EU support and the large share of funding going to energy efficiency in Lithuania, energy use in the 864 public buildings renovated was reduced by 236 GWh a year by the end of 2014, a cut of almost 3% in total annual energy consumption in the country.

Programme implementation

Looking closer into programme implementation and results, the evidence on achievements[68], however, was quite mixed: In terms of indicators of energy efficiency in public and residential buildings an incomplete and mixed picture emerged. The extent to which the output, result and impact indicators reported on by Managing Authorities were designed appropriately to capture evidence of achievements was variable and inconsistent. Not all programmes used indicators that were able to capture energy efficiency impacts specifically from public and residential buildings; and many did not include indicators that were specific to buildings at all.

While the most commonly used indicators focused on energy savings, these used a range of methodologies. The targets set by programmes also showed a range of levels of ambition, suggesting that Managing Authorities found it difficult to judge, at the beginning of the pro-

[67] WP 1: Synthesis Report – Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund (CF); Applica and Ismeri Europa, August 2016.

[68] Final Report Work Package 8: Energy efficiency in public and residential buildings, Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and the Cohesion Fund (CF); Ramboll Management Consulting A/S and Institute for European Environment Policy; July 2015.

gramming period, an appropriate level of achievement to aim for. In many cases, although allocations to the “Energy efficiency, co-generation, energy management” priority theme were increased over the course of the programming period, targets were not adjusted. While comparability across programmes is challenging, even where data on achievements is available for them, there is little correlation between the level of funding they made available and their results in terms of the two most commonly used types of indicator: greenhouse gas emissions, and energy reductions.

In addition to a general weakness in defining an explicit rationale for energy efficiency investments in public and residential buildings, operational programmes also found it difficult to establish a clear strategy for their interventions in this area. In particular, there was generally little attempt to show how ERDF/CF investments were integrated into, and formed a relevant contribution to wider national strategies to meet EU and national energy efficiency targets.

In some cases, this is partly explained by a low level of national strategic orientation on energy efficiency at the start of the programming period. While there were positive examples of programmes which stated a broader contribution to the development of a self-sustaining energy efficiency dynamic (for example, the development of a more capable energy efficiency services sector; or improvements in public understanding of energy efficiency; or the role of public buildings as exemplars), it was not always clear how these were followed through in the detailed design of interventions. This evaluation also draws attention to temporary, or implicit, rationales for energy efficiency investments, particularly the need during the financial crisis for ERDF/CF funds to contribute to economic activity in the short term, and a potential bias towards investment in public buildings in order to reduce future public expenditure, rather than making them on the basis of their relative cost-effectiveness and wider policy contribution.

Lessons learned: Recommendations from the ex post evaluation of the ERDF and Cohesion Fund 2007-2013 relating to energy efficiency measures

Using this focused evaluation on energy efficiency as example for the problems which may manifest themselves in the implementation phase, the recommendations from the evaluation study illustrate the challenge in general: 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, in an effective way ?

The authors of the ex-post evaluation on energy efficiency in public and private buildings noted as recommendations[69]:

(1) Programmes need to spell out clearly the rationale for the use of EU funding to support investment in energy efficiency in buildings and to show how it relates to national en-

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

ergy policy and to the support available from national and regional schemes, as well as to the objectives that have been set, so as to demonstrate the coherence of the policy and its justification.

(2) Bearing in mind the long term energy cost reduction for building owners, loans or other kinds of financial instrument are likely to be preferable to grant support for energy efficiency measures. Awareness-raising campaigns might be needed to overcome initial reservations.
(3) Energy audits should be a standard part of project selection criteria to identify the reduction in energy use intended and to verify its achievement.
(4) Financial support should be complemented by a range of non-financial measures to, including advice and guidance, certification schemes and building regulations.
(5) Indicators need to be more widely, and uniformly, applied to monitor the results of support. There is also a need for better data on the context concerned and developments in this, so that the indicators can be meaningfully interpreted. In this case, it means the availability of regional data on energy consumption and greenhouse-gas emissions.

Lessons 1 and 3 are at least partly addressed in the 2014-2020 period by the focus on results and a clear theory of change, translated into project requirements. However, in a context of shared management, their implementation is, along with lessons 2 and 4, something which the Commission can encourage but the final decision remains with the managing authority. For lesson 5, this is partly addressed by the increased focus on quality monitoring data. However, some of the context data does not currently exist and further work will be needed in partnership with Eurostat.

As can be seen from these recommendations, the complexity of supporting energy and low carbon transformation through Cohesion Policy schemes is quite high. More detailed studies on the mainstreaming of renewable energies in the light of the EU targets indicate the systemic complexity and a vast array of necessary adaptations in the project financing and in regulatory preconditions in order to reach the targets.

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

The database for the previous programming period 2007-2013 allow – for the first time – to analyze the concrete regional distribution of ERDF and Cohesion Fund resources at NUTS 3 level relevant for increasing energy efficiency and expanding the production and use of renewable energies. The following maps show

- which regions use a high or low share of their EU funds to energy efficiency and renewable energy projects (categorization codes 39 to 43 in Map 5.5)
- how much EU money was spent on projects in these categories in Mio. Euro (Map 5.6)
- how much this means in € per capita, displaying the wide spread of EU support intensity between new MS and Convergence Regions on the one hand and in the more developed regions of the EU 15[70] in Map 5.7
- in contrast, how much of the EU funds were allocated to projects in the fossil fuel sector of energy (gas, petrol etc.) in Map 5.8
- and, finally, how fossil-related projects were funded in relation to funds going to energy efficiency and renewable energy projects in Map 5.9.

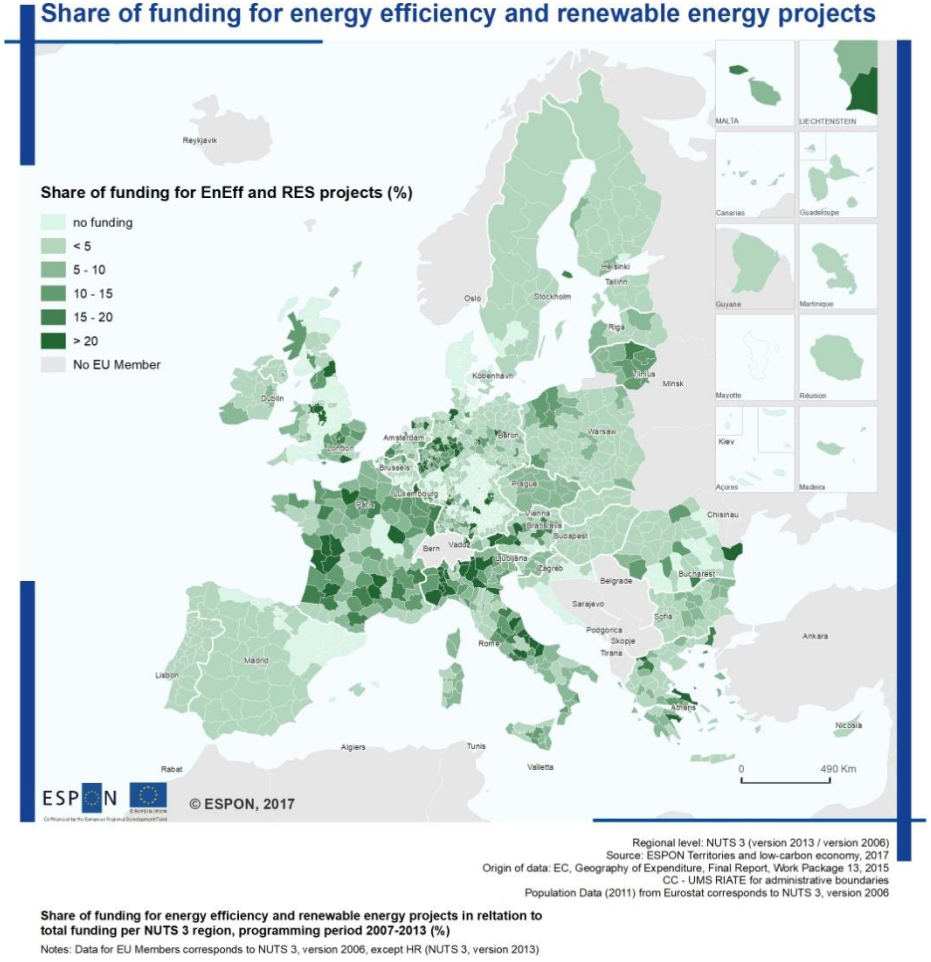
These maps indicate quite clearly, that

- most of the funds for energy related projects on efficiency and renewable is being spent in EU-12 countries and in Convergence Regions in the south of the EU (reflecting the Cohesion Policy regime) – in absolute terms and very significantly in funds per capita (Map 5.6 and Map 5.7)
- the relative share of funds to efficiency and renewable energy projects, however, is highest in EU-15 countries like France, Italy, Germany, UK, Austria, while there are some exemptions in Lithuania, Romania and Greece (Map 5.5)
- there are some regions in Poland, Romania and Greece with significant money allocated to fossil fuel projects, most regions in Europe did not use EU Cohesion Policy money for fossil fuel projects (Map 5.8),
- and in only a handful of regions in Poland and Rumania the funds going to fossil energy projects were higher than to efficiency and renewable projects. (Map 5.9)

Overall, these maps display 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 would be the potential to increase the share and also the efficiency of EU funds in many regions.

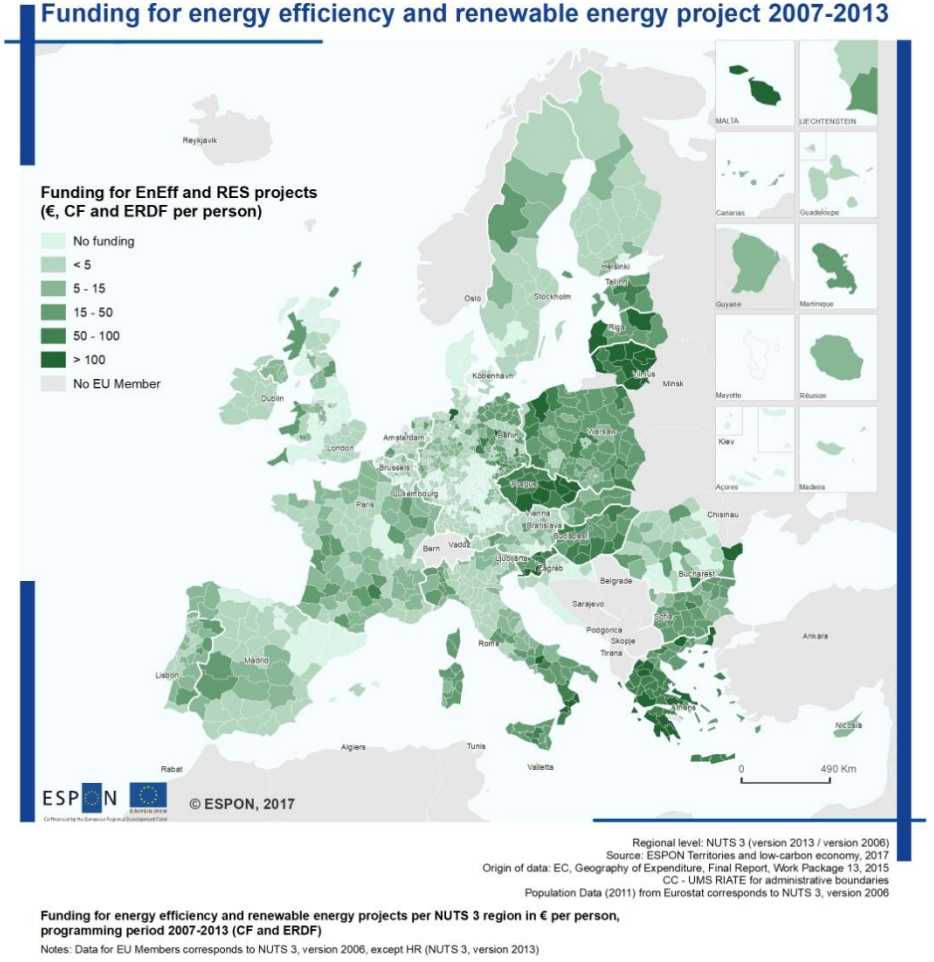
[70] For some regions this indicator could not be calculated, due to changes in the attribution of population and funds in some NUTS-3 regions.

Map 5.5: Share of funding for energy efficiency and renewable energy projects in relation to total funding per NUTS 3 region, programming period 2007-2013 (%)



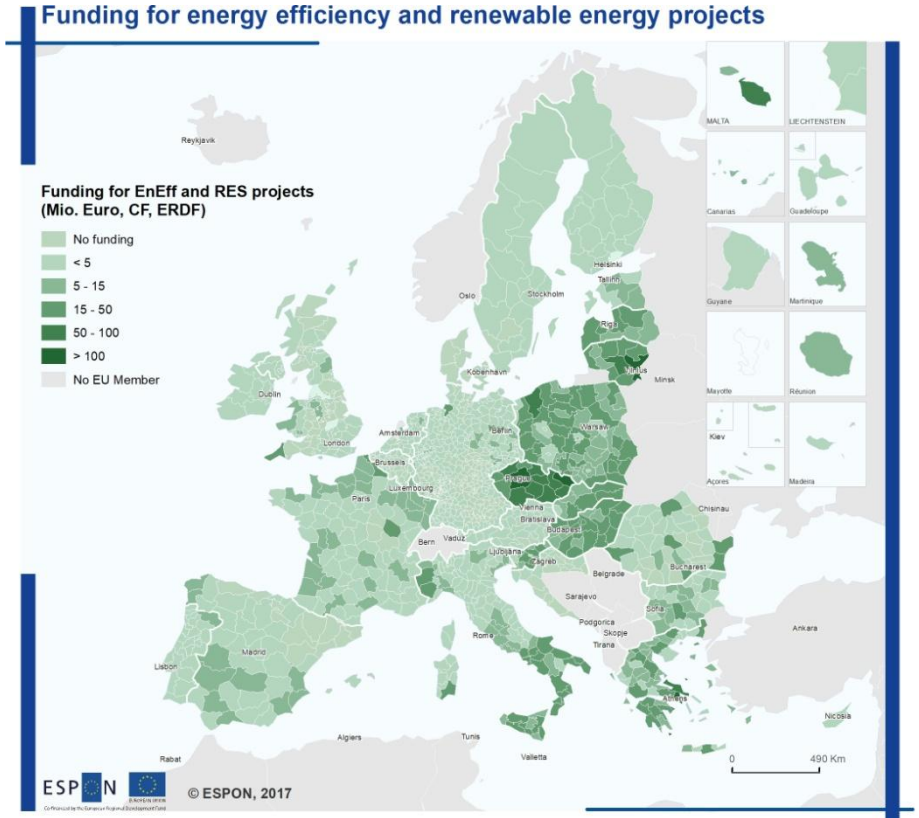
Categorisation codes 39 to 43.

Map 5.6: Funding for energy efficiency and renewable energy projects per NUTS 3 region in € per person, programming period 2007-2013 (CF and ERDF)



Categorisation codes 39 to 43.

Map 5.7: Funding for energy efficiency and renewable energy projects per NUTS 3 region in Mio. Euro, programming period 2007-2013 (CF and ERDF)

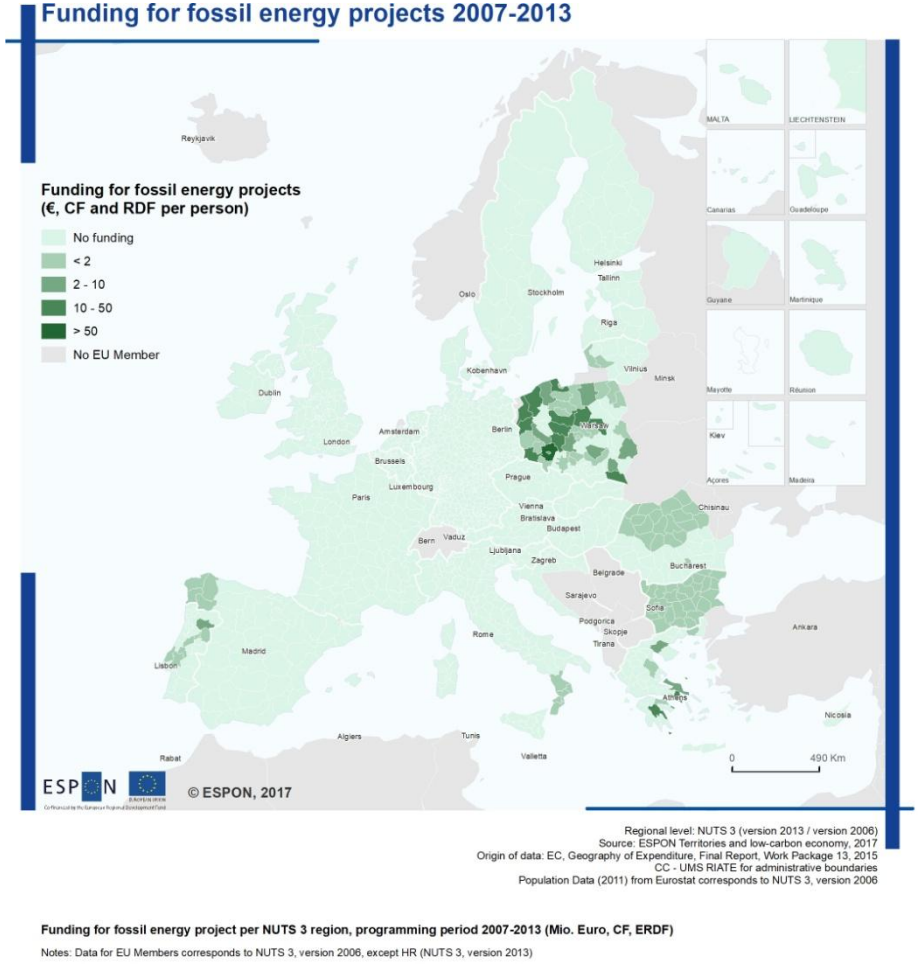


Funding for energy efficiency and renewable energy projects per NUTS 3 region, programming period 2007-2013 (Mio. Euro, CF and ERDF)

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

Categorisation codes 39 to 43.

Map 5.8: Funding for fossil energy projects per NUTS 3 region, programming period 2007-2013 (Mio. Euro, CF and ERDF)

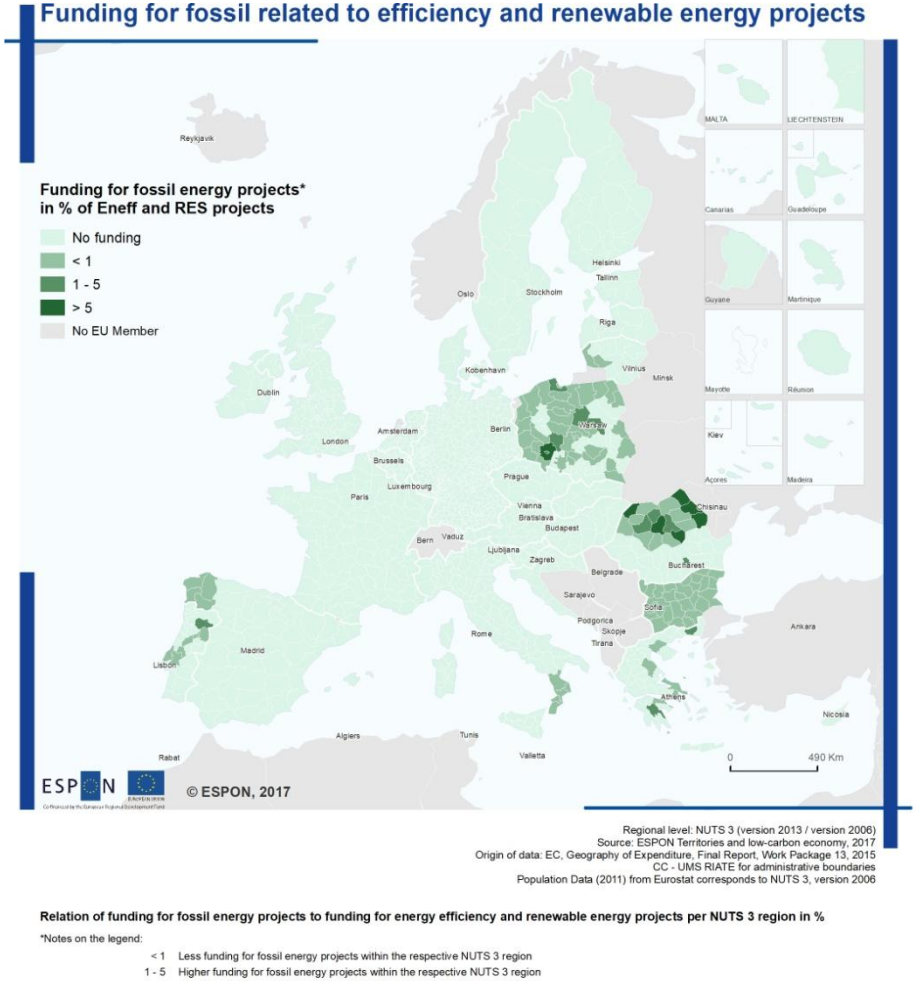


Funding for fossil energy project per NUTS 3 region, programming period 2007-2013 (Mio. Euro, CF, ERDF)

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

Categorisation codes 35 to 38.

Map 5.9: Funding for fossil energy projects relative to energy efficiency and renewable energy projects per NUTS 3 region in %, programming period 2007-2013 (%)



Relation of funding for fossil energy projects to funding for energy efficiency and renewable energy projects per NUTS 3 region in %

*Notes on the legend:

< 1 Less funding for fossil energy projects within the respective NUTS 3 region
1 - 5 Higher funding for fossil energy projects within the respective NUTS 3 region
> 5 Mainly / only funding for fossil energy projects within the respective NUTS 3 region

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

Aggregate funding in categorisation codes 35 to 38 relative to the aggregate of codes 39 to 43.

5.3 Cohesion Policy in the current 2014-2020 period

5.3.1 General framework: The Europe 2020 Strategy

Europe 2020 is a ten-year economic strategy introduced by the European Commission in March 2010[71]. Its stated aim is to promote smart, sustainable, and inclusive growth. Europe 2020 identifies eight headline targets to be attained by the end of 2020, involving (1) employment; (2) innovation – research and development; (3) climate change and energy; (4) education; and (5) social inclusion and poverty reduction.

The following table summarises these broad headline targets for the entire EU, along with the specific (sub)targets they entail.

Table 5.3: Europe 2020 EU-wide headline targets

1. Employment a) 75% of the 20-64–year-olds to be employed (EMP)
2. Innovation a) 3% of the EU's GDP to be invested in R&D (R&D)
3. Climate change and energy sustainability [12] a) greenhouse gas emissions 20% (or even 30%, if the conditions are right) lower than 1990 (GHG) b) 20% of energy from renewables (REN) c) 20% increase in energy efficiency compared to 2005 (EFF)
4. Education a) Reducing the rates of early school leaving below 10% (ESL) b) at least 40% of 30-34–year-olds completing third level education (TERT)
5. Fighting poverty and social exclusion a) at least 20 million fewer people in or at risk of poverty and social exclusion (AROPE)

Source: European Commission: Regional Focus 01/2015, The Europe 2020 Index: The progress of EU countries, regions and cities to the 2020 targets, 2015.

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

The project looks into the already existing and ongoing EU-support for with the aim of understanding the existing situation as a background for recommendations. Based on the analysis of the performance in the previous period, a number of significant changes in the EU Cohesion Policy strategies and institutional framework have been taken.

With respect to energy transformation in the EU, the above sections displayed

- how projects thematically relevant projects were funded by EU cohesion policy in the previous period of 2007-2013 in terms of structure and regional distribution (using the ECs project database Inforegio[72])

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

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

- what DG Regio evaluation reports of the previous period of cohesion policy implementation assessed the performance, analysed implementation barriers and problems concerning and came up with lessons learnt and recommendations for implementation and funding[73].

The analysis of relevant regulations of EU cohesion policy (Common Provisions Regulation), eligible priority themes and beneficiaries as for the period of 2014-2020 shows that many of the lessons learnt have been taken up in the reform.

Under the reform of EU Cohesion Policy 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, due to the immensity of the challenge in the area and the important benefits of such investments in terms of regional development, competitiveness, growth and jobs, as well as to alleviate energy poverty[74].

Relatively stable remained the spatial dimension and the differentiation of funding intensity between EU-15 and EU-12 countries. While some of the Convergence Regions in the South were reduced, due to economic progress, the general spatial pattern remained as in the period before, with high EU support intensities in the East and the South of the Union (Map 5.10 on Structural Fund eligibility, below).

With respect to the EU 2020 targets and to the lessons learnt in the previous period, the rules on the European Regional Development Fund (ERDF) for 2014-2020 were changed to stipulate a mandatory minimum spending for the low-carbon economy theme: 20% of national ERDF resources in more developed regions, 15% in transition regions and 12%[75] in less developed regions. While ring fencing also exists for the other key priorities of SME support, ICT and research and innovation, mandatory minimum allocations were only applied to the low carbon economy.[76]

Figure 5.10: Cohesion policy changes from programming period 2007-2013 to 2014-2020: New thematic objectives

<table>
<tr><th>2007-2013</th><th>2014-2020</th></tr>
<tr><td>Convergence</td><td rowspan="2">Investment for growth and jobs</td></tr>
<tr><td>Regional competitiveness and employment</td></tr>
<tr><td>European territorial cooperation</td><td>European territorial cooperation</td></tr>
</table>

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

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

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

[76] 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

Figure 5.11: Cohesion policy: Main differences between programming period 2007-2013 to 2014-2020

MAIN DIFFERENCES BETWEEN 2007-2013 AND 2014-2020

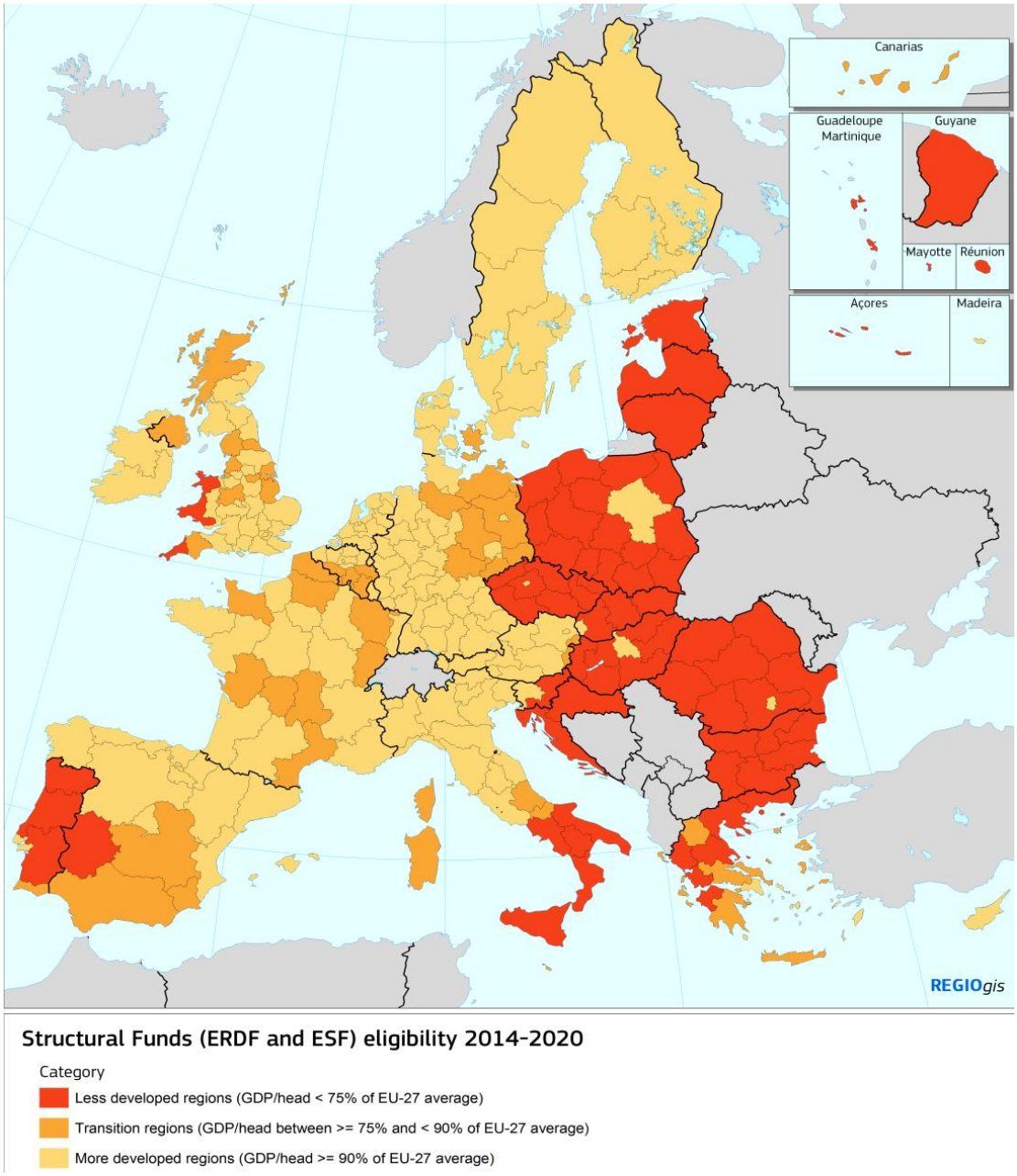
2007-2013	2014-2020
The Lisbon strategy. Cohesion policy was linked to the Lisbon strategy through earmarking requiring a share of cohesion policy funds (60-75 %) to be spent on Lisbon-related areas of investment.	The Europe 2020 strategy. All ESI Funds' interventions have to contribute to Europe 2020 strategy, but new rules on thematic concentration set out minimum level of resources which should be spent on some specific areas of intervention and a minimum allocation for the ESF.
Indirect link between cohesion policy and the Lisbon strategy through the national reform programmes concerning only programming stage.	Direct and explicit links between the relevant country-specific recommendations and the Partnership Agreements and the programmes during programming and implementation.
Separate strategic reporting for cohesion policy, EAFRD and the European Fisheries Fund (EFF) loosely linked with the Lisbon strategy reporting.	2017 and 2019 progress reports will cover all ESI Funds and are integrated into the European Semester.
Each Fund had its own thematic scope defined in a set of priorities.	A set of TOs common for the five ESI Funds is introduced, according to which a scope of intervention of every Fund is translated into concrete investment priorities (for cohesion policy) or Union priorities (the EAFRD and the EMFF).

MAIN DIFFERENCES IN STRATEGIC DOCUMENTS BETWEEN 2007-2013 AND 2014-2020:

2007-2013	2014-2020
The Community Strategic Guidelines for cohesion policy The Community Strategic Guidelines for Rural Development	The Common Strategic Framework covering the five ESI Funds
The National Strategic Reference Framework covering mainly the three cohesion policy Funds and only some parts were formally approved by the Commission The National Strategy Plans covering the rural development programmes and the fisheries programmes prepared by the Member States in close collaboration the Commission and partners	The Partnership Agreement covering all the five ESI Funds and a majority of its elements require a formal Commission's approval, including in case of amendment.
Different content of the cohesion policy, EAFRD and EFF programmes	Common, basic set of elements for all ESI Funds' programmes
Separate programmes for the ERDF (+CF) and the ESF	Multi-fund ESF-ERDF (or ESF-CF) programmes allowed as well.

Sources Figure 5.10 and Figure 5.11 European Commission, Directorate-General for Regional and Urban Policy, REGIO DG 02 – Communication, European Structural and Investment Funds 2014-2020: Official texts and commentaries, November 2015. http://ec.europa.eu/regional_policy/sources/docgener/guides/blue_book/blueguide_en.pdf.

Map 5.10: Structural Funds eligibility 2014-2020



Source: European Commission, Directorate-General for Regional and Urban Policy, REGIO DG 02 – Communication, European Structural and Investment Funds 2014-2020: Official texts and commentaries, November 2015

Figure 5.12: Cohesion policy 2014-2020: Europe 2020 goals and Thematic Objectives

EUROPE 2020 GOALS	THEMATIC OBJECTIVES
Smart growth	1. Strengthening research, technological development and innovation; 2. Enhancing access to, and use and quality of, ICT; 3. Enhancing the competitiveness of SMEs, of the agricultural sector (for the EAFRD) and of the fishery and aquaculture sector (for the EMFF);
Sustainable growth	1. Supporting the shift towards a low-carbon economy in all sectors; 2. Promoting climate change adaptation, risk prevention and management; 3. Preserving and protecting the environment and promoting resource efficiency; 4. Promoting sustainable transport and removing bottlenecks in key network infrastructures;
Inclusive growth	1. Promoting sustainable and quality employment and supporting labour mobility; 2. Promoting social inclusion, combating poverty and any discrimination; 3. Investing in education, training and vocational training for skills and lifelong learning; 4. Enhancing institutional capacity of public authorities and stakeholders and efficient public administration.

Source: European Commission, Directorate-General for Regional and Urban Policy, REGIO DG 02 – Communication, European Structural and Investment Funds 2014-2020: Official texts and commentaries, 2015.

Thematic objective 4 "Supporting the shift towards a low-carbon economy in all sectors": Investment priorities (Art. 5 ERDF)

Article 5 ERDF describes the investment priorities under Thematic Objective 4 (TO4), "supporting the shift towards a low-carbon economy in all sectors" by:

(a) promoting the production and distribution of energy derived from renewable sources;
(b) promoting energy efficiency and renewable energy use in enterprises;
(c) supporting energy efficiency, smart energy management and renewable energy use in public infrastructure, including in public buildings, and in the housing sector;
(d) developing and implementing smart distribution systems that operate at low and medium voltage levels;
(e) promoting low-carbon strategies for all types of territories, in particular for urban areas, including the promotion of sustainable multimodal urban mobility and mitigation-relevant adaptation measures;
(f) promoting research and innovation in, and adoption of, low-carbon technologies; (only ERDF not CF)
(g) promoting the use of high-efficiency co-generation of heat and power based on useful heat demand;

In terms of these investment priorities under TO 4, the ESI funds programmes will be contributing in the period 2014-2020[77]:

- € 13.3 billion from ERDF and CF for energy efficiency in public and residential buildings, leading to almost 1 million households with renovated dwellings and reduced energy bills for public buildings;
- € 3.4 billion from ERDF and CF to support energy efficiency in enterprises, with a focus on SMEs, leading to over 50,000 enterprises with improved energy performance;
- € 1.7 of ERDF and CF support for high-efficiency cogeneration.
- In addition to Cohesion Funds, € 870 million and € 113 million respectively from EAFRD and EMFF will be allocated to energy efficiency measures in rural development and in fisheries, leading to over 20,000 farm holdings with improved energy efficiency, and a significant number of more energy efficient fishing vessels.

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

With overall changes in resources allocated to Cohesion Policy as a backdrop, and under consideration of the difficulties in comparing data from the two programming periods, an estimate has been made as to how much more money will go to low carbon investments in the current programming period.

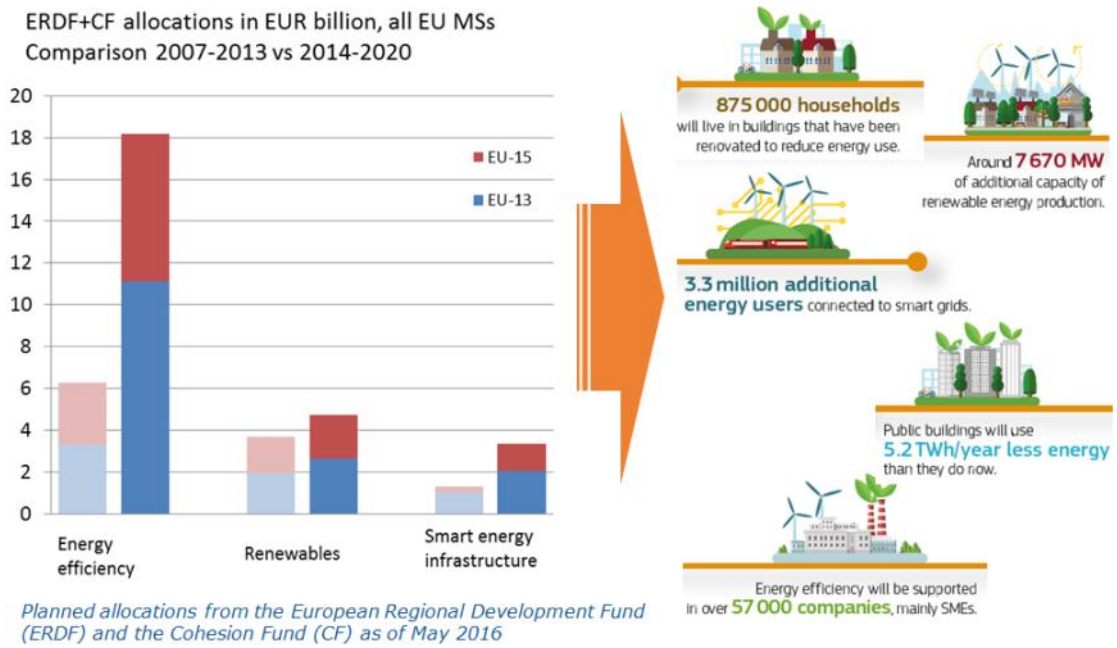
An overall tabulation of the data available at the European Structural and Investment Funds Open Data Portal allows a comparison between the share of funds allocated to low carbon economy within the ESI funds and within the ERDF.

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

As potential explanation for this allocation pattern can be stated that energy efficiency projects in private enterprises may form a new major focus in the current programming period, while investments in renewable energy production is dominated by national aid schemes and regulations, which also are varying greatly between MS.

[77] European Structural and Investment Funds 2014-2020: Supporting the shift towards a low-carbon economy; European Commission Non-paper, 13701/15 AS/AD/cs, ANNEX II DGG 2B; 2015

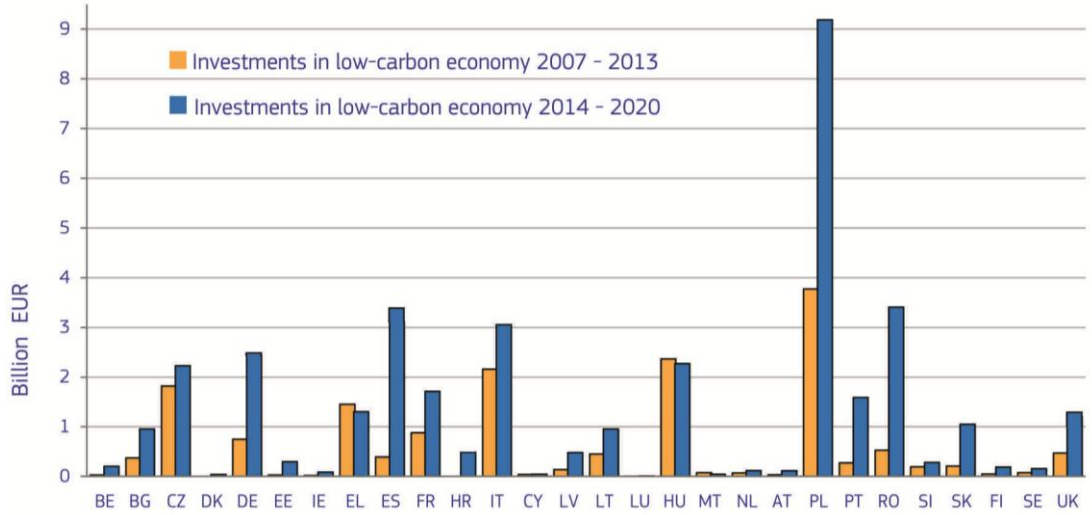
Figure 5.13: ERDF + CF allocations to energy efficiency, renewable and smart energy infrastructures 2014-2020 compared to 2007-2013



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

The distribution of Cohesion Policy funding across MS in 2014-2020 reflects the eligibility criteria (as displayed above), with Poland as by far the greatest beneficiary (over € 9 billion).

Figure 5.14: Cohesion policy allocations to low-carbon economy investments 2014-2020 compared to 2007-2013 in € billion

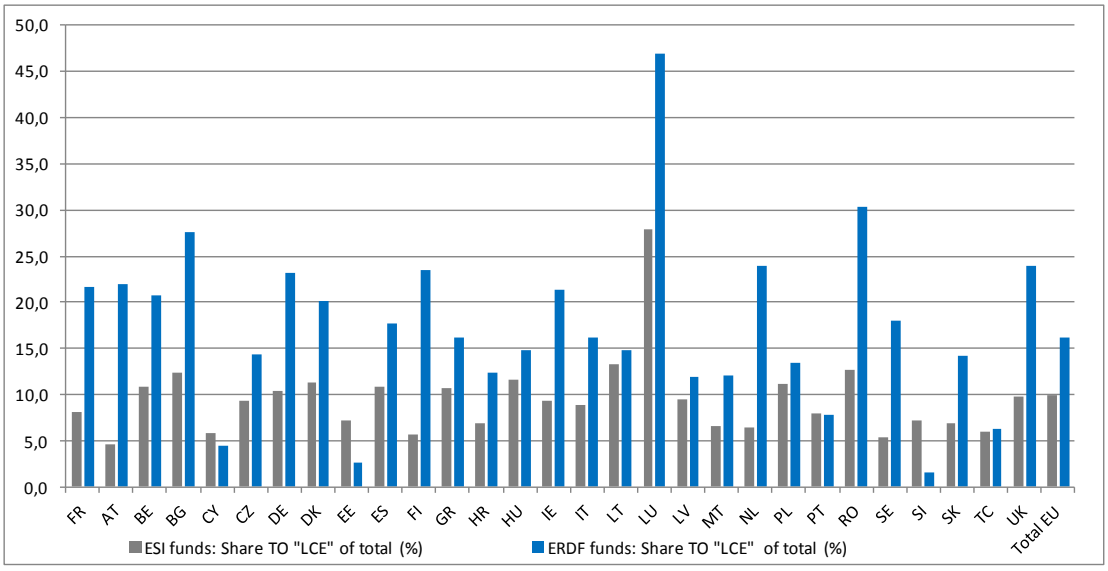


The figure shows the ERDF and CF amounts allocated in the Partnership Agreements (PAs) to low-carbon economy investments 2014-2020, compared to an estimate of similar allocations in 2007-2013. Source: How EU Cohesion Policy is helping to tackle the challenges of CLIMATE CHANGE and ENERGY SECURITY, paper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

The allocation strategies, however differ widely between MS: While some countries stepped up their allocations as far as 6 or 8 times more compared to the previous period (e.g. Romania, Estonia), some countries left their funding volume stable or even lower than before (e.g.

Hungary). Some countries apparently are using EU funding to substantially bolster their national low carbon strategies, with Lithuania on the top: Over 45% of total allocations are focusing on low carbon projects (Figure 5.15) – in a country, where Cohesion Policy overall has a significant impact on capital formation (over 52% of public capital formation was financed through EU Cohesion Funds in the previous period; see Table 5.1, above).

Figure 5.15: 2014-2020 – planned share of Thematic Objective "Low Carbon Economy" (TO LCE) of ESI funds and of ERDF funds (%) compared to 2007-2013



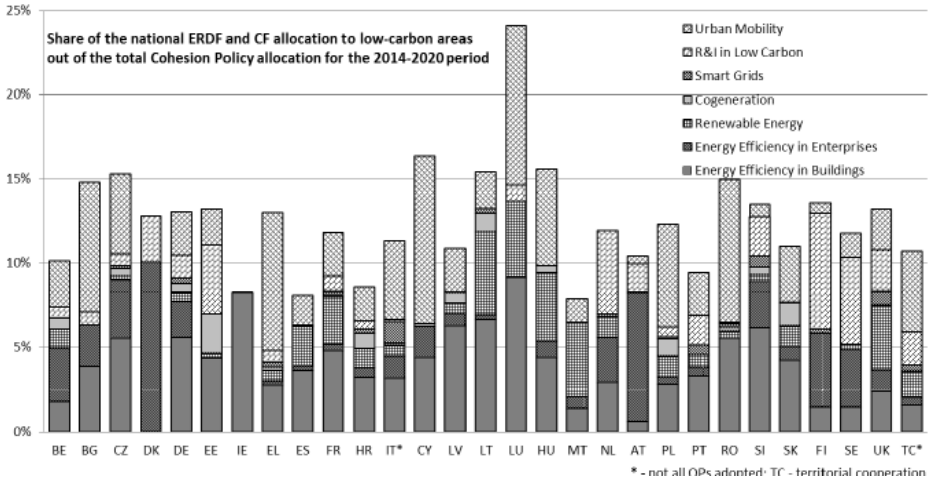
Source: European Structural and Investment Funds Open data portal (https://cohesiondata.ec.europa.eu/), own calculation.

The allocation patterns displayed in the figures above lead to the following main insights:

- According to the programmed allocation of funds, it has been a successful undertaking by the Commission to significantly increase the share for the thematic objective Low Carbon Economy.
- The contribution of cohesion policy money is – as in general – most relevant in the New Member States and in the Mediterranean, while in most of the large MS and in the northern countries the economic impact of ERDF money is rather low in relation to national policies.
- In some new MS the increase, however has been substantial, as in Poland, Bulgaria, Romania, Slovakia, Croatia, Latvia, Lithuania, where LCE-allocated funds more than doubled; also in Spain and Germany, where allocated funds jumped.
- In addition to cohesion policy, there is some minor contribution to the TO LCE from EAFRD, varying largely between MS.

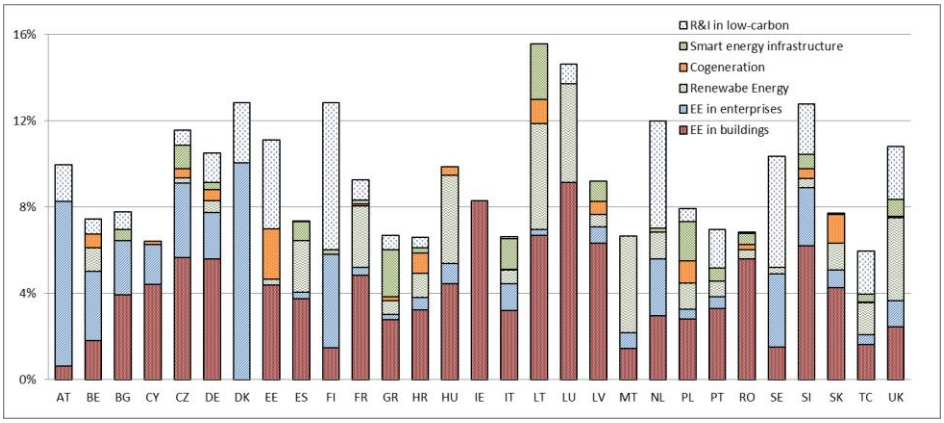
There also are great differences between MS and regions regarding the composition of the investment priorities selected – this is caused by varying economic and natural conditions as well as widely differing national energy systems and aid schemes (figures 1.16 to 1.18):.

Figure 5.16: Share of national ERDF and CF allocation to low carbon-relevant areas – allocation for the 2014-2020 period



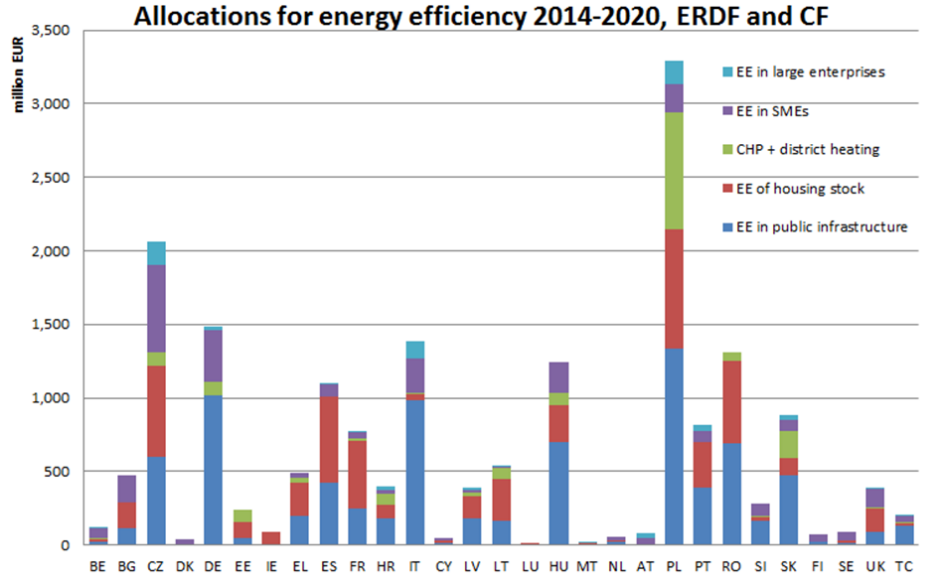
Source: European Structural and Investment Funds 2014-2020: Supporting the shift towards a low-carbon economy; European Commission Non-paper, 13701/15 AS/AD/cs, ANNEX II DGG 2B; 2015.

Figure 5.17: Share of the national ERDF and CF allocations to energy-related areas 2014-2020



Source: Energy and Managing Authorities Network, Presentation: Maud SKÄRINGER (European Commission), Brussels, 11 May 2016.

Figure 5.18: ERDF + CF allocations for energy efficiency 2014-2020



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

Overall, Cohesion Policy is the most relevant contributor by the EU to support investment in the transformation to low carbon economy. This is particularly true for Cohesion Fund money, addressing New Member States and some regions in the South. National policies, however, in comparison play a more significant role in most MS, particularly in the economically more developed regions. As particularly prominent example, Germany has supported the development of renewable energy production through generous feed-in tariffs, contributing through this measure over 20 times more than through direct aid money for investment[78].

These structural characteristics – limited contribution of Cohesion Policy within the context of other (national) policies and measures – will be of importance in the case studies (task 3) and illustrative examples (task 4) as well as in the in-depth interviews with programme administrators in task 5. It will be of particular interest, if Cohesion Policy can have additional effects beyond the funds being spent directly, such as providing a policy framework for national policies as well. Europe 2020 objectives, in general, will not be reached, if national policies are not aligned with EU policies. Cohesion Policy, in such a view, can serve as an orientation and example for national policy design, potentially creating a much higher impact indirectly than through EU funds.

5.4 EU Cohesion Policy: Potential impact seen from a regional perspective

5.4.1 "Trickling Down" of EU money – perceptions of EU funding sources

The use of EU Cohesion Policy funding for regional development across the EU is – of course – mainly defined through the overall regime and eligibility criteria, as has been shown in the sections above. In addition to that potential impact, there are a number of implementation barriers and factors limiting the potential effect with respect to a low carbon transformations strategy:

- National energy strategies and national regulatory and aid schemes are predominantly defining the attractivity of alternative funding mechanisms
- The use of EU Cohesion Policy funds in many MS, particularly in the EU-15, is only one possible option in a wide field of financial instruments
- Administrative and knowledge barriers have to be taken into account, since very specialized knowledge about a number of potential EU financing instruments have to be mastered
- the lack of sufficient national co-financing can a limiting factor
- in some MS, particularly in the EU-15, the added value of Cohesion Policy has been reduced to a degree, where the additional effort for administrating the programmes and for the investors are higher than the effect of the financial support.

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

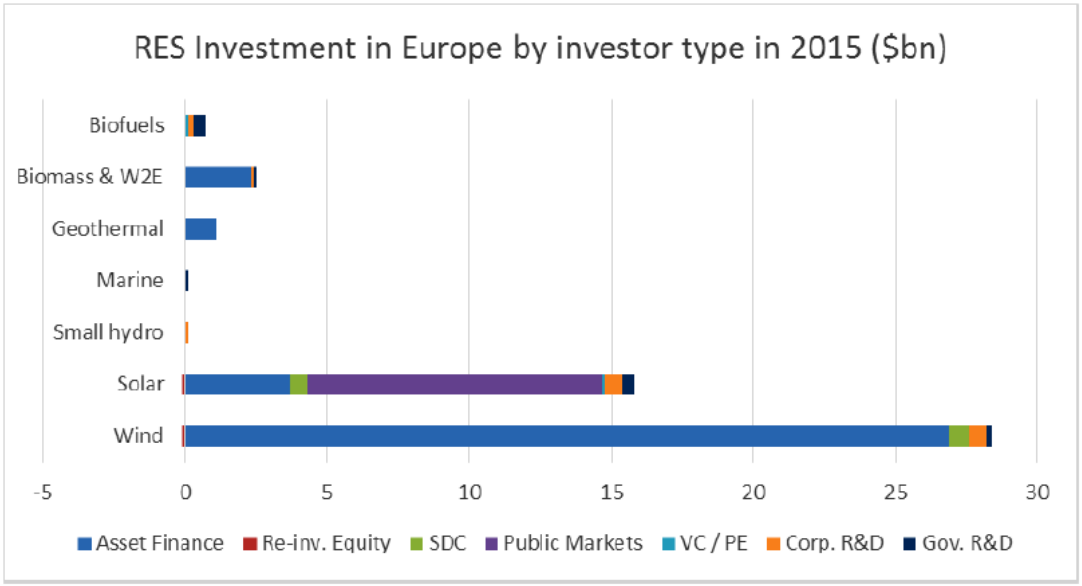
A comprehensive study on "Mainstreaming RES (2016)[79], has recently analyzed the complexity of bringing RES (or, in analogy LC-) projects on the ground in European regions. This sectoral analysis can illustrate the complexity of the question, what the potential impact of Cohesion Policy could be and how it could be increased in the future.

Figure 5.19 shows the RES investment levels in Europe in 2015, subdivided per investor type. The investments totalled to an amount of 48.8 billion dollar, which is a decrease of 21% compared to the previous year.

The general decline in new investments throughout Europe can form a threat to the 2030 targets and makes long-term estimates on new investments unpredictable. This also influences investors and investment decisions in new RE-projects.

The majority of the European investments in RES were based on asset finance in 2015. An example of asset finance investors are the utility companies. In 2014, nine of the largest European utilities invested a total of $11.9 billion in RES. Although this is an increase of 6% compared to 2013, it is almost 20% less than the total RES investment of these utilities in 2010.

Figure 5.19: RES Investment in Europe 2015 in $bn



Source: European Commission DG Energy: "Mainstreaming RES", (information on investment derived from data available by Bloomberg New Energy Finance, 2016), November 2016.

These trends are not very encouraging in terms of reaching EU low carbon targets, in fact, they make the necessity for public interventions visible.

[79] Source: 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, European Commission DG Energy, November 2016) Authors ECN/Oeko Institute/Eclareon/REBEL/SUER/BBH

Support mechanisms: Subsidies and feed-in tariffs

The potential of RES projects under present market circumstances (energy prices, CO_2 price) is currently not sufficiently profitable. Even large scale projects including off-shelf technologies like solar PV and onshore wind depend upon the presence of guaranteed subsidies as a trigger for private investment appetite. This is due to both the insufficient revenues compared to the costs, as to the uncertainty related to the expected revenues.

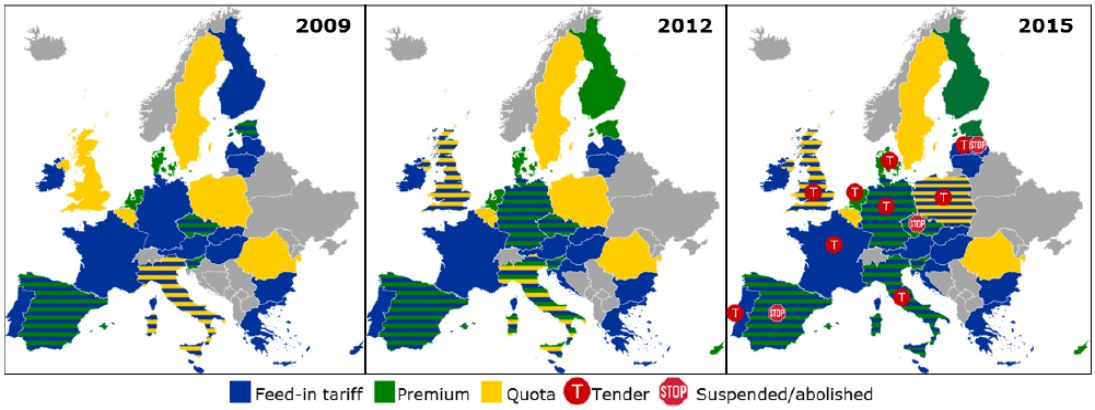
The existing incentive schemes for RES in European Member States all have a different impact on the attractiveness of RE-projects for financiers. In many projects, a mix of measures subsidies, guarantees or loans is used to attract private finance. However, not only do these measures have an impact on their own, it is also the long term certainty that it can provide which strongly influences the potential. Regulatory uncertainty can cause investments to drop significantly.

Hence the question is not only whether a subsidy scheme exists, but also to what extent the related cash flows can be guaranteed by the project developer via contracts with the authorities involved.

Many Member States are currently reconsidering or evaluating their support measures. In this reconsideration MS not only look into traditional subsidy schemes but also consider financial instruments such as debt and equity provision. Another trend in the evaluation of the support schemes is the development of operational subsidies, namely feed-in schemes. While early support schemes have mainly focused on fixed feed-in tariffs, new schemes are only providing a premium on the market price to RES producers.

The trend away from fixed tariff towards premium schemes can be explained by two main reasons: First of all, the economic concerns have caused MS to downsize support schemes as the financial burden was becoming too large, especially in the light of the economic recession. Second, feed-in tariffs do not stimulate RES to become more competitive as the tariff is fixed and thus might even lead to a higher electricity price.

Figure 5.20: Trends in feed-in tariffs, quota and premiums in EU MS, 2009-2015



Source: European Commission DG Energy: "Mainstreaming RES", (based on: Brückmann, R./Eclareon, 2016. Renewable energies – Overview on political frameworks in Germany and Europe), November 2016.

As mentioned earlier, in the current energy market RES projects are still dependent on public support, despite movements in RES policies. Especially typical innovative projects in an early phase of development require government funds before private funds can be attracted.

Feed-in schemes still account for 50-60% of onshore wind revenues. If these are surrounded with regulatory risks, this will limit appetite of banks and limited competition among funders. In the long term, the dependency on public funding should gradually be lowered, since a 27% penetration rate of renewable (EU-wide target) will not be possible in a constellation where total investment volumes depend on 50% or more of public investments.

Summing up: Under present market circumstances with low electricity prices and non-application of the “the polluter pays principle”, the RES business case does not lead to a feasible project without government intervention. If under new state aid guidelines subsidy schemes would be restricted this is likely to have an impact on even the 2020 targets, because of the uncertainties in the market.

While these developments seem to make the case for EU Cohesion funding, it also explains, why the overall incentive and price regimes differ widely between MS, uncertainty about the future regimes persist and the impact of additional money from Cohesion Policy sources is hardly relevant in regions of the EU 15. Only in EU-13 regions and in the South, a substantial and strategically relevant impact can be expected.

New EU sources of finance

EU provides a wider range of subsidy programmes and funds which are used to facilitate investments in RES than through Cohesion Policy. In addition, RES projects can be financed through EIB and EFSI money, which mainly focus on the deployment of (mature) technologies, like the ESI Funds. In addition, there are the NER300 (funded through the ETS allowances) and the InnovFin (under H2020) which focus on innovation and demonstration projects. A significant portion of all the above-mentioned funds are directed towards funding RES projects in the various MS.

Table 5.4 displays the main characteristics of ESFI and ESI funds, with the main difference that EFSI money can be used across all EU without the specific focus on less developed MS and regions. It is also unclear, as to what extent EFSI money will be addressing low carbon and RES development strategies.

Table 5.4: Main characteristics of EFSI and ESI Funds

	EFSI	ESI Fund
Objective	Launched jointly by COM and EIB to overcome current investment gap in the EU by mobilising private financing for strategic investments and SMEs.	Contribute to EUs strategy for smart, sustainable and inclusive growth, with a majority of the funding directed to the less developed/transition regions in the EU
Investment mobilisation goal	€ 60.8 bn of additional financing by EIB, € 315 bn in investment in the EU	€ 454 bn delivered (or € 637 bn in total, including national co-funding) through nationally co-financed multi-annual programmes
Available funding	EU guarantee (€ 16 bn) complemented by an EIB capital contribution € 5 bn	Under the Cohesion Fund, targeted achievement for 2014-2020 for RES capacity is 7 669 MW, and € 2.7 bn in investment spending (public and private)[63]
Timeframe	3 years from mid-2015, with possibility of extension	2014-2020
Eligibility	EFSI has no geographical or sectorial allocation or quotas	Focus on less-developed countries/regions
Thematic coverage	None specific	Includes 11 thematic themes, several relevant for RES (e.g. research and innovation, sustainable transport, low carbon economies)
What does it provide	Mainly loans, guarantees and equity investments. No grant funding is provided	Support mainly in the form of grants but also through financial instruments (e.g. loans, guarantees and equity investments)

Source: European Commission DG Energy: "Mainstreaming RES", November 2016 see https://cohesiondata.ec.europa.eu/overview. Additional funds for RE deployment are also made available under the ERDF.

The regional (and investor) perspective

Regions need an effective and transparent access to EU funding, in order to mobilize projects and complement national support schemes in an efficient way.

EFSI and ESI Funds may cover different risks and support different or same parts of the capital structure of a project or layered investment platform (e.g. equity or debt financing) provided that the rules on double funding and preferential remuneration are complied with[80]. EFSI and ESI Fund are quite different in character, they also complement each other. Beyond these are

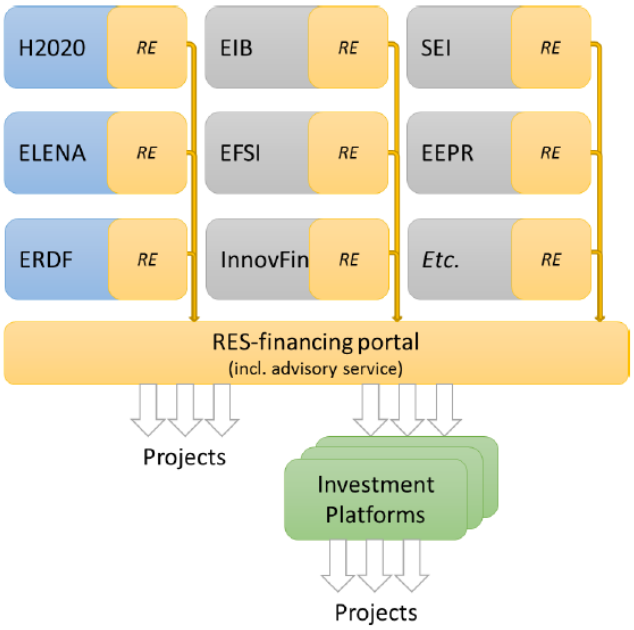
[80] http://ec.europa.eu/regional_policy/sources/thefunds/fin_inst/pdf/efsi_esif_compl_en.pdf, page 10.

the other above mentioned EU support instruments with focus on research and development, pilot projects etc.

From the viewpoint of a region as development promoting institution (or from an individual project developer), the EU support schemes alone would constitute a complex array of options. The authors of the “Mainstreaming RES”-report therefore suggest a user-oriented RES-finance portal, which could lead project developers through the maze of options, towards an optimal financing and aid package (Figure 5.21).

In their proposal, the RES-finance portal would act as an advisor to help an applicant with the best fitting financing and funding structure from European resources. After assisting in the financing structure, the portal can support in the further application to EIB, EIF, EC or financial intermediaries.

Figure 5.21: Illustration of RES finance portal



Source: European Commission DG Energy: “Mainstreaming RES”, November 2016.

However, referring to the above presented overview of differing national framework conditions (feed-in tariffs, aid schemes etc. in Figure 5.20), even realizing such a RES-finance portal would cover only part of the financial complexity for RES-related projects. The picture drawn in Figure 5.21 would need a country-specific complement with the national framework conditions, provided by national support schemes.

This example of a proposed RES finance portal in the context of discussing the potential impact of EU Cohesion Policy serves as an illustration of the complexities involved. As displayed above, it needs highly specialized knowledge to screen and assess all the offered financial support schemes, from (regional), national and EU levels, together with the regulatory conditions for realizing projects in a specific country.

5.5 Cohesion Policy related findings from case studies (task 3)

5.5.1 Task 3 approach

With the above background, displaying the complexities of project development in relation to regulatory and support schemes, it is understandable, why specific questions on the impact of EU Cohesion Policy addressed to regional development authorities and project developers are difficult to answer and it becomes even more difficult to assess the relevance of the impressions given by the interviewed persons.

Therefore, task 3 has applied a threefold approach geared to bring together information on regions with a successful record in promoting low carbon strategies:

- A meta-analysis on the content of available, thematically relevant case studies across the EU
- 5 in depth-case studies, covering strategies, policies and measures taken in the selected regions based on literature and data sources
- Interviews with regional development managers, energy agencies etc.

One element in task 3 is relating to Cohesion Policy: Which instruments are being used, what are potential impacts, what are problems and experiences in implementation.

5.5.2 Results from the case study meta-analysis

From the meta-analysis of the selected case studies across Europe some findings can be summarized (see task 3). It shows important aspects of regional low carbon development and comparing it to the content framework applied in the five case studies elaborated during the ESPON project at hand. Roughly, it can be stated that:

- About the half of reports (52%) provides with a general description of the region as background information, mainly concerning location, socio-demographic and regional economic structure and development.
- Information on energy strategy, energy consumption and renewable energy is the central issue in most of the reports (according to our selection criteria), with overall about 60%, up to 100% for key questions as e.g. energy consumption and renewable energy.
- Governance structures and regional policy portfolios are less elaborated, about 40% of all reports provide with information on these issues, but at least more than two thirds contain information about the regional governance system itself.
- Interrelation of regional, national and EU policy has been a topic of about a third of the reports, most elaborated in the course of the projects “Regions for Green Growth” and “CEP-REC”.
- *The role of cohesion policy for regional low carbon development* is being discussed in (only) about 23% of the reports, but has been an issue mainly in the project “Regions for Green Growth”, whereas other research projects did not put main emphasis on this aspect.
- Good practices have not been a major issue of the project reports screened at all, only 5% of all reports contain examples for successful implementation of specific activities within their regions.

This general picture from the case studies analysed in the meta-analysis leads to the conclusion that the focus of most studies had been in analysing energy strategies and projects, not EU or other support schemes.

Overall, the main findings from selected case studies screened in the meta-analysis of case studies can be summarized as:

- ERDF funds are seen as a major contributor for implementing energy related projects in southern and eastern regions (Greece, Italy, Spain, Czech Republic, Bulgaria, Romania, Estonia etc.)
- Regional institutions like Energy Agencies or thematically specialized Regional Development organisations are crucial to develop and finance projects, especially relating to EU funds and programmes (application procedures, documentation and auditing requirements)
- Embedding in national or other national thematic contexts, programmes and aid schemes is complex, but essential to raise the impact level and create an innovative background for project development and prioritisation; if there is no coherence with the national support environment, uncertainties are high and the potential for co—financing is limited.
- Administrative and knowledge barriers are significant, particularly in smaller and less developed regions
- National, regional or local sources for co-financing seem to be extremely limited in some regions, particularly in the East and Southeast, although the CP-share is already very high; this is particularly relevant, where municipalities are needed for co-financing, or, as in the case of Greece, the bank system is not able to provide financing.
- The relevance of municipalities as partners for project development and co-financing is being stressed several times and even in northern and more developed regions, small municipalities are not able provide for projects that need access to EU funds
- Some other, more developed regions, however, are well organized within their respective national settings, so that CP-funding is not essential, but they indicate that EU priorities are very helpful indirectly, also in view of opening long-term perspectives.

More details can be seen in Annex 2 on selections from case studies through the meta-analysis.

5.5.3 CP-related findings from task 3 case studies

From the ongoing case studies in this project results show the wide range of different experiences: While in Pazardzhik region in Bulgaria as well as in Burgos, Spain, EU Cohesion Fund money plays an important direct role in regional energy development, national strategies and support schemes are key in Greater Copenhagen, Greater Manchester and Vorarlberg regions.

Province of Pazardzhik, Bulgaria

Bulgaria joined the European Union as of the 01/01/2007. Since then, the country has access to and opportunity to use funds from the Community under the Cohesion Policy. The Province of Pazardzhik is part of the South Central Planning Region with administrative centre – city of Plovdiv.

The Cohesion policy has direct and visible impacts on the following priorities:

- Improvement of transport infrastructure and access to remote areas. There was renovation of the large part of the regional road network.
- Support to micro, small and medium-sized business through the financial tool JEREMIE.
- Development of advanced broadband networks for connection and electronic services for the business and citizens.
- There were measures to address employment in the region that had a good positive impact, as well.
- Projects to address conservation of environment, risk prevention and sustainable energy development.

Recommendations: projects in the area of research and innovation could be promoted with more policy actions. In the new period, 2014-2020. This can happen with the "Research and Innovation Strategies for Smart Specialisation", which aims at a developmental-economic transformation with a territorial dimension through:

- Focusing policy and investments support on core regional priorities, challenges and needs for knowledge based growth.
- Developing capacities, competitive edges and potential for excellence of the region.
- Support of innovation technology and practice and stimulation of investments in the private sector.
- Achieving the full participation of the involved stakeholders and encouraging innovation and experimentation.
- Evidence based plans for sound monitoring and assessment.

The Cohesion Fund aims to speed up economic, social and territorial convergence in the EU by providing grant financing to environment and transport infrastructure projects. Taking into account the high energy saving potential of the building stock in Pazardzhik Province, as well as the high potential of local renewable energy sources, the Cohesion policy might bring positive effect on the regional development by influencing, and co-funding the so called integrated energy projects.

The integrated energy approach is already well-known is some European regions, but yet poorly promoted in some Bulgarian regions, including Pazardzhik Province. Through Cohesion Policy measures, this integrated approach is being promoted and becoming a new standard in the region -an important impact beyond the financial contribution per se.

This integrated approach is applicable first in public buildings which might serve as demonstration pilots to the local community, and pave the way for the other two main target groups – the local industry and the residential sector. Once these two sectors realize the positive advantages of such integrated approach, they will certainly follow the local authorities in implementing these and transferring this experience and approach in their industrial premises/industrial systems and in their residential.

A key institutional prerequisite to make such policies and projects happen was the establishment of the Regional Energy Agency (REAP) in 2005, made possible through a project co-financed by the Intelligent Energy Europe Programme and supported by the Regional Administration.

The main activities of the energy agency in Pazardzhik are energy audits of small and medium-sized enterprises (SME), residential and public buildings, energy planning and programming at local and regional level and the promotion of energy efficiency, RES and sustainable urban mobility strategies, policies and practices at local/regional level.

In order to provide funding and channelling European money into the region, knowledge about funding opportunities and administrative procedures is essential. Promoting international programmes that focus on the financing and marketing of projects which emphasize on energy efficiency is essential to win public and private sector partners for project development. Hands-on exchange with international partners and best practice models, training of officials and firms are most important and effective activities of the agency. For example, the agency-developed manual on "Use of local energy sources and improve of energy efficiency in public buildings from Pazardzhik Province" has become a successful working tool to support local authorities in the implementation of energy efficiency measures and RES projects etc. It includes information on the relevant legal framework, provides planning documents as input for local authorities, gives information on financial tools and practical calculation and examples on good practice experience, e.g. on the transformation of public buildings.

The experience from Pazardzhik Province is that a region with small municipalities and little administrative capacities need a supporting unit such as REAP, particularly where projects are to be developed which need advanced expertise, such as identifying local RES potentials and evaluating their economic feasibility, as well as handling financial and EU-support issues.

Burgos, Spain

The ERDF focuses its investments on several key priority areas, known as "thematic concentration", with "low-carbon economy" as one of them. Key priority areas, where 50% the programme funds have to be spent (as in less developed regions) and 12% specifically towards low-carbon economy projects are the framework parameters for the Operative Programme (OP) in the region Castilla y León. Of the total of € 628.8 million in 2014 to 2020, *Action 4, for promoting the transition to a low carbon economy in all sectors will receive € 59.3 million or 9.4%. (*Action 6, protection of the environment and promoting the efficiency of resource us, will receive another 24.6% of the total). There are no other CP-related financial means dedicated to low carbon development in the region.

The regions' overall strategy is much in line with the national policy framework, particularly with the Spanish Energy Policy with regard to savings and energy efficiency, renewable energies and the the "Strategy for Energy Savings and Efficiency in Spain 2004-2020" (PER). Burgos follows a similar lines of policies, focusing on projects of biomass use and increasing energy efficiency as strategic priorities.

Within the framework of state level strategies, a great many of concrete policies and measures are developed and implemented by the Autonomous Communities (AACC), which adapt-

ing the designs to the particular local circumstances. Most AACC have established strategies or action plans and contribute aim to the achievement of national objectives.

A regional development agency is supporting these efforts: SODEBUR. It is in charge of social and economic development in industry, engineering, institutional cooperation and tourism. As one of the agency's 25 key projects in its strategic plan for 2015 to 2020, the project "Integral Renovation of Provincial Street lighting Project", PRIAP, will change the street lighting in 256 municipalities of the province of Burgos to LED technology, showing how energy efficiency is being promoted through new technologies.

Already in 2003, due to increasing energy needs, dependency from energy imports and environmental commitments of public bodies, Burgos Province Government promoted the creation of the regional energy agency AGENBUR. The purpose of this initiative was to establish a new culture in energy consumption, saving and promotion of RES. Burgos Provincial Energy Agency is focused on increasing public awareness about energy issues compatible with economic and environmental demands, on promoting of RES and on energy efficiency measures.

Based on a solid analytical background (evaluation and analysis of the energy system and of the future potential renewable sources), training and dissemination activities are being launched, technical advisory in RES and energy efficiency technologies, consultancy about financing programmes, economic incentives and subventions as well as institutional support as intermediary body are being offered to enterprises, public organisations and private households. Without the support from AGENBUR, a large share of EU-supported projects in various sectors (RES, energy efficiency, transport, biofuels, biomass, etc) could not have been developed and implemented.

Another example for the strategic support for the transition to a LC economy is the development of the so called "Biomass-Tool" by AGENBUR, serving as information and planning tool for the region, in order to develop projects generating local jobs, put local biomass in value such and to increase the use of renewable energies. The tool includes all kinds of biomass and all types of energy conversion (electric, thermal and mechanical), positioning AGENBUR as active knowledge broker and dissemination agency. Publishing a "biomass atlas" brought updated information on the region's biomass potential to the local actors and investors.

Greater Manchester, United Kingdom

Complementarity in this context is taken to mean the joint working of policies at EU, National and Regional levels in mutual support of shared goals. In general at a policy level, there is strong observable complementarity between the three levels in the area of low carbon, energy and climate change policy. EU target setting and informal support networks provide the stimulus and justification for regional activity and within the UK nationally there has been a desire to express leadership within Europe, which has stretched target-setting ambitions.

In terms of funding too, projects and programmes at the regional level are often enabled by European, national and regionally secured private sector funding coming together. This is

partly a function of match funding usually being a requirement of EU funding. Greater Manchester Energy Plan suggest that there is local awareness of the importance of the Lisbon Treaty in establishing energy policy as central to European activity and the resultant impacts on regulation (EU ETS, Energy Efficiency Directives and funding – especially IEE CONCERTO, INTERREG, ERDF, URBACT, and ELENA (GMEP2011: 79).

Complementarity between policy goals (as well as between policy levels) has also been possible with regional low carbon activity often being integrated within a range of other regional policy concerns including economic growth and fuel poverty etc. There appears to be particularly strong complementarity between ERDF priorities of stimulating enterprise and supporting growth, exploiting innovation and knowledge, creating the conditions for sustainable growth and growing and accessing employment with the regional Greater Manchester governance priorities.

There is also potential conflict: It is precisely this integration of low carbon ambitions with economic growth, employment and jobs that present potential conflicts and challenges for achieving carbon reductions and addressing climate change. Increasing development and GVA in general generate a net increased energy demand and an increase in carbon emissions. GMCA recognise this tension in their scrutiny of the Low Carbon Hub where it was recognised that it was a "Challenge to connect low carbon to the wider GM growth and reform agendas", even where these developments are relatively high performing in carbon terms. At the regional level this tension plays out in striving to meet competing objectives from National and EU policy and funding requirements.

Greater Copenhagen

Historically the Danish government has been strong in developing alternative energy policies, keeping up R&D investments in energy technologies even when the oil price dropped in the 80s and continuously forming a strong energy technology sector, mainly the wind sector, also in designing biomass, fossil fuel and waste to energy plants. Danish energy technologies now have a very strong position at the international market, supported through Denmark's active international role as promotor for the renewable energy sector and CO_2 reduction policies.

National energy policy can drive and influence the region's initiatives and projects: It set a framework for the renewable energy sector by promoting a fixed price scheme with favourable feed-in tariffs for decades. A successful penetration of wind power was a result of this policy. The local level, through active regions and municipalities give a significant impact on consumption patterns and sustainable lifestyles, contributing to higher energy efficiency.

In March 2012, a new ambitious energy agreement was adopted which should bring Denmark closer to reaching the target of 100% renewable energy in the energy and transport sectors by 2050. Committing to large investments up to 2020 in energy efficiency, renewable energy and the overall energy system, it is hoped to reach continued energy self-sufficiency together with the depletion of the remaining Danish fossil fuel reserves. (Source: Danish Energy

Agency 2011) [14]. Denmark's 2020 targets include approx. 50% of electricity consumption supplied by wind power and more than 35% of final energy consumption supplied from renewable energy sources.

The Danish subsidy scheme has been designed to promote energy efficient use of renewable energy also in industrial production processes by bridging the price gap between renewable and fossil fuels. This state subsidy scheme will support industries in transitioning to renewable energy sources or district heating to power manufacturing processes, thereby replacing fossil fuels with renewable energy such as wind, solar, biogas, or biomass. The third part of the scheme involves support for energy efficiency improvements made in direct connection with the transition to renewable energy or district heating.

This national framework also leads to intensive activities on the local level, planning for a renewable energy future. In Greater Copenhagen, the establishment of the Copenhagen Cleantech Cluster (CCC) in 2009, is representative of a new more deliberate era and ambitious green growth policy making and branding, supporting green growth policies, R&D and networking.

For the current CP-period 2014-2020, Denmark has allocated around € 346 million of ERDF money with investment priorities which include a prominent focus on environmentally friendly and resource-efficient economy.

In the former 2007-2013 Cohesion Policy period, where € 613 million ERDF-money were available, this has helped to aid over 3500 start-ups and new jobs, 245 RTD (Research technological development) projects and 104 renewable energy projects. Indirectly, this CP engagement lead to a higher number of patents and international recognition for the CCC as one of the world's leading cleantech clusters by OECD and UNCTAD.

It is important to note that the Research, Technological Development and Innovation (RTDI) policy has been a strategic pillar for the Low Carbon transition from the very beginning, allowing for what later became labelled "Green Growth" in a competitive international economic environment. Through this intelligent policy mix of tariffs, investment aid and research; a strong innovation capacity has been developed, leading to successful overall growth combined with less total energy consumption and an increased share of RES. CP played a supporting role in strongly nation-led policy framework.

Vorarlberg, Austria

Although Austria had been active in the protection of the environment before its accession to the EU, the European Commission has been the driving force ever since. It is the EU level that sets the goals and impels Austria to act.

The EU energy- and climate objectives[81] base on the Kyoto Protocol. In addition, the EU committed itself in 2007 to their 20-20-20 targets as part of the climate and energy package and adopted in 2014 a framework for climate and energy policy by 2030 to meet the long-term goal of reducing greenhouse gas emissions by 80% to 95% by 2050 in the most cost-effective way possible. Targets were defined to put the EU on the way to achieve the transformation towards a low-carbon economy as detailed in the 2050 low-carbon roadmap. This roadmap emphasises the need to implement measures in all main sectors responsible for greenhouse gas emissions in Europe. This includes power generation, industry, transport, buildings, construction and agriculture.

The Austrian national policy framework in recent years has strongly been influenced by EU policies –be it as strategies formulated, or directives and regulations with binding effect. Local actors expressed their view of EU policy being very important to national and hence regional low carbon development by urging national policy makers into action. A small country like Austria, seems to be otherwise in doubt that it is up for the challenge. Obligatory reporting of all Member States is seen as an important source of information for the national/regional policy makers, serving also civil society by providing knowledge on the state of things and progress being made.

All in all the EU policies in low carbon development are regarded as innovative by regional stakeholders as in the example of the National Energy Efficiency Act 2016, which was criticized because of its poor implementation impact (low impulse, massive administrative efforts, established measures were sold as new; etc.).

However, regional policy is in aligned with national policy which again is derived from EU policy. Regional and national funding schemes support those. No hints were found that indicate deviating or conflicting objectives. If any, Vorarlberg's policies tend to be more progressive than their national counterpart.

The unanimous Landtag decision approving the Energy Autonomy – Vorarlberg, made energy to an important theme of the state of Vorarlberg. This lead to a reallocation of ERDF funding to the "biomass" area for increased investment in biomass power plants. It is this investment in biomass power plants that is the only issue that came to mind when asking interviewees about the effects of cohesion policy in Vorarlberg's low carbon development.

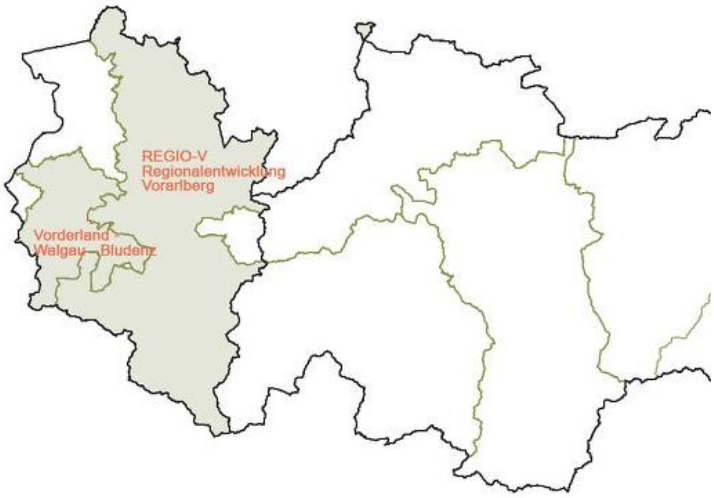
In the operational programme itself mentioned the Vision Rheintal as potential beneficiary but consultations with stakeholders indicated that there were many hick-ups in the funding process, resulting in minimal input from ERDF funds to that programme. The Vision's set-up was not compatible with the funding logic concluded the consulted stakeholders.

[81] Read more on http://ec.europa.eu/clima/policies/strategies_en

Interviews suggest that using financial means of cohesion policy for low carbon development is rather unattractive. Potential beneficiaries are increasingly reluctant to submit funding applications due to the administrative burdens, extra efforts and uncertainties regarding the actual distribution of funds. All in all the cohesion policy – in the narrow, OP-focused sense – seems to play an insignificant role in low carbon development of the region.

It is worth mentioning, that EAFRD/Leader also impacts low carbon development in Vorarlberg, although not in the Rhine Valley, which represent – to a large extent -, the urbanised region of Vorarlberg. In the former programming period the local action group "REGIO-V" was an important partner to promote and support low carbon development in their LEADER region. In the latest programming period, a second local action group was formed that incorporates Rhine Valley territory.

Figure 5.22: EAFRD/LEADER – local action groups in Vorarlberg 2014-2020



Source: Netzwerk Zukunftsraum Land LE 14-20

Their input to local carbon development remains to be seen. In addition, EAFRD funds can be used co-finance UFI projects (in the fields of biomass local heating systems, construction, expansion and consolidation of heat distribution networks), projects financed by klimaaktiv mobil and the Climate and Energy Fund (for investments in KEM and photovoltaic systems in agriculture).

The "Climate and Energy Model Regions" are a good practice example for making bottom-up work possible through a local agencies and projects approach, which is funded by the national climate and energy fund. The region has to apply for national funding with a work concept describing the status quo, sets goals and benchmarks, identifies (RES- and efficiency-) potentials and includes a plan for concrete actions in the region (approx. 60,000 inhabitants). A regional manager is then driving the implementation of projects of the action plan, establishing close networks and working relationships with key actors and the local economy in the region. Dissemination and awareness programmes lay down a foundation for these project-oriented implementation activities.

Summarizing, there is a considerable effect of EU policies on transformation efforts in the province of Vorarlberg (and in Austria in general), but the impact of Cohesion Policy in its concrete sense is very limited, This is mainly due to the minimal size of the OP where, broken down into thematic priorities, there is too little money available to make a significant contribution.

5.5.4 Conclusions – experience with CP in the five case study regions

The case studies, using local expertise directly and desk research, attempt to bring in a thorough investigation of regional, practical implementation experience. The five case studies on selected regions cover available in-depth information, structured in the same way. Through the comprehensive case study approach

- it was possible to consider the regional economic and policy background in terms of understanding the national and regional level policy context in which Cohesion Policy is introduced,
- in order to relate CP to other funding programmes and support opportunities,
- and to assess the complementarity and/or potential target conflicts of present funding/support strategies.

The regional case study approach involving local actors in (EU-) regional development and energy transition is regarded as most important for practice-minded recommendations. Since at the regional level project development and financing are key for realization, to use all potential sources for funding, from EU, national and local sources, is mandatory for a successful transition process.

As a general conclusion, the coherence between national, regional and European policies – with special emphasis on Cohesion Policies – is key to success. In most cases, RES and energy efficiency strategies started before and independently of CP but has been stimulated and other EU policies and national strategies. Within the case study framework,

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

EU policies serve as guidelines and stimulus – the effectiveness on the ground, however, largely depends on the national and regional policies and actions.

As can be concluded from Locate case studies and from others (see meta-analysis, above), as well as from the results in task 4 on regional governance, well organized regions can have a major impact on how many and how well-conceived projects are being developed and implemented. The regional level is closer to the economic and municipal actors, who have to be involved and informed about future possibilities in energy transition and on the road to a LC economy – and it is these players who have to be convinced and active in implementation.

National policy frameworks, however, are the key to letting things happen and supporting such an operative role of the regional level institutions.

The *view of regional actors* on the relevance of CP programmes largely depends on the budget dimension of the programmes, depending on the development status of the region:

- In more developed regions, the relevance compared to other sources of financing and supporting LC-related projects is marginal. Other programmes and support for innovative actions are more relevant, be they 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 an important themes and regional development opportunity.
- Less developed regions, in contrast, profit largely from these special funds allocated for priority themes, often putting LC economy as an more prominent theme in front as would have been the case in purely national support schemes. There is significant money inflow from outside to the region, targeted for investment in certain thematic priorities – here CP has an immediate impact on where and how local resources (public or private) are being allocated.
- Here, in less developed regions with access to major CP funding, it is of an even greater relevance how well organized CP-programme administrations are being established and how this operative CP-programme management is being complemented with national/regional expert institutions who provide thematically focused support, consultation and planning to prepare the ground for continuous project development. The examples of Pazardzhik in Bulgaria and Burgos in Spain show, how even small regional energy agencies can make a difference: Groundwork on a region-specific analysis on energy efficiency and RES-potential, developing a regional energy strategy are the basis; providing economic feasibility studies and hands-on consultancy to municipalities and investors relating to legal issues and access to (EU-)funding are most relevant for getting things going.
- In the case of more developed regions, such as Manchester or Copenhagen, priorities, policy designs and development strategies have been explicit and formulated towards a transition to LC economy independently from CP-programming before. There, the overall package of national and regional policies and institutions was built up already from the beginning, with a wider concept of economic transformation, involving RTD and economic specialisation strategies as well as citizen participation, awareness and consumer behaviour-oriented programmes. In the case of Denmark, involving the capital region Copenhagen, it was a national strategy and policy package contributing to a large-scale specialisation in energy technologies and also in developing innovative legal frameworks, in order to bring technology changes on the ground at high speed (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.).

With respect to procedural and administrative aspects of CP-programme development and implementation, there is an unanimous call for reducing the efforts for both sides, administrators and – even more relevant – beneficiaries. In more developed regions, these procedural efforts are seen as a reason for avoiding CP-funds, particularly for more innovative and RTD-oriented projects. In most cases, EU-CP-money does not provide higher support than national state support, so that extra CP-procedures are seen as an additional burden (and risk) with no advantage compared to strictly national funding (as for instance, in Austria and Denmark). The risk on the side of beneficiaries and programme managers rests with the spe-

cifics of control procedures during and after project implementation: In innovative and RTD projects, e.g. the interpretation of eligible costs offers a wide range of uncertainties, on top of the innovation risk of the projects per se.

Summing up, lessons from LC transition oriented CP-programme implementation are threefold:

- CP-programmes and funds can be used for strengthening and orienting regional transition processes, particularly relevant in less developed regions
- National policy frameworks are of highest relevance in terms of the effectiveness of LC-transition strategies – if pursued actively and forward-oriented it can become a major contribution to “green growth”
- A complementary network of research, consultancy and innovative firms in regional context, open for exchange and innovation with outside partners, is key to providing a continuous flow of project development and implementation – a CP-OP administrative unit alone is not sufficient to initiate and support project development.

Good practice examples and successful approaches also contribute to the knowledge about how to efficiently use European, national and regional policy measures in general (see some good practice examples and recommendations relating to the design and operative terms of LC-projects in task 3, case studies). These good practice examples demonstrate convincingly that a wide range of contributors to regional innovation and project development are necessary.

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 LC economy transition. The example of Denmark and the region of Greater Copenhagen seems to be leading in European perspective, but it is a realistic path even for smaller regions like Burgos and Pazardzhik – provided, national policy frameworks are supporting such regional development strategy approaches.

5.6 Contextual analysis in task 4: Potential impact of regional level policy making on LC-transformation

The role of the regional level as key to successfully designing and implementing transition strategies to a low carbon economy has been researched and analysed in a EU-wide analysis in task 4. From there, a twofold conclusion can be drawn:

- Regions with a higher range of (policy) authority and potential to define their own policies have a significantly higher degree of attention and focus on LC-related strategies
- These regions also seem to have been more successful in relation to changing patterns of energy consumption and production (based on the performance indicators derived from task 1)

The Regional Authority Index (RAI) used there is incorporating dimensions like institutional depth, policy scope, fiscal autonomy, borrowing autonomy, and representation (see task 4). Data on exploitation of renewable resources and energy consumption patterns were collated from tasks 1 & 2 for each NUTS 2 region in the ESPON space. They had to be matched to the administrative boundaries used for the RAI index.

To produce an overall score which measured a *region's progress* towards a low carbon economy a composite index was created – for data availability reasons, this index encompasses Solar PV, wind energy and energy consumption in buildings only, but delivers the changes between 2002-2012 (solar PV and wind are by far the biggest contributors to renewable energy and have the biggest physical impact, buildings account for 40% of energy used in the EU).

The analysis shows – highly significant – that the greater the degree of regional autonomy the greater progress towards a low carbon economy a region seems to be making. Regions with a low degree of autonomy, on the contrast, show less progress and potential for a transformation process towards a LC-economy.

The question of interrelation with cohesion policy in elaborating regional strategies and initiatives is extremely difficult to extract at this level of investigation (in task 4), so it can only be postulated that regions with a successful record of LC-transformation are also able to integrate and use CP-programmes and measures in complementary way.

The illustrative examples in task 4 have also highlighted the influence of international initiatives to the regional level. In some cases, the strategies developed at the regional level seem to be more influenced by international initiatives rather than by national policy measures. In addition, there is also evidence of the influence of international bottom-up initiatives, for example, the Covenant of Mayors. It seems that (active) regions are seeking to look above their respective national government for inspiration for their initiatives on the low carbon economy.

5.7 Experience from CP programme managements

5.7.1 In-depth interviews with key representatives of national and/regional authorities

Based on this background information, a series of in-depth interviews have been be 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), in order

- 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 study and policy assessment regions).

The information collected by these interviews are forming the background for recommendations for future adaptations and options for bringing added value through CP to the regional implementation of low carbon economy.

5.7.2 Summary from CP-expert interviews

During the expert interviews, the issue of a need for simplification of the EU Cohesion Policy was raised several times. Although the interviewees' opinions on the extent of simplifications needed were divided, the issue was raised several times. While some stated that it would be only natural that beneficiaries needed to follow the rules of those giving the money, others argued that the procedural side of the Cohesion Policy was too strong. This would lead to a smaller real impact of the projects and a longer implementation time. So far, only few projects are being 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 following the respective 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 the case especially for a country like Greece, where it can address market failures, but, as one interviewee explained, using financial instruments in the end means negotiating loans. As this requires special expertise, this could lead to other increased administrative burdens, subsequently leading to another specialised layer of administration. The targets for renewable energies are regarded as quite high and as a long-term goal of society, so policy makers and society in general need to back up the transition to a low carbon economy.

For FIs it was further stated that the requirements for obtaining 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 and in the end, a loan from a private bank would be much easier to obtain. FIs would be more useful for supporting innovation and more likely an alternative to grants and private loans, if the risk of a failure could be accepted by the lending institutions.

Energy efficiency and renewable energy are two sides of a coin and need to be pushed forward complementarily. While some renewable energies tend to become increasingly profitable, a balance between necessary support and market distortion remains difficult to obtain.

5.8 Smart Specialisation in Energy

The key approach for regional transition to a LC 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 regions' experience, that it is necessary 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 field.

"The Smart Specialisation approach combines industrial, educational and innovation policies to suggest that countries or regions identify and select a limited number of priority areas for knowledge-based investments, focusing on their strengths and comparative advantages."[82]

The S3 concept was developed in 2009 by an expert group of the EC and published in their report "Knowledge for Growth"[83,84]. Against the backdrop of the economic crisis of 2008 and an overall deficit of R&D in Europe compared to the US, innovation and knowledge were identified as key growth-driving factors. Acknowledging that innovation, by its nature, could not be solely state driven, governments and especially regional authorities were encouraged to actively fulfil a modern governance role and to engage all sectors of society.

"Addressing the issue of specialisation in the R&D and innovation is particularly crucial for regions/countries that are not leaders in any of the major science or technology domains. Many would argue that these regions/countries need to increase the intensity of knowledge investments in the form of high education and vocational training, public and private R&D, and other innovation-related activities.[85]

Smart Specialisation has been designed for supporting regions to find their particular strengths instead of forcing investments into technologies, which are regarded fashionable at some point of time.

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's programming period 2014-2020. By mid July 2017, 17 countries and 170 regions have been registered, among which 66 EU regions participated in "five interregional partnerships of smart specialisation on the fields of bioenergy, smart-grids, marine renewable energy, sustainable buildings and solar" by June 2017[86].

The Joint Research Centre in Sevilla[87] operates the EC's Smart Specialisation Platform[88], which provides advice to EU Member States and regions for designing and implementing their

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[82] OECD, http://www.oecd.org/sti/inno/smartspecialisation.htm, last accessed on 15 July 2017

[83] Knowledge for Growth. Prospects for science, technology and innovation. Selected papers from Research Commissioner Janez Potočnik"s Expert Group. Available at http://ec.europa.eu/invest-in-research/pdf/download_en/selected_papers_en.pdf, last accessed on 15 July 2017.

[84] The expert group, consisting of economists, was established in 2005 after the Lisbon strategy and particularly in an overall fear of further lagging behind in the global ICT sector. The group should "provide advice and insight about the problems and issues that would promote the emergence and development of an efficient and effective European system of research and innovation".

[85] Smart Specialisation: The Concept. in: Knowledge for Growth, p 20ff.

[86] 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

[87] DG Joint Research Centre

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

S3. Under the overall S3, several priority areas have been defined, such as “key enabling technologies”; “agro-food”, “health”, “energy”, “digital growth” and “others”. The platform not only provides material and information, it also training policy makers, facilitates peer-reviews and mutual learning and is an access hub for relevant data.[89]

Under this roof, four thematic platforms – on agri-food, energy, industrial modernisation, and methodology – are operated, all at least partly relevant for supporting transition strategies towards a LC economy. The Smart Specialisation Platform on Energy (S3PEnergy) addresses energy issues as part of the European efforts to achieve a knowledge-based energy policy in regions.[90]

A mapping of the different energy specialisations, which are the technologies included in the Strategic Energy Technology Plan (SET-Plan)[91], reveals for example a concentration of Electric vehicles in Germany among other regions in Spain, France, Sweden, Finland, Austria and Italy. This has been carried out in a first step of the smart specialisation process (SSP) to identify groups of regions with common interests in certain energy technologies. SETIS, the Strategic Energy Technologies Information System, offers the results of this mapping in an interactive map, where NUTS2 regions with a specialisation on energy are listed.[92] The mapping also revealed that at this time only 7 of the MS had national and regional strategies related to energy.

S3PEnergy lists two main objectives: The first objective is to support the implementation of the smart specialisation strategies of those regions/countries that have chosen energy-related priorities in their S3 (under Thematic Objective 1), in particular as regards energy innovation activities at (sub)national, regional and local levels. Second, S3PEnergy wants to assist MS in the uptake of the Cohesion Policy funding opportunities for energy (under TO 4 and 7e).[93]

Overall it seems to be a most innovative and potentially most relevant approach to support regions in their efforts in economic development, with particular focus on energy- and resource-related themes: RES production, innovative distribution and storage technologies (“Smart grids”) and efficiency technologies in the building and production sectors are key fields for the transition to a Low Carbon Economy. Under a European policy framework and long-term commitments with respect to decarbonization, it seems worthwhile to strengthen the links between innovation-oriented regional development, concrete energy project development and

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

[90] http://s3platform.jrc.ec.europa.eu/s3p-energy

[91] These are Smart grids, Electric vehicles, Solar, Bioenergy, Geothermal, Wind, Hydro, Ocean, Combined heat and power (CHP)/Heating & Cooling, Carbon capture utilisation and storage (CCU/S), Hydrogen/Fuel cells, Nuclear, Storage, Oil/Gas, Energy efficiency, Renewable & energy generic, which could all lead to a decarbonisation of the European energy sector.

[92] See the map: https://setis.ec.europa.eu/node/10451

[93] http://s3platform.jrc.ec.europa.eu/s3p-energy

CP funds to be channelled into the regions. It cannot be evaluated in the context of this project, however, how far the S3PEnergy platform already is making an impact, but it seems that there is great potential for future intensification.

5.9 Conclusions and recommendations

5.9.1 Main results on the potential impact of CP

Using EU data, regulations and programming sources, as well as available evaluation studies, experience with the former and changes to the current cohesion policy's thematic focus on the transition to low-carbon economy have been discussed. Through results from tasks 3 and 4, integrating practical experience with cohesion fund implementation from case studies, interviews and illustrative examples, relevant interpretations and experience from regional agencies were made accessible.

Task 4, analysing the national/regional policy contexts for regions, it has been attempted to elaborate a policy context for the measures supported by EU Cohesion Policies. Although it is not possible within the framework of this study to synthesise and analyse all policy levels in Europe and their interaction, it is recognized that the recommendations for EU Cohesion policy should take that context into account. Analysing performance data from task 1 and relating these with a Regional Authority Index, task 4 concludes that regions with a higher degree of (political) autonomy perform better on the way towards an LC-economy than regions with little policy potential. While it cannot be distinguished from the analysis what the impact of CP to the better performance of the active regions was, it seems plausible also that such regions are better capable of using EU funds effectively to support their overall strategies.

Based on the analyses performed in task 5 and referring to the discussions with regional energy and programme experts, a number of conclusions on the use of CP funds in the regions across Europe can be formulated. Relating 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 need to be stressed:

- The relevance of Cohesion Funds and Cohesion Policy in general for creating impulses to the LCE-transition, has been established quite clearly through both elements of research, comparison of Cohesion Fund allocation for the periods 2007-13 and 2014-20, ex-post evaluations as well as 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:

- Overall, the coherence between EU and national policy frameworks is varying greatly between MS and the interaction of EU and national policy mixes is little researched and understood (particularly in a comparative way, which could lead to evidence-based recommendations on how to reorganize EU and national governance and policy making.
- Systematic cross-checking with national policies and measures, under the assumption that only effective interaction with national regulatory and aid schemes will be able to provide substantial impacts, is needed since it seems clear that there still are a number of contradictory rules and support schemes in operation (as e.g. in the proverbial state aid to install oil tanks for heating in private houses)
- Overlapping competencies and a maze of similar initiatives on national and regional levels, particularly in federal states, tend to make policies less effective and are binding administrative and consultancy resources ineffectively
- Concrete barriers to CP programme implementation are administrative barriers, the need for administrative expertise and large capacities, and the lack of knowledge about access to CP-funding in industry, SMEs and research institutions.

5.9.2 Recommendations for CP-implementation in the current period

Looking for recommendations for best using CP funds in European regions, innovative network structures for promoting LCE-transition seem to be a potential key factor. Overarching networks and platforms, such as the Smart Specialisation Platform on Energy[94], 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 play an important role for promoting LCE-strategies and supporting the development of innovative projects in the regions. In order to increase the impact of these institutions it is necessary to better understand their working experience and analyse what they would need to have a wider roll out and intensify their contribution to regional activities. Therefore, the concrete experience on promoting LCE transition and supporting regions, municipalities and enterprises in their respective innovation fields should be researched and – based on this – *measures to support the support structures* be designed:

- What are the needs of these organisations and innovation promoters to better fulfil their tasks ?
- What are national/regional needs to better interact with other regional partners and these support institutions ?
- How can incoherences in the respective national/regional policy frameworks be overcome, such as barriers in the energy-related legal systems and in contradictory economic aid priorities (relating to tariff structures, barriers for locally produced energy to be fed in and be shared, etc.)?

[94] 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

Most of these issues reach back to the overarching question of conflicting policy goals and strategies on national and EU levels: As long as it is is not a clear priority 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.

Concluding from the case studies and the meta-case study review (in task 3) In order to bring a regional development strategy towards LC economy on the ground, a number of *essential governance prerequisites* have to be provided:

- 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 detailed, high 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 with respect to energy and low carbon transition economy which are needed independently. CP programmes can be drafted and implemented effectively only, if such institutional groundwork has been put in place before. If a country cannot provide for such regional structures, the effectiveness of CP will be very limited. The S3P-Energy approach could become an EU-wide tool which is also helping countries and regions to provide such institutional prerequisites.

Therefore, a wider and more intensive application of the S3PEnergy-approach across Europe's regions seems to be a promising way of supporting the transition to a LCE. Despite the concept being developed almost 10 years ago, in 2017, S3 still seems to be more of a conceptual framework than a precise strategy to be applied by regional governments. It is possible, that some regional authorities are still not aware of the necessity of actively implementting S3-strategies or unaware of how crucial such thematically focused innovation can be in the long run for both, economic development and social well-being.

For this reason it is recommended to actively strengthen the roll out of the S3PEnergy, with a particular effort to involve regions lagging behind in economic development, but also showing potential in either RES production 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,
- would lead to project development on the ground,
- providing project potential EU CP-fund support and thus would
- generate employment and tax revenues through "green growth".

In consequence, to regions who need such innovative impulses, probably an actively provided *introductory phase* to the S3 approach would be advised, also some consulting on how to create supportive administrative and governance structures around the S3Energy strategy.

Such an approach needs engaging all sectors of society (private, public, civil society, research and academy) and therefore also needs an adaptation of conventional administrative structures and procedures. It seems this field – regional governance – will need most of the societal innovation as precondition an essential environment, to make technological change and behavioural adaptations possible. Engaging all sectors of society (private, public, civil society, research and academy) is key to a successful implementation of smart specialisation strategies. All relevant stakeholders in a region need to identify the region's strengths and opportunities together. Innovation leaders, such as Copenhagen region and others, have shown convincingly that such an 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 actively rolled out S3 Energy in many more regions.

5.9.3 Recommendations for the post-2020 programme framework

Another question arises with the perspective of preparing for next programming period, in which new regulations will have to be developed in order to contribute to the achievement of the even more ambitious EU 2030 targets – while facing a considerable cut in CP money as result from the Brexit.

For this long-term perspective, with the overreaching ambition to contribute significantly to the achievement of the EU 2030 on energy and CO_2, it seems reasonable to

- learn from the experience of the current period, especially in terms of the active regional deployment of smart development strategies,
- to address the administrative barriers and problems of national co-financing in some regions,
- to adapt to budgetary restrictions for the policy mix to be used and
- to link and expand new financial instruments in a coordinated way to the 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 seen in amore general, LCE-oriented perspective:

Based on this proposal (conceived for RES-mainstreaming); a generic approach to LC-project finance in the framework of post-2020 Cohesion Policy could be formulated:

- a generic project finance portal is established, 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 helps project developers to analyse economic feasibility of their proposals under optimal financing conditions
- Smart Specialisation Platforms are being rolled out in terms of thematic and regional scope, with a major focus on the transition to Low Carbon Economy
- The financial support scheme of the past and current periods, involving substantial grants to infrastructures and investments in R&D or SME-development is focused on least developed regions and less developed regions, with a clear link to the thematic spectrum of the regional S3 strategies.

Since is conclusion and proposal 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, national/regional policy frameworks and (horizontal) Financial Instruments is twofold:

- Regional institutions (governments, development agencies, intermediaries etc.) and individual project developers should have EU-wide access and advice to the whole array of support schemes and financing instruments in the phase of project development, investment decision and implementation;
- On the EU-side of CP (and complementary support schemes and Financial Instruments) there should be a clear cut differentiation between publicly financed infrastructure and self-sustained projects which have to be maintained through revenues in a market situation; for such projects, the risk should remain with the investor after having consumed a stimulating support from EU and/or national sources. With this approach, much of the control and auditing barriers of current CP programme administration could be reduced.

As a consequence, there would be a sharp distinction between public infrastructure and projects in a private law framework, be they profit or non-profit oriented. Publicly financed infrastructure would remain under public maintenance, providing service to society and businesses, these costs could be subsidized through CP funds according to the developmental status of a region (as in the past and current periods), maybe even up to 100%.

CP-support for market-oriented projects, in a private law framework, would be much less in relation to the full project costs, only oriented towards better or sooner introduction to a market. The percentage of support should be differentiated by, again, the developmental status of the regions involved, but it could also be differentiated to specific market conditions and other national/regional framework conditions (as in the example of tariff schemes being used in very different ways in the MS).

Overall, these recommendations are focusing on the possibilities for supporting the shift to a Low Carbon Economy through Cohesion Policy, based on the idea that ERDF and CF money can play an important role as catalysts. In a new programming period, post-2020, even more complex schemes of funding and regulating investments in new technologies and businesses will be existing. Therefore, it is mandatory that regions and regional actors will be faced with a flexible and manageable EU/national support system and that they will have competent advisory systems at hand to make investments easier to decide and implement.

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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)

Appendices

Appendix Task/Chapter 2: Data used in Wind and PV potential calculation

Within this project different data sources for land use and meteorological conditions are used. The table below shows data that is used for the potential modelling.

Table A.1: Dataset for potential modelling

Data used	Application
CORINE-EU (250 m)	Land use
Global Land Cover (500 m)	Land use (mostly for vegetation)
MODIS	Land use (verification due to lower resolution in the EU)
NATURA	Conservation Areas
IUCN	Conservation Areas
SoDa Web Service 2010	Solar Radiation Data
COSMO-EU-Solar	Solar Radiation Data
COSMO-EU-Wind	Wind Speed, Temperature, Air Pressure
MERRA	Wind Speed
SRTM	Digital Elevation Model/Hydro Potential

Source: Consortium 2016.

Land Use Data

In this project renewable supply potential for wind and photovoltaic installations will be aggregated on NUTS3-level, while the potential calculation will be performed on a European wide 10 x 10 km grid.

Within this process, the different grid cells receive the NUTS code, based on their location. The assignment of the grid cells was conducted based on the largest overlap to a specific NUTS3 area. On average one NUTS-3 region consists of around 104 grid cells. Map A.1 is presenting the aggregation of the grid cells to NUTS3-level for Germany.

The land use data is aggregated for each grid cell. As a result, each grid cell contains a percentage of different land uses. For each of these land uses a potential calculation is performed separately.

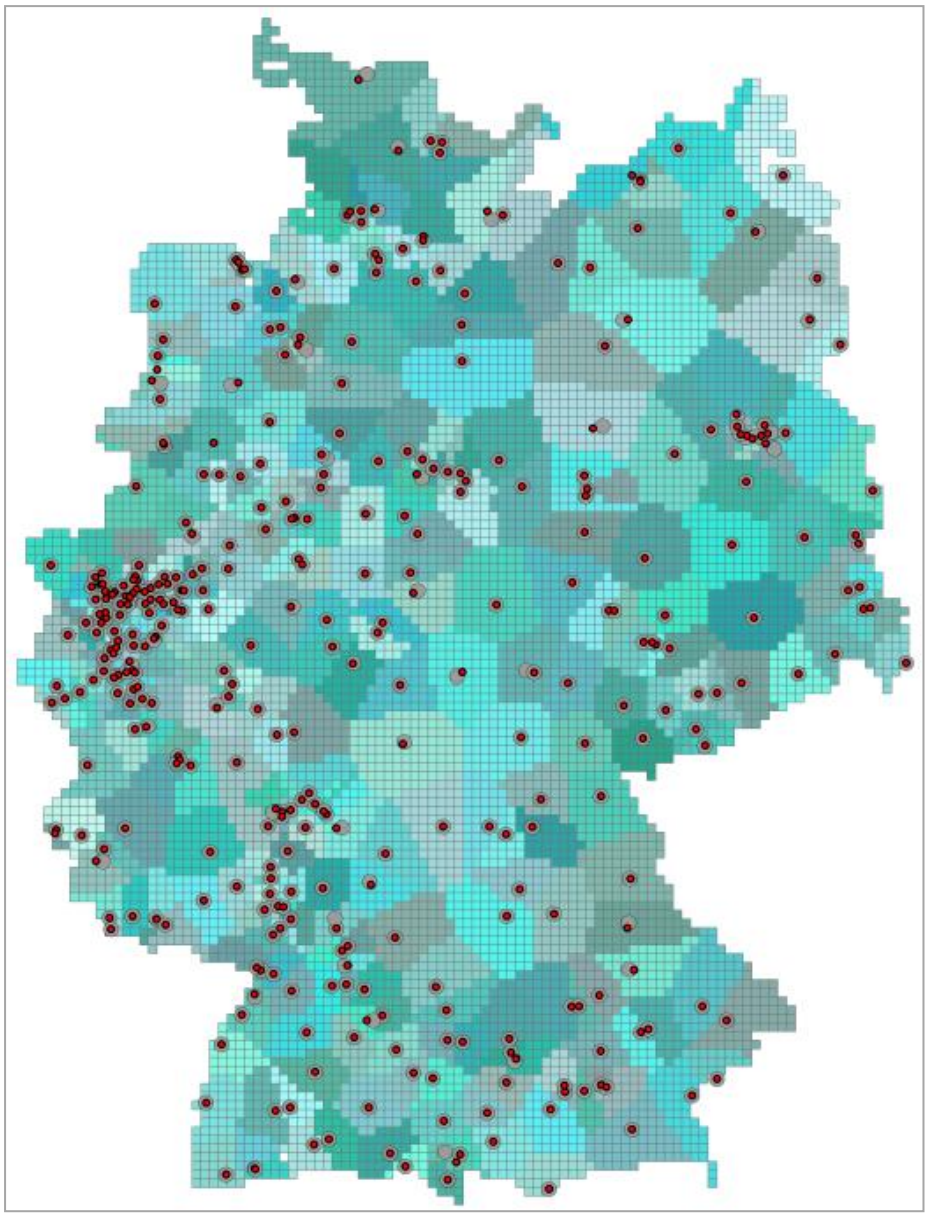
Map A.2 presents land use data for the example of Cologne while Figure A.1 and Map A.3 show the assignment of land use data to the grid cells.

In the beginning it has been tested if it would be feasible to increase the data quality of the land use data and use cadastre data for some countries, i.e. land utilization data. However, there are two major setbacks that should be considered:

(1) Acquisition of data is very difficult. The data is very often in the possession of cadastre offices and very expensive. The existent data for Germany cost ~ € 120,000.
(2) Huge data size prevents a calculation in an adequate time period as whole Europe has to be covered

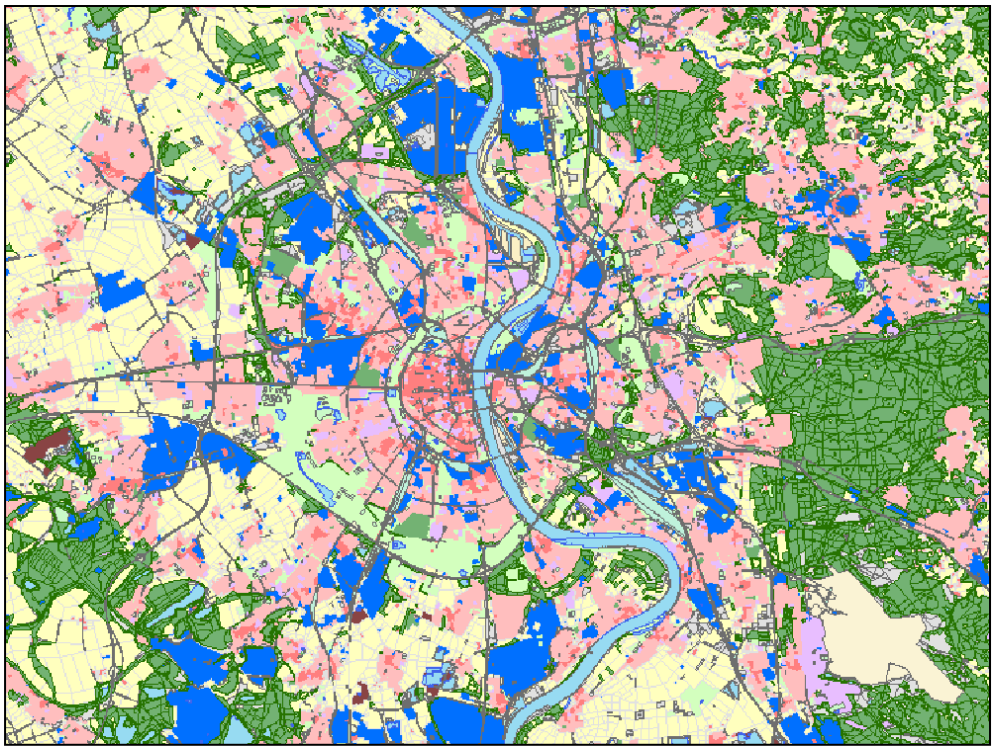
As a consequence the initial proposed data will be used. However, the testing process is not finished and it might be possible to at least present an example and therefore determine to possible deviation to the data used. First insights based on an analysis for North Rhine-Westphalia in Germany showed acceptable, not too high differences between using catastre data and the land use dataset suggested here. This analysis will be described in more detail in the interim report.

Map A.1: Example of RE cell grid assignment



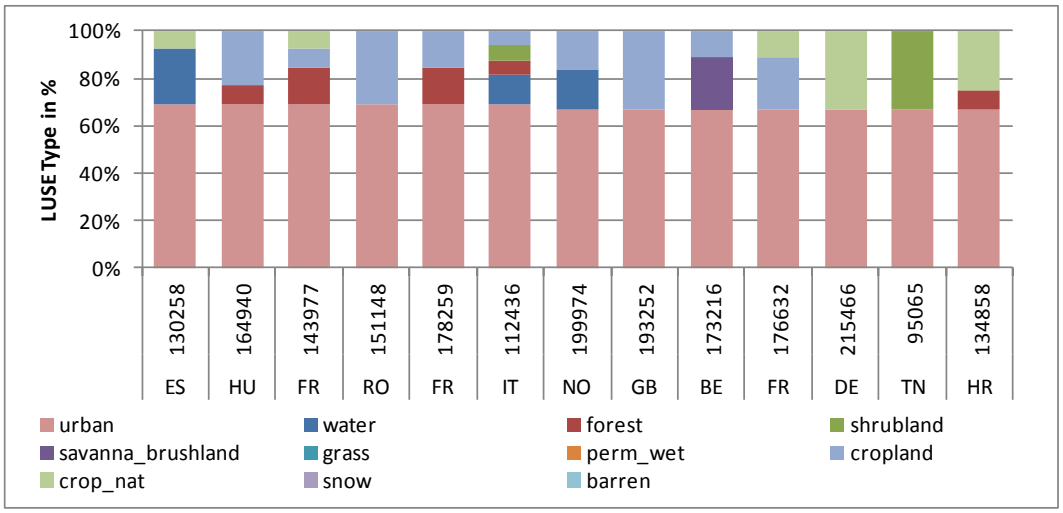
Source: Fraunhofer ISI, based on previous projects, red dots indicate electricity network hubs.

Map A.2: Land utilization data (Example of Cologne)



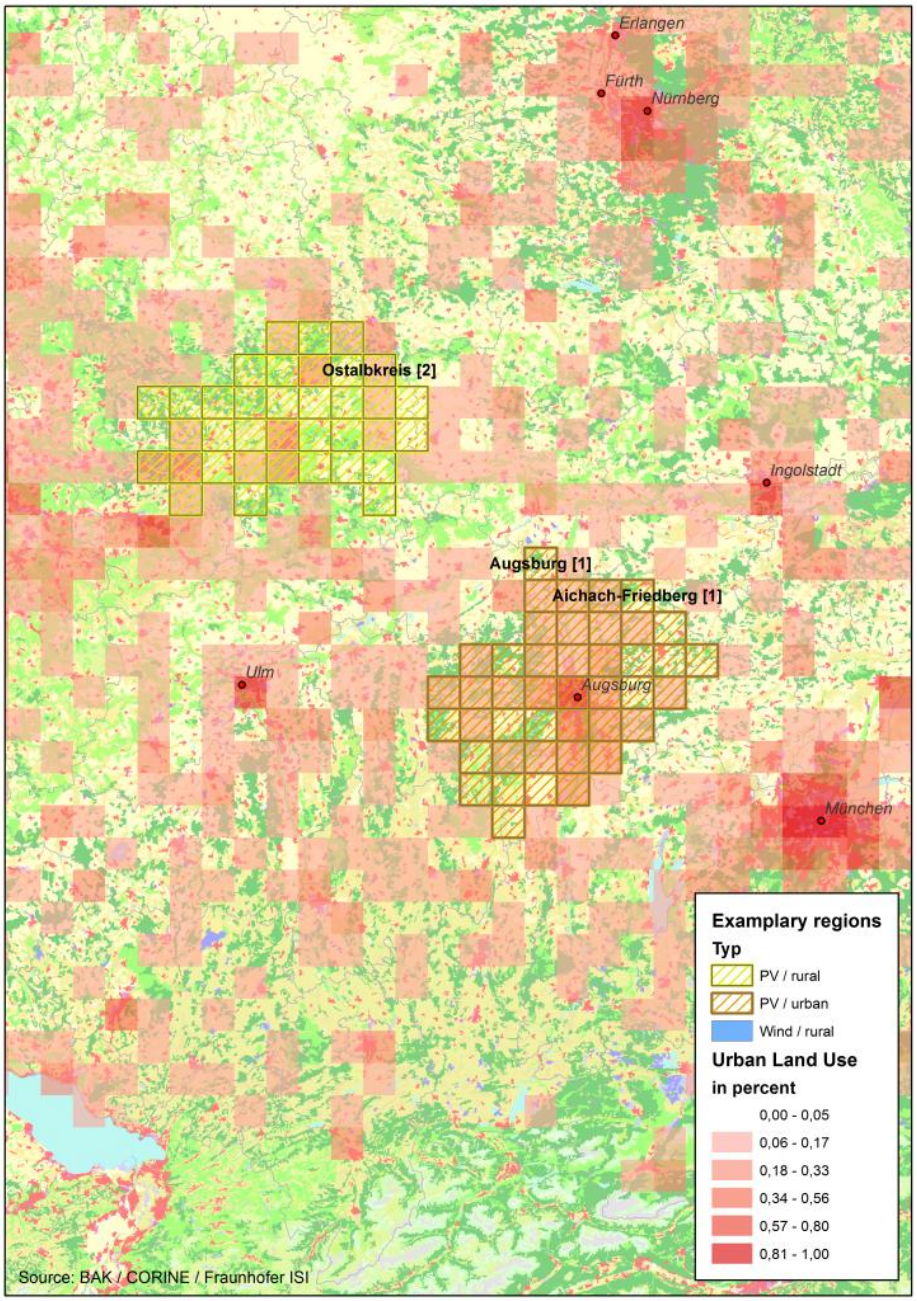
Source: Fraunhofer ISI.

Figure A.1: Representation of 13 examples of urban grid cells in the potential model



Source: Fraunhofer ISI.

Map A.3: Example of land use calculation using the 10 x 10 km grid



Source: Fraunhofer ISI. Some remarks on the initial work and testing.

Meteorological Data

For wind speed, temperature and air pressure different data sources have been accessed. Reanalysis data[95] provide spatially evenly distributed data with less or even without data gaps. Reanalysis data providing hourly time series are e.g. Merra and COSMO-EU as well as solar radiation data based on satellite images. Merra Data has a spatial resolution of 1/2 de-

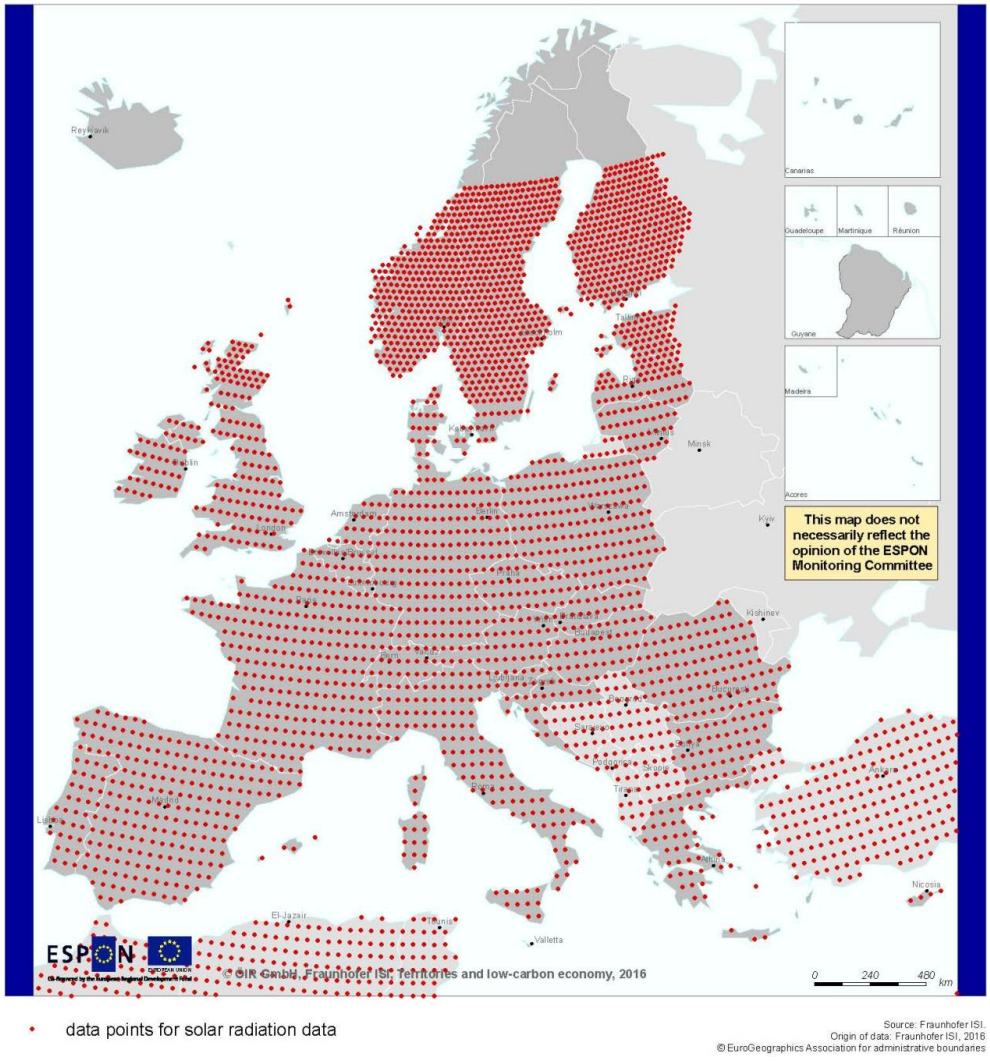
[95] Data from meteorological data assimilation projects as a gridded data set incorporating observations and numerical weather prediction models

grees latitude × 2/3 degrees longitude. As discussed above for potential calculations a high spatial resolution is necessary. Differences in spatial resolution have a high impact on the results. Different meteorological data sources for wind potential calculation and wind electricity production lead to differing yearly energy yields.

Solar Radiation Data

Solar radiation data is necessary for the calculation of technical and economical potential of photovoltaic installations, for small as well as large scale installations. To assess the impact and value of electricity generated from PV installations, hourly time series are necessary. In this project for each country solar irradiance data for several data points (stations) is considered. Map A.4 shows the distribution of the stations in Europe. The stations are distributed with a distance of 0.25 times 0.25 degrees of longitude and latitude. This implies that one station represents an area of less than 2,500 km². The northern areas of Sweden, Norway and Finland as well as Iceland are not covered. As the yearly solar radiation in these areas is very low, resulting full load hours would be low and potentials are very likely to be skipped by techno economic full load hour restrictions.

Map A.4: Distribution of data points for solar radiation data



Wind Speed and Temperature Data

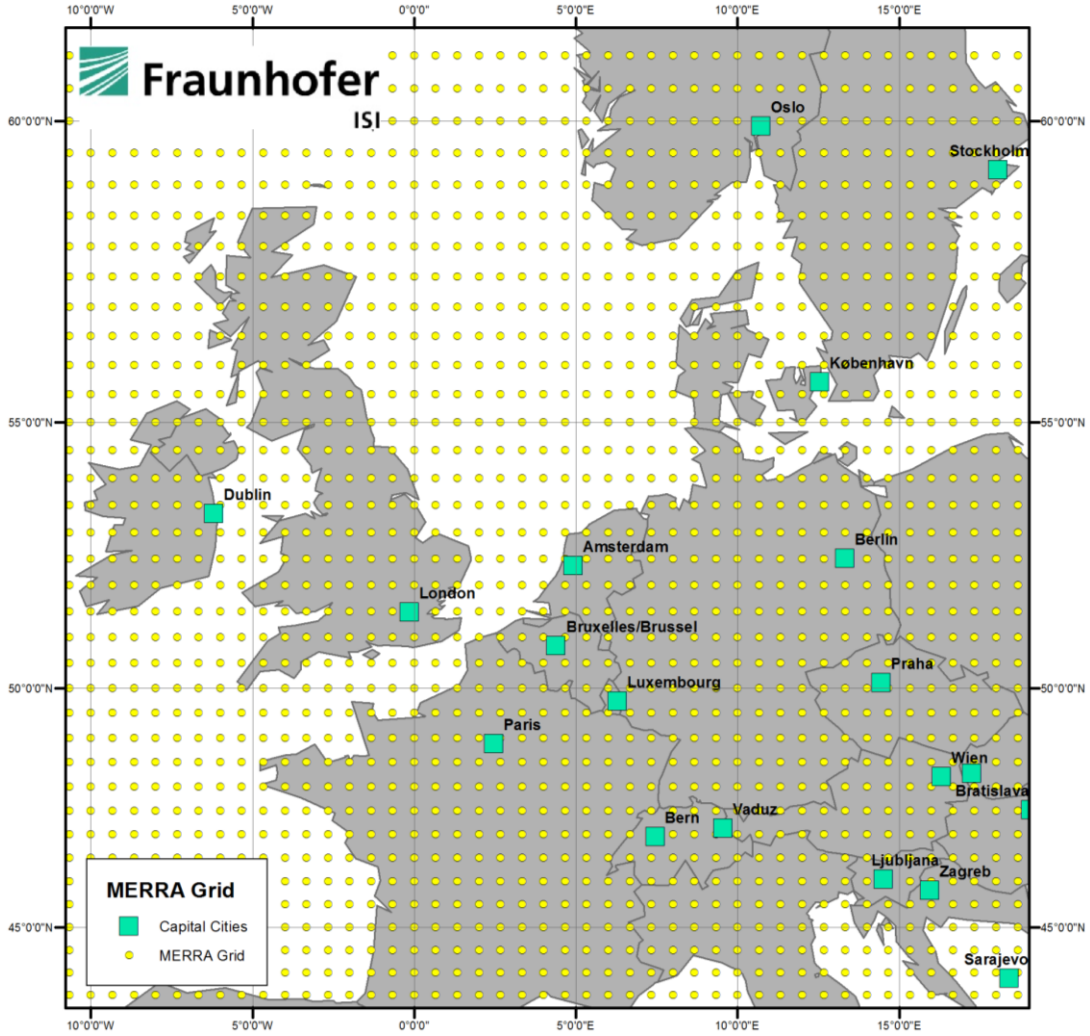
Wind speed data is necessary to calculate the technical and economic potential of wind power installations.

Temperature as well has a small impact on the electricity output of wind power plants but strongly influences efficiency of photovoltaic installations. The efficiency of photovoltaic modules decreases strongly with rising module temperatures.

For wind speed and temperature data two data sources are considered.

The first data source considered is Merra (NASA 2013). Merra provides hourly temperature as well as wind speed data at different heights. The spatial resolution is 1/2 degrees latitude × 2/3 degrees longitude equalling approximately a 50 km times 50 km grid in central Europe (see Map A.5). Up to now times series data for the years 2006 to 2014 is operational for potential calculation at Fraunhofer ISI.

Map A.5: Distribution of data points for Wind speed and temperature data (MERRA)



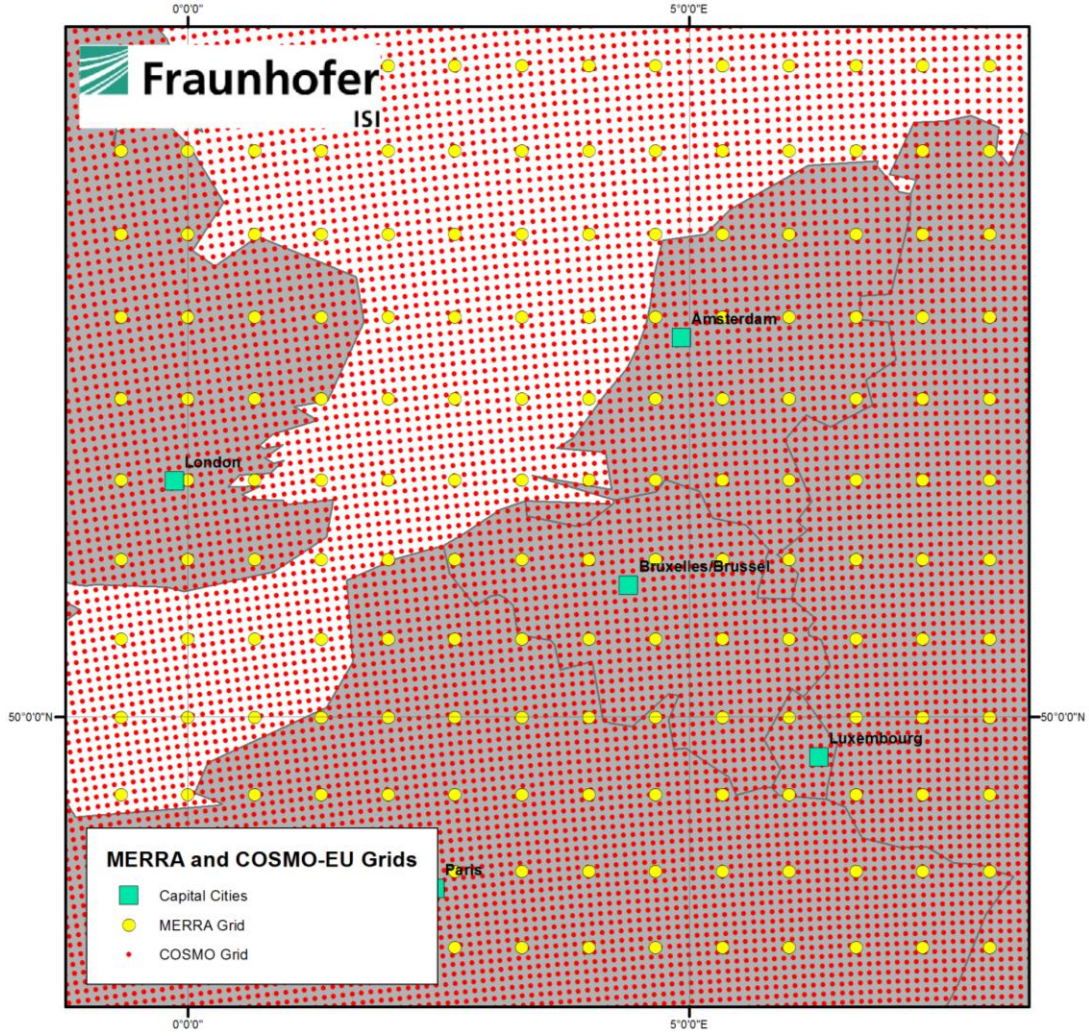
Source: Fraunhofer ISI based on MERRA.

The second data source considered is COSMO-EU. COSMO-EU provides hourly data at different heights as well, but with a higher spatial resolution. Data points of COSMO-EU data are

provided on a 7 km times 7 km grid (see Map A.6). As data preparation and operationalisation are more time and hardware intensive, up to now only time series data for the years 2006 to 2013 is operational at Fraunhofer ISI.

Both datasets are valuable, Merra is easier to assess and operate and needs less storage and calculating time, while COSMO-EU data is more accurate and provides a better fit to e.g. wind atlas data.

Map A.6: Distribution of data points for Wind speed and temperature data (MERRA vs. COSMO-EU)



Source: Fraunhofer ISI based on MERRA and COSMO-EU.

Technological Data

Besides land use and meteorological data, technology specific restrictions as well as technological and economic data for renewable energy technologies is necessary.

Technological data include mainly efficiency indicators and for PV installations, orientation of those installations (south-east, south, south-west). For wind power installations these are mainly parameters as the ratio of rotor diameter to generator capacities, the hub height and minimal technological safety distances between installations based on hub height and rotor diameter.

Besides technological data also other technology specific restrictions are included in the assessment. On the one hand these are policy restrictions as minimum distances due to acceptance issues and economic restrictions as very low full load hours due to low wind speeds or low radiation values lead to very high costs. Areas with very low full load hours are excluded from a detailed economic assessment to save calculation resources.

The calculation of the techno-economic potential in Enertile does not include policies. On one hand collecting all relevant national and regional policies for all technologies which are then very hard to integrate in a potential calculation covering not only small regions but Europe results in an very extensive amount of work that is better invested at other points because on the other hand including policies in a potential calculation cause results that are not comparable between regions any more. If we would include region-specific policies, regions with very restrictive renewable policies would have only very low potential and could gain a quite high exploitation rate. This would reflect the opposite of the actual situation in that region and an analysis of exploitation degrees would not be possible.

One important policy for wind power potential is the definition of minimum distances to settlements. Very small distances below 250 m cannot be considered in the approach. For minimum distances to settlements one least restrictive distance of 250 m[96] will be used. A standard distance representing a frequently used minimum distance in countries with high usage of wind power – will be tested in a sensitivity analysis.

In Task 1 the ration between renewable energy produced and consumed in one region will be analysed. In case of direct use of renewable energy the renewable energy consumption is equal to the renewable energy production (e.g. solar thermal technologies). Renewable electricity production cannot be matched easily to electricity consumption as electricity is widely distributed by electricity grids. Nevertheless the determined renewable electricity production in task 2 for each region will be used in task 2 to calculate the ratio between renewable electricity production and electricity consumption in task 1. These values need to be interpreted carefully.

[96] This can be discussed and set to 0m as very least restrictive politically driven minimal distance to settlements.

Appendix Task/Chapter 4

Table A.2: Overview of dimensions and their scores making up the RAI

Dimension	Scores	
Institutional Depth	0: No functioning general purpose administration at the regional level; 1: a deconcentrated, general purpose administration; 2: a non- deconcentrated, general purpose administration subject to central government control; 3: a non- deconcentrated, general purpose administration not subject to central government control	
Policy Scope	0: the regional government has very weak or no authoritative competence over (a) economic policy, (b) cultural-educational policy, (c) welfare policy, or (d) institutional-coercive policy; 1: the regional government has authoritative competence in one of (a), (b), (c) or (d); 2: the regional government has authoritative competence in at least two of (a), (b), (c) or (d); 3: the regional government has authoritative competence in (d) plus at least two of (a), (b), or (c); 4: the regional government meets the criteria for 3, and has authority over immigration, citizenship, or right of domicile.	
Fiscal Authority	0: the central government sets the base and rate of all regional taxes; 1: the regional government sets the rate of minor taxes; 2: the regional government sets the base and rate of minor taxes; 3: the regional government sets the rate of at least one major tax: personal income, corporate, value added or sales tax; 4: the regional government sets the base and rate of at least one major tax: personal income, corporate, value added or sales tax.	
Borrowing Autonomy	0: The regional government does not borrow (e.g. centrally imposed rules prohibit borrowing). 1: The regional government may borrow *under prior authorisation (ex ante)* by the central government and it borrows under one or more of the following centrally imposed restrictions: – Golden rule (e.g. no borrowing to cover current account deficits) – No foreign borrowing or borrowing from central bank – No borrowing above a ceiling – Borrowing is limited to specific purposes 2: The regional government may borrow *without prior authorization (ex post)* under one or more of the same centrally imposed restrictions. 3: The regional government may borrow without centrally imposed restrictions.	
Assembly	0: the region has no regional assembly; 1: the region has an indirectly elected regional assembly; 2: the region has a directly elected assembly.	
Executive	0: the region has no regional executive or the regional executive is appointed by central government; 1: the region has a duel executive appointed by central government and the regional assembly; 2: the region has an executive appointed by a regional assembly or that is directly elected.	
Law Making *For each element a region satisfies a score of 0.5 is given*	Multilateral Law Making Regions are the unit of representation in a national legislature Regional governments designate representatives in a national legislature Regions have a majority representation in a national legislative based on regional representation The legislature based on regional representation has extensive legislative authority.	Bilateral Law Making Regions are the unit of representation in a national legislature Regional governments designate representatives in a national legislature The regional government or its representatives in a national legislature are consulted on national legislation affecting the region The regional government or its representatives in a national legislature have veto power over national legislation affecting the region

Dimension	Scores
Executive Control	0: no routine meetings between the central government and the regional government(s) to negotiate national policy affecting the region; 1: routine meetings between central government and the regional government(s) without legally binding authority; 2: routine meetings between central government and the regional government(s) with legally binding authority
Fiscal Control	0: neither the regional government(s) nor their representatives in the national legislature are consulted over the distribution of tax revenues; 1: the regional government(s), or their representatives in the national legislature negotiate over the distribution of tax revenues, but do not have a veto; 2: the regional government(s), or their representatives in the national legislature have a veto over the distribution of tax revenue.
Borrowing Control	0: regional government(s) are not routinely consulted over borrowing constraints; 1: regional government(s) negotiate routinely over borrowing constraints but do not have a veto; 2: regional government(s) negotiate routinely over borrowing constraints and have a veto.
Multilateral Constitutional Reform	0: the central government or national electorate can unilaterally change the constitution; 1: a national legislature based on regional representation can propose or postpone constitutional reform, raise the decision hurdle in the other chamber, require a second vote in the other chamber or require a popular referendum; 2: regional government or their representatives in a national legislature propose or postpone constitutional reform, raise the decision hurdle in the other chamber, require a second vote in the other chamber or require a popular referendum; 3: a legislature based on regional representation can vote
Bilateral Constitutional Reform	0: the central government or national electorate can unilaterally reform the region's constitutional relationship with the centre; 1: a regional referendum can propose or postpone reform of the region's constitutional relationship with the centre; 2: the regional government can propose or postpone reform of the region's constitutional relationship with the centre or require a popular referendum; 3: a regional referendum can veto a reform of a region's constitutional relationship with the centre; 4: the regional government can veto a reform of the region's constitutional relationship with the centre.

Table A.3: Summary of national institutional structures energy efficiency policies and trends

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
Austria	In the first National Energy Efficiency Action Plan (NEEAP), Austria calculated a 2016 savings target of € 80.4 PJ in accordance with the ESD Directive. This means that savings of at least 80.4 PJ in final energy should be achieved by 2016 as a result of energy efficiency measures. The on-going voluntary agreements in place since 2009 define quantitative energy savings targets for the participating organisations (the Association of Gas and Heat Suppliers, the Association of Austrian Electricity Companies, and the Petroleum Industry Association and the Energy Trading Association) up to 2016. In these voluntary agreements, the interest groups encourage their member companies to adopt energy efficiency measures and energy services by making them available. The measures for achieving these saving targets can be freely selected by the companies. The voluntary agreements are subject to regular monitoring. In accordance with Article 3 of the EED, Austria set its indicative national energy efficiency target for final energy consumption of 1,100 PJ in 2020, corresponding to final energy savings of 200 PJ compared to a "business as usual" scenario. Main energy efficiency policy measures include: – "klima:aktiv", the national programme for climate protection, which aims to introduce energy efficient and climate-friendly technologies and services in the fields of construction and living, mobility, company policies and renewable energy sources. – "Environmental Support" – grants for companies with the emphasis on climate protection, energy saving, renewable energies and prevention of air pollution – Smart Metering and Informative Billing – Standard Fuel Consumption Tax (NoVA) – Platform for energy efficient appliances – Energy saving programme for federal buildings
Belgium	In Belgium energy efficiency is a competence of the three Regions (Flanders, Wallonia and Brussels-Capital), with supporting measures from the federal government. The main measures introduced by the Federal government are tax reductions, the transposition of the EU directives on labels and on Ecodesign and the promotion of public transport by railway. The regions have mainly, each for its own territory, implemented the EPB directive; promoted further energy efficiency by households through grants, audit schemes, awareness raising, etc.; fostered energy savings in industry through voluntary agreements (Flanders, Wallonia); implemented mobility measures; and promoted renewable energies and cogeneration by setting up green and CHP certificates systems. Main energy efficiency policy measures include: – Public service obligation on electricity distribution network operators in Flanders – Promotion of renewable energy and cogeneration through a Green Certificates system (3 regions) – Voluntary agreements with industry 2003-2020 (Flanders and Wallonia) – Implementation of the Energy Performance of Buildings (EPB) directive, including previous K-level regulations (3 regions) – Subsidies for energy saving investments in Wallonia and Brussels – Transposition and implementation of the Labelling and Ecodesign directives – Diverse set of measures in the transport sector in the three regions – Flanders – Subsidies for energy saving measures in horticulture (greenhouses)
Bulgaria	The "Energy Strategy of the Republic of Bulgaria to 2020" sets energy efficiency as its highest priority. The National Action Plan for Energy Efficiency adopted indicative national targets to 2020 for additional energy savings of 716 ktoe per year in final energy consumption and 1590 ktoe per year in primary energy consumption below the reference scenario of trends for energy consumption in Bulgaria and other EU countries from 2013. Main energy efficiency policy measures include: – Individual targets for energy savings, energy traders. – Mandatory energy audits of industrial systems with an annual consumption over 3,000 MWh (excl. ETS) and implementation of the prescribed measures – Individual regulation and metering of heat in multifamily buildings connected to district heating. – Mandatory annual technical inspection of vehicles and control of engines. – Mandatory energy audits and certification of public buildings with an area of over 250 m^2 and implementation of the prescribed measures

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
Croatia	In accordance with the requirements of the ESD Directive, the Republic of Croatia set the target of reducing final energy consumption in 2016 by 19.77 PJ, as reflected in its Energy Strategy, the National Energy Efficiency Programme, and in its first National Energy Efficiency Action Plan. The sectoral distribution of the target was revised in the 3rd NEEAP. Many Croatian cities have voluntarily joined the "Covenant of Mayors", an initiative which encourages European cities to combat climate change by developing Sustainable Energy Action Plans (SEAPs) which are a basis for future implementation of specific projects on energy efficiency and use of renewable energy sources. Main energy efficiency policy measures include: – Energy audits and energy management in large companies; Energy efficiency education and training. – Introduction of efficient electric motor drives; Energy audits of small and medium-sized enterprises. – Programme of energy renovation of family homes; Increasing the number of nearly zero energy buildings; Energy labelling of household appliances and energy standards. – Financial incentives for energy efficient vehicles; Developing an alternative fuel infrastructure; Promotion of integrated transport. – Energy Efficient Public Lighting Programme; Programme of energy renovation of public sector buildings. – Programme of energy renovation of commercial non-residential buildings (building refurbishment, EE lightning systems, solar and photovoltaics systems).
Cyprus	The Ministry of Energy, Commerce, Industry and Tourism is responsible for the adoption and implementation of energy efficiency policy including renewable energy and energy efficiency. The Cyprus Institute of Energy (NGO) was founded in 2000 to assist the Government in the promotion and implementation of policies and measures in RES and energy efficiency. However, in March 2015 the CIE was shut down and all of its operations were transferred to the Ministry of Energy, Commerce, Industry and Tourism. Main energy efficiency policy measures include: – Emissions trading scheme – Training and education for energy management and certified energy auditors – Law for the energy performance of buildings, minimum efficiency requirements. nZEB – Subsidised CFL lamps. – Grants for scrapping of old cars – National strategy for upgrading the public transport system
Czech Rep	The National Energy Efficiency Action Plan (NEEAP) represents the main tool of the Czech energy efficiency policy. The 1st and 2nd NEEAPs require reaching 9% energy savings in 2016. The 2nd NEEAP expected savings of 19,724.4 TJ for the period 2008-2010 and according to NEEAP evaluation savings of 27,097 TJ were reached. The Czech energy saving target in the 3rd NEEAP is set to 47.78 PJ of new savings in 2020. It corresponds to 6.83 PJ or 1.5% of annual savings. The Czech government decided to use an alternative scheme to comply with Article 7 of the Energy Efficiency Directive and the selected alternative measures are mainly of financial character. Main energy efficiency policy measures include: – Benefits of implementing the recommendations of mandatory energy audits – Eco-design Directive for Energy-using Products – Promotion of energy savings in industry in the Operational Programme Enterprise and Innovation for Competitiveness – Promotion of energy savings in family houses in the Green Savings Programme Integrated Regional Operational Programme – Emission and performance standards for new passenger cars – Operational Programme Environment 2014-2020 – Extension of the role of public sector in demonstrating new technologies
Denmark	The Danish government's ambition is to become independent of fossil fuel by 2050. A key element in fulfilling this target is energy efficiency and an increased use of renewable energy, as reflected in the documents "Our future energy", 2011; and "Energy Agreement", 2012. The Minister of Climate, Energy and Building is responsible for national and international efforts on energy issues. The Danish Energy Agency is adviser to the minister, it assist other authorities, administers Danish energy legislation and conducts analysis and assessments of development in the energy sector. The

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
	Danish approach to increase energy efficiency is to ensure stability by having long term political agreements; have a broad focus on households, industry and buildings at the same time; and to use a variety of measures including economic incentives, standards and information. Main energy efficiency policy measures include: – The Energy companies savings effort (Energy saving obligations for utilities) – Mandatory Energy Audit for large – Enterprises Centre for energy savings in enterprises – Strategy for energy renovation Better Homes – Green owner Fee – Energy and emissions regulations for taxis, limos and healthcare transportation. – Promoting energy renovation in the public sector – The Energy companies savings effort (Energy saving obligations for utilities)
Estonia	The governmental unit responsible for energy issues is the Energy Department in the Ministry of Economic Affairs and Communication (MoEAC). In implementing energy efficiency measures, the MoEAC is supported by the Fund KredEx (Fund KredEx was founded in year 2001 by the Ministry of Economic Affairs and Communications with a purpose to improve financing possibilities of enterprises, manage credit risks connected with export, enable people to build or renovate their home and develop energy-efficient way of thinking).The major strategy document is the National Development Plan for the Energy Sector until 2020 approved by the Parliament in June 2009. The Development Plan of the Estonian Electricity Sector until 2018 sets the strategic objectives for the power sector. The third National Energy Efficiency Programme 2007–2013 was approved by the Government in 2007. In September 2011, the MoEAC adopted a further implementation plan of the Programme that was presented to the European Commission as the Second Energy Efficiency Action Plan of Estonia (NEEAP2). Main energy efficiency policy measures include: – There are no special programmes targeted to energy efficiency in industry at national level. Nevertheless, efficiency improvement plays an important role in environment related measures. The National Programme for Abatement of Greenhouse Gases for 2003-2012, as well as obligations of the European Emission Trade System have contributed to efficiency improvements in industry – The measures introduced by the National Housing Development Plan for the years 2008–2013 are carried out by the MoEAC, together with KredEx and in co-operation with local authorities. – A Regulation of the Government from December 2008 stipulates stricter minimum requirements for energy performance of buildings – There are no transport related national programmes targeted directly to increasing energy efficiency. Nevertheless, there is an indirect impact as a result of measures planned in the Transport Development Programme for years 2007–2013. – Almost all rates of excise duties on fuels are harmonized with the EU stipulations, only oil shale is partially exempted from the excise duty.
Finland	The 2013 National Energy and Climate Strategy lays down the roadmap for Finland to meet its targets for greenhouse gas reductions. An action plan was adopted by the Government in February 2010 to define the energy efficiency measures over the next ten years to meet the energy efficiency targets for the period 2010-2020. The Energy Department of the Ministry of Employment and the Economy is the government body responsible for energy policy. Energy Authority started its operation at the beginning of 2014. Motiva Oy is a state-owned company that helps the government to implement its energy efficiency policies and measures. Voluntary energy efficiency agreements and energy audits continue to be among the key policies in several sectors, including industry and municipalities. Main energy efficiency policy measures include: – National Energy and Climate Strategy 2013 – Action Plan on Energy Efficiency Measures 2010 – Energy taxation – Energy efficiency agreements – Energy audits – Building regulations (2003, 2007, 2010, 2012), new buildings – Building regulations, renovation – Eco-design – Energy efficiency agreement, oil-heated buildings

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
	– Emission caps on new cars – Carbon dependent car taxation – Energy efficiency agreements, municipalities, private services and real estate sector – Energy audits
France	The national agency in charge of implementing RUE, RES and environmental policies is ADEME, the French environment and energy management agency. It operates within a 4 years agreement with the government (2009-2012). The official target is to bring the annual reduction in the final energy intensity to 2%/year from 2015 and to 2.5%/year by 2030. Since 2006 there is an energy saving obligation scheme for utilities with a target of 345 TWh cumac (lifetime cumulated and discounted) for the period 2010-2013: end of 2011, 15 TWh of annual energy savings (232 TWh cumac), had been certified, mainly in the household and service sectors. Since 2011, the scope was extended to oil companies. Main energy efficiency policy measures include: – White certificate scheme – Local energy information centres – 2012 Thermal Regulation (RT 2012) – Tax credit for energy efficiency works and RES – Energy performance audits – Audits subsidies in buildings – Car labelling – Ecological Bonus – Voluntary agreement "CO_2 objective " – Quota Allocation plan – Energy audits and subsidies
Germany	From September 2010, Germany initiated a transformation of its energy system, with the so-called "Energiewende", which includes ambitious energy efficiency targets. Electricity consumption is planned to be cut by 10% until 2020 and by 25% until 2050. However, a remaining shortfall to meeting the primary energy target in 2020 is estimated to be around 10 to 13% based on current forecasts. To fill this gap, the German Federal Ministry for Economic Affairs and Energy presented the "National Action Plan on Energy Efficiency" (NAPE) in December 2014. The NAPE includes new and further developed policy measures to increase energy efficiency in buildings, industry and the tertiary sector. The German Federal Ministry for the Environment, Nature Conservation, Buildings and Nuclear Safety (BMUB) also presented a "Climate Action Programme 2020" which includes further policy measures for the transport sector. The NAPE measures, together with the transport measures, are expected to lower primary energy consumption by 500 to 620 PJ by 2020, substantially contributing to closing the gap to the primary energy target. Main energy efficiency policy measures include: – Introduction of a competitive tendering scheme for energy efficiency – Support of Energy Performance Contracting – Energy Efficiency Networks Initiative – Upgrading the KfW efficiency programme – Obligation to perform energy audits for non SMEs (implementation of Art. 8 EED) – Upgrading and increased funding of the CO_2 Building Renovation Programme – Energy saving legislation – National Top Runner Initiative – National Energy-efficiency Label for Old Heating Installations – Extension of HGV toll to all vehicles >7.5 t – Differentiation of HGV tolls based on vehicles energy consumption – Strengthening of public transport
Greece	As reflected in Greece's national energy strategy and in the updated NEEAP, the energy efficiency target set for 2020 is to achieve final energy consumption levels of 18.4 Mtoe. The target was based on final energy consumption, as this determines the requirements and demand for energy. Primary energy consumption in 2020 will amount to 24.7 Mtoe, whereas the energy intensity of primary energy consumption and the energy intensity of final energy consumption in the Greek economy in 2020 will be equal to 0.109 and 0.081 koe/€ respectively. The energy savings target for the period 2014-2020, as calculated under Article 7 of the Directive concerning the adoption of energy efficiency obligation schemes, is 3,332.7 ktoe (38.8 TWh) in total, out of which the total for all new annual savings is 902.1 ktoe (10.5 TWh).

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
	Main energy efficiency policy measures include: – Information system for monitoring energy efficiency improvement and achieved energy savings – Programmes to provide financial support for investment in energy-saving technologies and research – The "Energy Saving programme" (ΕΞΟΙΚΟΝΟΜΩ) – Relocation of enterprises to industrial-business zones and business parks – Innovative Entrepreneurship Supply Chain, Food, Beverages – Green Enterprise – Regulation on the Energy Performance of Buildings. – Saving Energy at Home – Energy upgrading of social housing buildings- "Green Pilot Urban Neighborhood" programme – Transport infrastructure projects – Promotion of economical, safe and eco-driving. – Incentives for the replacement of private vehicles and to promote the use of energy-efficient vehicles (vehicles fuelled by biofuels and hybrid vehicles)
Hungary	Hungary's energy policy is described in the document "The Business Model of Energy Sector". The Energy Efficiency Action Plan attached to the document includes specific provisions for the annual reduction of the energy intensity by 3.5%/year, for decreasing primary energy demand by 1.79 Mtoe per year and for the annual reduction of CO_2 emissions by 5 Mt. In 2011 and 2012 Hungary's energy efficiency agency, the "Energy Center" Energy Efficiency, Environment and Energy Information Agency Non-Profit Limited Company, has been replaced by the National Environmental Protection and Energy Center Non-Profit Ltd: its main focus is the management of European Union Funds. The implementation of the Energy Service Directive is carried out by ÉMI Nonprofit Ltd. from March 2012 Main energy efficiency policy measures include: – Promotion of CHP (basic decree 56/2002 and amendment 206/2009) – Energy Efficiency Loan Fund – Environment and Energy Operative Programme – Support of the Energy Efficient Renovation of Residential Buildings Built with Industrialised Technology – Residential energy saving programme "For Successful Hungary" – Low for District Heating Services 2005/18 – Combined road-rail transportation
Ireland	Ireland's third National Energy Efficiency Action Plan (NEEAP3) was published in August 2014. NEEAP3 reiterates the government's commitment to achieving a 20% reduction in energy demand across the whole of the economy by 2020 through energy efficiency measures. It notes that although substantial savings have been made in the last three years "it is clear that a significant acceleration of effort is required" if they are to achieve their 2020 targets. It describes in detail the measures and associated savings achieved in 2012 and targeted for 2016 and 2020 for buildings, public sector bodies, industry, transport, supply side, as well as cross cutting measures. Main energy efficiency policy measures include: – Residential retrofit – Commercial and Industry retrofit – 2015 Building regulations – Buildings other than Dwellings – Functional Airspace block – More efficient road traffic movements – Accelerated Capital Allowance – Large industry Energy Network
Italy	The 3rd National Energy Efficiency Action Plan, submitted in 2014, sets the final end-use energy savings target of 15.5 Mtoe for 2020. In order to reach the targets over the period 2014-2020, Italy intends to rely on the White Certificate obligation scheme, and two additional energy efficiency schemes: the tax deductions and the "Thermal Account" (Heating & Cooling Support Scheme). Main energy efficiency policy measures include: – White Certificate Scheme: obligation imposed on electricity and gas distributors having more than 50,000 end users, to generate each year a certain amount of energy savings – energy audit: promotion of specific energy efficiency intervention with a payback

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	period minor than four years. – Tax deduction: reductions of personal and corporate income tax granted for actions improving the energy efficiency of existing buildings – new standards required by the EPBD for buildings and by the Ecodesign Directive for space heating and cooling – promotion of sustainable transport systems: new railways on ordinary lines, 45 km by 2016 and 140 km by 2020, and on high-speed/high-capacity network, 57 km by 2016 and 500 km by 2020 – Thermal Account: incentive scheme to PA to implement energy efficiency improvement actions in buildings and technical installations
Latvia	Improving energy efficiency (EE) is one of Latvia's national priorities, as it allows for the cost effective reduction of risks associated with security of energy supply, sustainability and competitiveness of manufacturing and other sectors, whilst creating new jobs and promoting growth. Based on Art.3 of Directive 2012/27/EU, the indicative national EE target set for Latvia based on primary energy savings in 2020 is 0.67 Mtoe, which is equivalent to final energy savings of 0.457 Mtoe, providing for energy savings in multi-apartment residential buildings, central and municipal government buildings, industry, services and transport, as well as district heating systems. Meeting the above-noted EE target directly contributes to achieving the national renewable energy (RES) target to increase the share of RES in gross final energy consumption up to 40%, as well as greenhouse gas emission mitigation target. The particular division of the Ministry of Economics, consisting of 4 departments (Energy Market and Infrastructure Dept., Renewable Energy and Energy Efficiency Dept., Construction and Housing Dept., Construction Information System Project Division), is in charge of energy sector. Particular attention is paid to the EE investments support (co-financing) measures. Particular frontrunners are financially supported. The Ministry of Economics is a responsible authority for EU ERDF and CF co-financing. The national Climate Change Financial Instrument (CCFI), supervised by the Ministry of Environmental Protection and Regional Development, is targeted to EE and RES measures in both public institutions and business entities, including improvements in building envelope, heating system and production technological equipment. In 2015- 2020, CCFI will be followed by the GHG Emissions Quotas Auctioning Instrument. Main energy efficiency policy measures include: – Complex Solutions for GHG Emissions Reduction in Industrial Buildings and Technological Equipment – Efficient Use of Energy Resources, Reduction of Energy Consumption and Transfer to RES in Manufacturing Industry – Energy Performance: Thermal Insulation Standards 2014 – Increasing Heat Energy Efficiency in Multi-Apartment Buildings – Systematic Inspection of Technical Conditions of Motor Vehicles Applying the differentiated tax rates for passenger cars – Promotion of clean and energy-efficient road transport vehicles – Public procurement – Development of public transport network – Increasing Energy Efficiency in Public (Central Government and Municipal) Buildings – Investments in Public Territories Lighting Infrastructure to Reduce GHG emissions – Complex Solutions for GHG Emissions Reduction (buildings and technological equipment)
Lithuania	In the National Energy Independence Strategy (NEIS), approved by the Lithuanian Parliament in 2012, the government sets the objective to improve the efficiency of all types of energy in a way that figures of energy consumption in buildings, various installations and devices in households, technological processes in industry and transport systems moved towards those that are in economically developed EU countries. In the scope of energy efficiency, the NEIS sets a goal to increase energy consumption efficiency by 1.5% a year. Seeking to achieve this goal, crosscutting and sectorial measures are being implemented. Main energy efficiency policy measures include: – National Energy Independency Strategy aims at setting the main goals for Lithuanian energy sector development. – EU Structural Funds 2007-2013 for More Efficient Cogeneration and Heat Supply Systems – Lithuanian Environmental Investment Fund – Programme for the Renovation/Upgrading of Multifamily Buildings – EU Structural Funds 2007-2013 – Special Programme for Climate Change

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
	– EU Structural Funds 2007-2013 for Comprehensive Development of Ecological Public Transport – EU Structural Funds 2007–2013 aim at supporting the repair and/or renovation of public buildings' external envelope and upgrading and/or reconstruction of building energy systems – Programmes for Modernization of Educational Institutions, Libraries and Cultural Centers – Renovation of State Institutions aims at supporting living (halls of residence, orphanages and etc), administration, science, health, culture and other special buildings that do not satisfy minimum energy efficiency requirements set in STR 2.01.09:2012.
Luxembourg	The Government has recognized the importance of the energy efficiency in the buildings sector and has implemented extensive building regulations for the residential and the tertiary sectors. Additionally, grant schemes aim at promoting the renovation of the buildings stock and the development of renewable energy sources. Main energy efficiency policy measures include: – Energy Efficiency Obligation Scheme (2015- 2020) – Voluntary agreements (2010-2016) – Building regulations of residential buildings and grant schemes (2008-2012) – Regulation on the energy performance of residential buildings (revision) (2012-) – Grant schemes for efficient new residential buildings, renovations and renewable (2013- 2016) – Increase of fuel taxes (2007-) – CO_2-related vehicle tax (2007-) – Grant scheme for low CO_2 emission cars and electric cars (2007-2014) – Regulation on the energy performance of nonresidential buildings (2011-) – Regulation on the energy performance of nonresidential buildings (revision) (2015-)
Malta	The Policy section of the SEWCU unit deals with establishing and promoting policies which relate to energy use in Malta. This is done on two main pillars which are Energy Efficiency and Renewable energy. The policy unit believes that energy efficiency is a primary objective for the Maltese Islands and if achieved will reduce the intrinsic dependence on imported fuel. To this effect the policy unit is tackling this issue through various fronts. SEWCU is responsible in designing and implementing policies which promote energy efficiency amongst the various entities. SEWCU supports the various schemes which are issued from time to time by competent authorities to this effect, such as the incentive schemes for building envelope improvement which include roof insulation and double glazing. In the long term, policies and initiatives are being studied and projected to substantial decarbonisation of the energy (including transport) sector by 2050. Main energy efficiency policy measures include: – Promotion of solar water heaters and PVs – Energy saving for social households – Subsidiary schemes for building insulation and double glazing – Feed-in tariffs – Smart meter roll out – Promotion for energy services for SMEs – Malta Enterprise energy audits – Grant scheme on electric vehicle purchases – Electric vehicle charging points – Car scrappage scheme
Netherlands	In the Clean and Efficient programme (Dutch: Schoon en Zuinig), introduced in 2007, the Dutch government set ambitious targets for 2020 for Greenhouse gas emission reduction (-30%), the share of renewables in the energy mix (20%) and the improvement in energy efficiency (increasing to 2,0% per year). The programme can be seen as an intensification of the existing multi-level policy approach. General cross-cutting measures such as energy taxation, fiscal measures such as the energy investment deduction and the European emission trading scheme form a general base for stimulating energy efficiency. Voluntary sectoral or sub-sectoral agreements were made with industries, services, major transport organisations and key players within the household sector. These agreements aim at a continuous improvement in efficiency. Energy efficiency standards have been introduced for most sectors to set a lower limit for efficiency. Innovators and frontrunners are financially supported. Main energy efficient policy measures include: – Energy investment deduction (EIA)

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	– Environmental Action Plan – Long-term agreements 2 – Energy Performance Standard (EPN) – More with less plan – Long-term agreement with road transport – Energy saving in transport (EBIT) – New driving force campaign
Poland	Pursuant to Directive 2012/27/EU, Poland set a national energy efficiency target for 2020. It aimed to achieve a primary energy consumption reduction by 13,6 Mtoe in the years 2010-2020, which also means an improvement of energy efficiency of the country economy. The target was also expressed in terms of an absolute level of primary energy consumption in 2020, which is 96,4 Mtoe and final energy consumption – 71,6 Mtoe. Poland has made significant progress on the way to meeting its national target in the field of energy efficiency improvement, i.e. achieving, by the 2016, the final energy savings of no less than 9% of the average national final energy consumption in 2001-2005. Main energy efficiency policy measures include: – Energy efficiency improvement scheme (White Certificates) under the Energy Efficiency Law. – The priority programme "Smart Power Grids"; – Operational Programme Infrastructure and Environment 2014-2020 (Investment Priority 4.iv.) – Development and implementation of smart distribution systems at average and low voltage levels; – Information and educational campaigns; – Operational Programme Infrastructure and Environment 2014-2020; – Regional Operational Programmes 2014-2020 – Support to entrepreneurs focused on low-emission economy and resource-efficient economy Part 1 – Energy/Electricity audits of enterprise; – Support to entrepreneurs focused on low-emission economy and resource-efficient economy Part 2 – Increasing energy efficiency; – Access to financial instruments dedicated to SMEs (PolSEFF); – Improvement of energy efficiency, Part 4 – Energy saving investments in Small and Medium Business; – Operational Programme Infrastructure and Environment (Measure 9.1) – Highly efficient power generation; – Operational Programme Infrastructure and Environment (Measure 9.2) – Efficient energy distribution; – Operational Programme Infrastructure and Environment 2014-2020 (Investment Priority 4.ii.) – Promoting energy efficiency and usage of renewable energy sources in enterprises. – Thermal modernisation fund (of budget 1999-2014 equal 1,885 billion PLN and achieved finally in 2014 energy costs savings over 0,8 billion PLN per year). – Green Investment Scheme. Part 1 – Energy management in buildings of selected public sector entities; – Operational Programme Infrastructure and Environment 2014-2020 (Investment Priority 4.iii.) – Supporting energy efficiency, intelligent energy management and use of renewable energy source in public infrastructure, including public buildings and residential sector; – Improvement of energy efficiency, Part 3 – Subsidized loans to build energy-efficient homes; – Operational Programme PL04 "Saving energy and promoting renewable energy sources" in Financial Mechanism EOG in years 2009-2014 (area no. 5 – energy efficiency and area no. 6 – renewable energy sources); – Green Investment Scheme, Part 5 – Energy management in buildings of selected public sector entities; Efficient use of energy (Part 4 – LEMUR) – Energy-efficient public utility buildings; – Operational Programme Infrastructure and Environment (Measure 9.3) – Thermal modernisation of public utility buildings; – Efficient use of energy (Part 6 – SOWA) – Energy – efficient street lighting systems – Operational Programme Infrastructure and Environment 2007-2013 (Measure 7.3) – City transport in metropolitan areas and (Measure 8.3) – Development of intelligent transport systems – Green Investment Scheme (Part 7 – Gazela) – Low-emission urban transport.

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
Portugal	In 2013 the National Action Plan for Energy Efficiency (PNAEE) for 2013-2016 was approved by the Council of Ministers of 28 February, in accordance to the principles of Directive 2006/32/EC. This review took into account the 2020 horizon perspective, according to the directive 2012/27/EU. This document includes a wide range of programmes and measures across all sectors, and it is considered essential for Portugal to achieve the goals set out in the Directive 2006/32/EC. As a result of the economic crisis, which had significantly altered the previewed national primary energy consumption, nowadays it is considered that the previous estimated goals were achieved with a consumption of 23.8 Mtoe. The new objective considered in the recast of NEEAP settles a more ambitious target requiring an additional effort in reducing primary energy consumption (between 1.2 and 1.7 Mtoe) up to 22,5 Mtoe. Main energy efficiency policy measures include: – National Energy Strategy 2020 (ENE 2020) – Intensive Energy Consumption Management System (SGCIE) – Energy labelling Buildings (2013) – Building code REH 2013 – Regulation for Energy Management in the Transport Sector. – Sustainable mobility promotion and good practices adoption – Energy Efficiency Program in Public Administration (ECO.AP) – Energy labelling Buildings (2013) – Building code REH 2013
Romania	Adopted in August 2014, Law no. 121/2014 on energy efficiency transposed the requirements of Directive 2012/27/EC. Law no.121/2014 on energy efficiency established, within ANRE, the Energy Efficiency Department. The Department is responsible with transposing the provisions of the law into secondary legislation. Other institutions involved in the field of energy efficiency are the Ministry of Energy, Ministry of Economy, Trade and Tourism that implements government policy in the energy sector, including energy efficiency and renewable resources; the Ministry of Regional Development and Public Administration for the housing sector, the Ministry of Environment, Water and Forests, the Ministry of Internal Affairs, for local government, the Ministry of Transport, for the transport sector. These institutions are cooperating with ANRE. In 2014, Romania developed the third National Energy Efficiency Action Plan, according to the provisions of the Directive 2012/27/EC. Romania's national indicative energy efficiency target for 2020 is to save 10 million toe of primary energy, which represents a reduction of 19% in the volume of primary energy consumption (53 million toe) forecasted in the Primes 2007 model for the realistic scenario. Achieving this target implies that in 2020 primary energy consumption will be 43 million toe, while total energy consumption will be 30 million toe. The measures provided by the NEEAP III represented the basis for establishing 11 national EE Programmes Main energy efficiency policy measures include: – National Investment Plan – Energy Efficiency in industry framed in EU-ETS – The promotion of CHP's – Energy Audit and Energy Management – Thermal rehabilitation of governmental buildings Thermal rehabilitation of residential buildings financed by bank loans with government guarantee – Program to stimulate the national car park renewal for legal entities and liberal professions – Modernization of urban public transport – Alternative Mobility – Thermal rehabilitation of buildings (offices, commercial buildings – Promoting the development of energy service companies – ESCOs
Slovakia	Key responsibility for the energy policy preparation and implementation in the Slovak Republic lies on the Ministry of Economy; the policy is approved by Government and implemented also by other relevant ministries (mainly Ministry of Environment, Ministry of Transport, Construction and Regional Development). Ministry of Environment cares for environmental issues linked with energy. In January 2006, the Slovak Government has approved the latest Energy Policy of the Slovak Republic. It covers a period of 25 years and will be updated in 2013. National climate policy is based on the Strategy of the Slovak Republic Relating to the Global Climatic Change. Energy legislation related to energy efficiency, energy conservation and wider RES utilisation consists of nine fundamental Acts: Energy Act, Heat Energy Act, Regulatory Act, Energy Performance of Buildings Act, Act on Regular Inspections of Boilers and AC-systems, Act on Energy Labelling and Ecodesign Act, Energy Efficiency Act and Act on Promotion of RES and high efficient CHP. There are other executive regulations to above men-

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
	tioned acts which are prepared in an advanced stage of legislation process. Act amendments are in preparation in accordance with recast of relevant EU directives. There are several strategic documents existing in the Slovak Republic, e.g. National Energy Efficiency Action Plan 2011 ÷ 2013 and Concept of Energy Efficiency of the Slovak Republic. Main energy efficiency policy measures include: – National Energy Efficiency Action Plans – Mandatory Energy Audits in Industry and Agriculture – Mandatory Energy Manager in Heat Delivery Branch – Efficiency Standards for Boilers – Feed-in Tariffs for RES based Electricity and CHP – Energy Performance Certificates of Buildings – Subsidies for housing development – Subsidy programme for purchase of solar thermal collectors and biomass boilers – Minimum Quantity of Automotive Fuels Produced from RES – Regular Emission Inspection of Vehicles
Slovenia	Directorate for energy under Ministry of Infrastructure (ME) is in charge for the implementation of national programmes for energy efficiency and renewable energy sources. The Ecological fund (Eco-fund) is a public financial institution engaged in promotion of environmental investments in Slovenia. Its activities include provisions of subsidies and low-interest loans for investments in energy efficiency measures (EEM) and renewable energy sources (RES). In promotion and implementation of EEM and RES local energy agencies are also very active. National energy programme has been accepted in 2004. First National energy efficiency action plan has been accepted in 2008. The "Third National Energy Efficiency Action Plan" for 2020 sets target to limit primary energy consumption at 7125 Mio toe. This will be achieved with implementation of different measures with cumulative final energy savings of 4564 GWh. Operational Programme for reduction of greenhouse gas (GHG) emissions until 2020 presents measures that will limit growth of GHG emissions of non-ETS to maximum 4% in 2020 compared to 2005. Long term energy programme is under preparation. Main energy efficiency policy measures include: – Energy efficiency obligation scheme – Excise duties on fuels and electricity – Support scheme for electricity generated from RES and in CHP – Financial incentives for efficient electricity consumption – Financial incentives for energy-efficient renovation and sustainable construction of residential buildings. – Financial incentives for the energy efficient heating systems. – Regulation on efficient use of energy in buildings. – Regulation on energy related products – Promoting sustainable freight transport – Improvement of efficiency of cars – Promotion of public transport – Financial incentives for efficient use of electricity – Green procurement
Spain	The IDAE is the national agency responsible for the promotion of energy efficiency and renewable energies in Spain. The IDAE is a public body belonging to the Ministry of Industry, Energy and Tourism (MINETUR) through the Secretariat of State for Energy, as established by Royal Decree 344/2012 of 10 February. in addition, Royal Decree 20/2012 of 17 July provides that the IDAE shall be considered an instrumental resource of the General State Administration own instruments means the General State Administration's (AGE), and by adding to their tasks the support to the development of technologies aimed at the decarbonising of electricity generation and the provision of technical and financial assistance to MINETUR. The National Action Plan for Energy Efficiency 2014-2020 has been recently approved, in compliance to the requirements set out by Directive 2012/27/EU on energy efficiency. This Plan is the first action Plan in the context of Directive 2012/27/EU and third (NEEAP3) as stated by Directive 2006/32/EC on end-use efficiency and energy services energy. This plan is a continuation of previous plans approved within the framework of the Strategy for Energy Saving and Efficiency 2004-2012 (E4) and Action Plan 2011-2020 (NEEAP2) Main energy efficiency policy measures include: – Spanish National Energy Efficiency Fund (NFEE) – JESSICA-F.I.D.A.E Fund (Energy Diversification and Saving Investment Fund) – Aid Programme for SMEs and the large firm in the industrial sector

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	– State Plan to boost rental housing, building rehabilitation, and urban regeneration and renovation 2013-2016. – Aid programme for the energy rehabilitation of existing buildings in the residential sector, for housing and hotel uses (PAREER-CRECE) – Plan to boost environmental preservation in the hotel industry (PIMA SOL). – PIVE Plans (Efficient-Vehicle Incentive Programme) – PIMA Air Plans (Plan to boost environmental preservation "PIMA Aire" to purchase commercial vehicles) – MOVELE Programme to support the purchase of electric vehicles – Aid Programme for modal change actions and a more efficient use of transport modes – Registration duty on new motor vehicles (Law 34/2007 on air quality) – Energy efficiency regulation in outdoor lighting installations (Royal Decree 1890/2008) – Law 15/2014, on the Public Sector rationalisation – Aid Programme to renew municipal outdoor lighting installations
Sweden	Sweden has a national target to reduce its economy's energy intensity by 20% by 2020. The target is expressed as primary energy/GDP. In the transport sector there is a target of a fossil-free vehicle fleet by 2030. Following general elections in September 2014, a new government consisting of the social democrats and the environment party came to power. Simultaneously, several policy instruments for energy efficiency expired. As of autumn 2015 there is no decision on instruments replacing all of those expired. Main energy efficiency policy measures include: – Energy and carbon dioxide tax, the purpose of which is a combination of reducing harmful emissions while promoting efficient use of all energy – Networks for sharing experience in energy efficiency – Building codes – Municipal planning – Municipal energy advisors – Technology procurement groups.
UK	In 2012, the UK Government launched its Energy Efficiency Strategy (updated in 2013), which identified the barriers to energy efficiency take up and the socially cost effective energy efficiency potential that remains in the UK economy. In the household sector a succession of Energy Efficiency Obligations from 1994 to 2012 delivered most of the insulation measures and promoted energy efficient heating systems and appliances. The EU Emissions Trading Scheme (EU ETS), which covers 40% of UK emissions, is a key EU measure driving energy efficiency improvements in the industry sector. In addition, the UK introduced the Climate Change Levy in 2001. Companies that are part of Climate Change Agreements (CCAs) and which successfully meet the conditions of their agreement are eligible for a discount on the levy. The Government also implemented the CRC Energy Efficiency Scheme which targets large, non-energy intensive businesses and public sector organisations and emissions not already covered by the EU ETS or Climate Change Agreements. Main energy efficiency policy measures include: – Climate Change Levy – Climate Change Agreements – Energy Efficiency Obligations – Green Deal – Building Regulations – Ultra Low Emissions Vehicles policies – Salix – Greening Government Commitments – Carbon Reduction Commitment

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
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Iceland	In accordance with Article 4 of Directive 2009/28/EC the National Renewable Energy Action Plan (NREAP) sets out the Government's strategic approach and concrete measures on how Iceland will meet the mandatory national targets for 2020 laid down in Directive 2009/28/EC, including the overall target and the 10% target on share of energy from renewable sources in transport. The NREAP is based on the template for the national renewable energy action plans, adopted by the Commission. Comprehensive Energy Strategy for Iceland policy document aims to: Have renewable energy sources replace imported energy. Iceland's energy harnessing shall be sustainable for the good of society and the public. A precautionary and protective approach will be followed in hydroelectric and geothermal energy production. The energy strategy will support diversified industry, emphasising the development of ecologically beneficial high-tech industry. The energy strategy will aim at sustainable utilisation, avoiding for instance aggressive utilisation of geothermal areas. To encourage better energy utilisation, for instance, by developing industrial parks and factories, horticulture stations, recycling and other activities utilising the steam energy of sustainable geothermal plants. Connection of the Icelandic electricity system to Europe, through an interconnector The energy policy of Iceland aims for carbon neutrality. Iceland is well under way in that regard, as all sectors in Iceland, except for transport and fishing, use mostly renewable energy from hydro or geothermal origin.
Liechtenstein	The general measures taken by Liechtenstein are related to: building renovation, promotion of the Energy standard, residential technical installations, solar collectors, photovoltaic, demonstration facilities, a hydrogeological map for using near-surface geothermal energy for heating purposes, offer of cooperation to "Energy City for Everyone" municipalities. The Government of Liechtenstein also promoted several by-laws on the energy sector. Below are a list of measures related to the energy sector: – Energy Efficiency Act, – Heated Regulations, – Heat insulation regulations, – Energy standard for State Building, – Supply requirements, – Liechtenstein Energy concept/Energy vision 2020, – Green electricity auditing and certification system, – Promotion of photovoltaic system of private owner, – Promotion of energy generated by private owner, – Promotion of energy generated by systems for efficient energy production and – Municipalities' participation in the Energy City label. Besides the internal measures, the Government of Liechtenstein have also invested in renewable energy clean development mechanism (CDM) projects in countries like Vietnam and Thailand for purchase of Certified Emissions Reductions Certificates (CER), for offsetting carbon emissions. Under this contract, the country plans to offset 55,000 tons of CO_2 emissions
Norway	The alteration to a more environmental friendly production and use of energy in Norway is managed by Enova SF. Enova is a public enterprise for promoting energy savings, and production of energy from renewable resources which is fully owned by the Government of Norway, represented by the Ministry of Petroleum and Energy. The main mechanisms Enova relies on are financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals, but the agency also provides advice to both households and the private sector on energy saving measures. Enova SF administrates the Energy Fund. The income of the Energy Fund comes from a levy to the distribution tariffs that is mandatory and from allocation from the revenue of the Fund for climate, renewable energy and energy restructuring. In 2014, the total income was just under NOK 1.9 billion. With resources from the Energy Fund, Enova has in cooperation with the market triggered annual energy results totaling 18.7 TWh during the period 2001 to 2014. The government agency Transnova was established in 2009 as a trial funding programme with the goal of contributing to halt the trend of the fast increase of greenhouse gas emissions from transport. As per 01/01/2015, Transnova became part of Enova which is now responsible for managing the funding programmes directed towards the transport sector.

Country	Country profile (based on edited extracts from ODYSEE-MURE and IEA databases)
	Main energy efficiency policy measures include: – Energy Fund The purpose is to promote environmentally friendly restructuring of energy end-use and energy production, as well as contribute to development of energy and climate technology – Enova support schemes – energy management – energy measures – new energy and climate technologies – Enova Recommends – a scheme which shall make it easier to choose products and solutions with good energy performance Enova support schemes – investment grant for selected technologies – Introduction of battery electric vehicles Enova support schemes – energy management – energy measures maritime & land-based transport – new energy and climate technologies – biogas and biofuels – electric charging infrastructure – Enova support schemes – energy measures – new energy efficient buildings
Switzerland	The aim of Swiss environmental policy is to ensure that natural resources are maintained over the long term and continue to be available to future generations. The Federal Office for the Environment (FOEN) contributes in four key areas. At national level, it is responsible for protecting the population against natural hazards. It protects the environment and human health by reducing the adverse effects of pollutants, noxious substances and noise. It works to preserve and promote biological and landscape diversity as well as natural production factors such as wood or touristic landscapes. Finally, the FOEN is responsible for Switzerland's international environmental policy.

Table A.4: Key sources for the EU and ESPON partner states

Country	Links to documents	Nature of document
Austria	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-austria.pdf	report providing overview of Austria's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Austria	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/Documents/EEW2/Austria.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy implementation
	http://www.justiceandenvironment.org/_files/file/2011%20CC%20AT%20eff.pdf	Analysis of Austria's energy efficiency legislation and policies conducted by Justice and Environment, 2011
	http://www.en.bmwfw.gv.at/Energy/EnergyEfficiency/Seiten/default.aspx	Austria's Federal Ministry of Science, Research and Economy
	https://en.energyagency.at/projects-research/energy-climate-policy.html	Austrian Energy Agency
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
Belgium	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-belgium.pdf	report providing overview of Belgium's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Belgiumhttps://www.iea.org/publications/freepublications/publication/Energy_Policies_of_IEA_Countries_Belgium_2016_Review.pdf	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Belgium/Country_Report_Belgium_translated_final_FR.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy implementation (in French)
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
Bulgaria	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-bulgaria.pdf	report providing overview of Bulgaria's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Bulgaria	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Bulgaria/Country_Report_Bulgaria_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy implementation
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
Croatia	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-croatia.pdf	report providing overview of Croatia's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Croatia	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Croatia/Country_Report_Croatia_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy implementation
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports

Country	Links to documents	Nature of document
	http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/projects_and_initiatives/energy-efficiency-programme-in-croatia.html	UNDP, Croatia energy efficiency programme
	http://www.sciencedirect.com/science/article/pii/S0301421513005375	Bukarica, V and Robić, S (2013) Implementing energy efficiency policy in Croatia: Stakeholder interactions for closing the gap, *Energy Policy*, 61: 414-422
Cyprus	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-cyprus.pdf	report providing overview of Cyprus's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Cyprus	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Cyprus/Country_Report_Cyprus_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	https://www.ucy.ac.cy/erc/documents/Zacharides_35-51.pdf	Zacharadis, T (2014) The Effect of Energy Efficiency Policies on the Medium-Term Energy Outlook of Cyprus, *Cyprus Economic Policy Review*, 8(1): 35-51
Czech Rep	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-czech-republic.pdf	report providing overview of the Czech Republic's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Czech%20Republic	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Czech_Republic/Country_Report_Czech_Republic_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.ecn.nl/docs/library/report/2002/rx02056.pdf	van Wees, MT, Uyterlinde, MA and Maly, M (2002) Energy efficiency and renewable energy policy in the Czech Republic within the framework of accession to the European Union, *Energy*, 27: 1057-1067
	http://bankwatch.org/sites/default/files/shadow-CZ-EE-RES.pdf	Position of CEE Bankwatch Network and the Zelený Kruh association of environmental non-governmental organizations
Denmark	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-denmark.pdf	report providing overview of Denmark's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Denmark	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Denmark/Country_Report_Denmark_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	https://stateofgreen.com/en/sectors/energy-efficiency	State of Green gathers leading Energy Efficiency profiles, solutions and news in Denmark
	http://www.ea-energianalyse.dk/papers/2009_june_eceee2009_togeby.pdf	Togeby et al. (2009) Danish energy efficiency policy: revisited and future improvements, ECEEE 2009 Summer Study
	http://www.danishenergyassociation.com/The	Danish Energy Association – energy effi-

Country	Links to documents	Nature of document
	me/Energy_Efficiency.aspx http://www.danskenergi.dk/~/media/EU/Why_obligations_schems.ashx	ciency
	http://www.energyefficiencycentre.org/Who-We-Are	Established in September 2013, the Copenhagen Centre on Energy Efficiency (C2E2) is a joint activity of the Danish Government, the UN Environment (UNEP) and the Technical University of Denmark (DTU). It is dedicated to accelerating the uptake of energy efficiency policies and programmes at a global scale
Estonia	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-estonia.pdf	report providing overview of Estonia's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Estonia https://www.iea.org/publications/freepublications/publication/Estonia2013_free.pdf	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/estonia/Country_Report_Estonia_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	https://www.mkm.ee/en/objectives-activities/energy-sector/energy-efficiency	Republic of Estonia Ministry of Economic Affairs and Communications
	http://www.cbss.org/wp-content/uploads/2015/06/EFFECT_Energy_Efficiency_BSR_update2015.pdf	Energy Efficiency in the Baltic Sea Region - Policy Review. EFFECT – Dialogue Platform on Energy and Resource Efficiency in the Baltic Sea Region
	http://www.baltic21.org/energy/estonia.html	The Council of the Baltic Sea States
	http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2003c/Panel_1/1028blechschmidt	Blechschmidt, K (2003) Energy planning in Poland and Estonia against the background of their energy efficiency policies, ECEEE 2003 Summer Study
Finland	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-finland.pdf	report providing overview of Finland's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Finland https://www.iea.org/publications/freepublications/publication/Finland2013_free.pdf	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Finland/Country_Report_Finland_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://tem.fi/en/energy-efficiency	Ministry of Economic Affairs and Employment
	http://iepd.iipnetwork.org/policy/energy-efficiency-agreements	Industrial Efficiency Policy Database
	http://www.motiva.fi/files/8005/Energy_Efficiency_in_Finland_A_Competitive_Approach.pdf	Motiva Oy
France	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-france.pdf	report providing overview of France's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=France	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/France/Country_Report_France_	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States en-

Country	Links to documents	Nature of document
	FINAL.pdf	ergy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.developpement-durable.gouv.fr/IMG/pdf/14111_Brochure_Climat_2013_version_GB.pdf	Ministry of Ecology, Sustainable Development and Energy
	http://www.s-ge.com/sites/default/files/BBK_France_Energy_Efficiency_Sep-2014_1.pdf	Switzerland Global Enterprise, Energy Efficiency in France
	http://www.cdcclimat.com/IMG//pdf/12-12-11_climate_brief_no23_-_energy_efficiency_directive.pdf	CdC Climat research
	http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/FRANCE.pdf	Climate change legislation in France, Grantham Research Institute on Climate Change and the Environment
Germany	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-germany.pdf	report providing overview of Germany's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Germany	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Germany/Country_Report_Germany_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://aceee.org/files/proceedings/2016/data/papers/9_158.pdf	Schlomann, B; Rohde, C and Ringel, M (2016) Energy Efficiency Policies in the German Energy Transition, ACEEE Summer Study on Energy Efficiency in Buildings
	http://sticerd.lse.ac.uk/dps/case/cp/CCCsummary.pdf	Power, A and Zulauf, M (2011) Cutting Carbon Costs: Learning from Germany's Energy Saving Program, LSE Housing and Communities, Centre for Analysis of Social Exclusion, London School of Economics
	http://www.bmub.bund.de/en/topics/climate-energy/	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
	http://www.sciencedirect.com/science/article/pii/S030626191630383X	Ringel, M.; Schlomann, B.; Krail, M and Ringel, M (2016) Towards a green economy in Germany? The role of energy efficiency policies, Applied Energy, 179: 1293-1303;
Greece	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-greece.pdf	report providing overview of Greece's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Greece	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Greece/Country_Report_Greece_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.jessicafund.gr/wp-content/uploads/jessica-instruments-for-energy-efficiency-in-greece-en.pdf	JESSICA Instruments for Energy Efficiency in Greece EVALUATION STUDY, EU funded (2011)
	http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/GREECE.pdf	Climate legislation in Greece, Grantham Research Institute on Climate Change and Environment
Hungary	http://www.odyssee-mure.eu/publications/	report providing overview of Hungary's

Country	Links to documents	Nature of document
	national-reports/energy-efficiency-hungary.pdf	energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Hungary	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Hungary/Country_Report_Hungary_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.inderscience.com/offer.php?id=37394	Elek, L (2010) Energy efficiency policies and measures in Hungary, *International Journal of Global Energy Issues*, 34(1): 42-67
	http://www.ceemproject.eu/wp-content/uploads/2014/11/Territorial_Strategy_North_Hungary_20140930.pdf	Central Environmental and Energy Management as a Kit for Survival, EU funded study
	http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/HUNGARY.pdf	Climate legislation in Hungary, Grantham Research Institute on Climate Change and Environment
Ireland	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-ireland.pdf	report providing overview of Ireland's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Ireland	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Ireland/Country_Report_Ireland_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.dccae.gov.ie/energy/en-ie/Energy-Efficiency/Pages/National-Energy-Efficiency-Action-Plan-(NEEAP).aspx#	Department of Communications, Climate Action & Environment
	http://www.seai.ie/Publications/Energy_Policy_Publications/Energy_Modelling_Group_Publications/Unlocking-the-Energy-Efficiency-Opportunity-Main-Report-.75081.shortcut.pdf	Sustainable Energy Authority of Ireland (2015) Unlocking the Energy Efficiency Opportunity
Italy	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-italy.pdf	report providing overview of Italy's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Italy	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Italy/Country_Report_Italy_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.iefe.unibocconi.it/wps/wcm/connect/9d796b1b-e394-44ff-9154-e9819fd0b81b/RR+20.pdf?MOD=AJPERES	Status-quo Analysis of Energy Efficiency Policies in 8 EU Countries – National Report for Italy, IEFE - The Center for Research on Energy and Environmental Economics and Policy at Bocconi University
	http://www.enea.it/en/research-development/energy-efficiency	ENEA – Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Country	Links to documents	Nature of document
	https://www.researchitaly.it/en/news/the-italian-energy-efficiency-action-plan-2014-is-online/	Research Italy, the portal of Italian research
Latvia	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-latvia.pdf	report providing overview of Latvia's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Latvia	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Latvia/Country_Report_Latvia_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.emeraldinsight.com/doi/abs/10.1108/14777831211255097	Ozolina, L. and Rosˇā, M (2012) A review of energy efficiency policy and measures for industries in Latvia, *Management of Environmental Quality: An International Journal*, 23(5): 517 – 526
	http://bankwatch.org/sites/default/files/shadow-LV-EE-RES.pdf	Latvia: Energy Efficiency and Renewables, CEE bankwatch network
	http://www.lsta.lt/files/seminarai/2015-04-09_Ryga/02.-ey-bus-2015-jurijs-spiridonovs.pdf	Energy policy trends in Latvia, Ministry of Economics, Republic of Latvia
Lithuania	http://www.odyssee-mure.eu/publications/profiles/lithuania-efficiency-trends.pdf	report providing overview of Lithuania's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Lithuania	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Lithuania/Country_Report_Lithuania_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.esparama.lt/documents/10157/490675/18_2014_Vasauskaite.pdf/0286e858-b173-45f4-a2bc-4588a06c1dbf	Vasauskaite, J., Streimikiene, D. (2014), Review of Energy Efficiency Policies in Lithuania, Transformations in Business & Economics, 13(3C (33C)): 628-642
	http://www.cbss.org/wp-content/uploads/2015/06/EFFECT_Energy_Efficiency_BSR_update2015.pdf	Energy Efficiency in the Baltic Sea Region, EFFECT – Dialogue Platform on Energy and Resource Efficiency in the Baltic Sea Region
	http://www.sciencedirect.com/science/article/pii/S1364032112001396	Streimikiene, D; Volochovic, A. and Simanaviciene, Z (2012) Comparative assessment of policies targeting energy use efficiency in Lithuania, *Renewable and Sustainable Energy Reviews*, 16(6): 3613–3620
	http://www.sciencedirect.com/science/article/pii/S0301421502002938	Klevas, V and Minkstimas, R (2004) The guidelines for state policy of energy efficiency in Lithuania, Energy Policy, 32(3): 309-320
Luxembourg	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-luxembourg.pdf	report providing overview of Luxembourg's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Luxembourg	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Luxembourg/Country_Report_Luxembourg_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy

Country	Links to documents	Nature of document
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.ukace.org/wp-content/uploads/2012/11/ACE-Proceedings-2007-06-Integrating-policies-for-renewables-and-energy-efficiency-comparing-results-from-Germany-Luxenbourg-and-Northern-Ireland-ECEEE-Summer-Study-2007.pdf	Kranzl, L et al. (2007) Integrating policies for renewables and energy efficiency: Comparing results from Germany, Luxembourg and Northern Ireland, ECEEE 2007 Summer Study, Saving Energy – Just do it!
Malta	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-malta.pdf	report providing overview of Malta's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Malta	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Malta/Country_Report_Malta_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://mra.org.mt/wp-content/uploads/2012/08/1.2.Energy-Policy.pdf	Malta Resources Authority, A proposal for an energy policy for Malta
	http://meerea.org/	Malta Energy efficiency and renewable energies association
Netherlands	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-netherlands.pdf	report providing overview of the Netherland's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Netherlands	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Netherlands/Country_Report_Netherlands_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	https://www.government.nl/topics/energy-policy/contents/saving-energy	Government of Netherlands
	https://www.ecn.nl/docs/library/report/2009/e09045.pdf	Boot, P.A. (2009) Energy efficiency obligations in the Netherlands A role for white certificates?, ECN, Energy Research Centre of the Netherlands
	http://www.sciencedirect.com/science/article/pii/S0301421516300866	Vringer, K; van Middelkoop, M and Hoogervost, N (2016) Saving energy is not easy: An impact assessment of Dutch policy to reduce the energy requirements of buildings, Energy Policy, 93: 23-32
	http://trinomics.eu/project/evaluation-of-the-dutch-multi-annual-agreement-on-energy-efficiency-mja3/	Evaluation of the Dutch Multi-Annual Agreement on Energy Efficiency (MJA3), Trinomics, Ministry of Economic Affairs of the Netherlands
Poland	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-poland.pdf	report providing overview of Poland's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Poland	Policies and measures database from the International Energy Agency

Country	Links to documents	Nature of document
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Poland/Country_Report_Poland_PL_02.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.rynek-gazu.cire.pl/konferencje/dokumenty/2_Ministerstwo_Gospodarki.pdf	Poland Ministry of Economy, Poland's energy efficiency policy in the context of the EU climate goals
	http://stat.gov.pl/cps/rde/xbcr/gus/ee_energy_efficency_in_Poland_2000-2010.pdf	Central Statistical Office, Energy Efficiency in Poland in years 2000-2010
	http://documents.worldbank.org/curated/en/511551468333847648/Poland-Energy-Efficiency-and-Renewable-Energy-Development-Policy-Loan-DPL-Program	World Bank (2011) Poland – Energy Efficiency and Renewable Energy Development Policy Loan (DPL) Program (English)
	https://www.researchgate.net/publication/274532493_Policy_Instruments_for_Supporting_Energy_Efficiency_in_Poland	Wyrwa, A; Figorski, A and Gula, A (2004) Policy Instruments for Supporting Energy Efficiency in Poland, *Energy & Environment* 15(2):261-270
Portugal	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-portugal.pdf	report providing overview of Portugal's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Portugal	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Portugal/Country_Report_Portugal_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	https://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/porjs.pdf	Seixas, J and Martinho, S (2000) A methodological framework to assess policies and measures through "best practices" identification – The case of renewables, CHP and energy efficiency in Portugal, UNFCCC *Workshop on Best Practices in Policies and Measures*, 11 – 13 April 2000, Copenhagen
	https://www.researchgate.net/publication/280111661_BUILDING_ENERGY_EFFICIENCY_REVIEW_OF_BRAZILIAN_AND_PORTUGUESE_REGULATIONS	Krebs, L et al. (2014) Building energy efficiency: review of Brazilian and Portuguese regulations, conference paper
	http://www.sciencedirect.com/science/article/pii/S187661021502874X	Rodrigues, F et al (2015) High Energy Efficiency Retrofits in Portugal, *Energy Procedia*, 83: 187-196
	http://proceedings.eceee.org/visabstrakt.php?event=5&doc=2-256-15	Sousa, JL; Martins, AG and Jorge, HM (2015) Are energy efficiency obligations an alternative? The case-study of Portugal, ECEEE Summer Study proceedings
	http://www.centrodeinformacao.ren.pt/PT/publicacoes/PublicacoesGerais/Energy%20and%20Climate%20Change.%20World%20Energy%20Council%202007%20%20-%20%20Portuguese%20National%20Assesment.pdf	WEC Energy and Climate Change Study Group (2007) Climate Change Policies and Measures Portuguese National Assessment, World Energy Council
Romania	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-romania.pdf	report providing overview of Romania's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Romania	Policies and measures database from the International Energy Agency

Country	Links to documents	Nature of document
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Romania/Country_Report_Romania_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.justiceandenvironment.org/_files/file/2011%20CC%20RO%20eff%20final.pdf	Justice and Environment – European Network of Environmental Law Organisation (2011) Energy Efficiency Legislation and Policies Romania
	http://bpie.eu/wp-content/uploads/2016/09/RO-article_Improving-the-energy-efficiency-of-residential-buildings-in-Romania.pdf	Buildings Performance Institute Europe (BPIE) (2016) Improving the energy efficiency of residential buildings in Romania – Delivering across a range of national strategic priorities
	http://arpee.org.ro/wp-content/uploads/2014/04/Cartea-Alba-english.pdf	Romanian association for the promotion of energy efficiency (2013) Energy efficiency in Romania – White Book, AGIR Publishing House
	https://www.researchgate.net/publication/273791850_Policy_towards_the_building_energy_efficiency_in_Romania	Zapodeanu, ID and Isopescu, DN (2014) Policy towards the building energy efficiency in Romania, Bulletin of the Polytechnic Institute of Jassy, CONSTRUCTIONS. ARCHITECTURE Section Tomul IX (LXVI)(Fasc. 4):65-73
Slovakia	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-slovakia.pdf	report providing overview of Slovakia's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Slovakia	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Slovakia/Country_Report_Slovenia_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://en.siea.sk/	Slovak Innovation and Energy Agency, Ministry of Economy of the Slovak Republic
	http://bankwatch.org/sites/default/files/shadow-SK-EE-RES.pdf	CEE Bankwatch network, Slovakia: Energy Efficiency and Renewable Sources, Position paper of Friends of the Earth-CEPA: Supporting sustainable energy in EU Cohesion Policy in 2014-2020
	http://cenaa.org/analysis/10-years-of-energy-policy-in-slovakia/	Nosko, A, 10 Years of Energy Policy in Slovakia, Centre for European and North Atlantic Affairs
	http://library.fes.de/pdf-files/id-moe/09379.pdf	Izakovičová, J et al (2012) Resource Efficiency Gains and Green Growth Perspectives in Slovakia, Friedrich Ebert Stiftung
Slovenia	http://www.odyssee-mure.eu/publications/profiles/slovenia-efficiency-trends-english.pdf	report providing overview of Slovenia's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Slovenia	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Slovenia/Country_Report_Slovenia_SL_01.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports

Country	Links to documents	Nature of document
	http://www.sciencedirect.com/science/article/pii/S0360544210002884	Al-Mansour, F (2011) Energy efficiency trends and policy in Slovenia, *Energy*, 36(4): 1868-1877
	https://www.researchgate.net/publication/240295419_Energy_efficiency_policy_in_Slovenia	Beravs, F (2001) Energy efficiency policy in Slovenia, International Journal of Global Energy Issues 16(1), DOI: 10.1504/IJGEI.2001.000915
	https://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/br2_2016_slovenija_-_textual_part.pdf	Republic of Slovenia, Ministry of the Environment and Spatial Planning (2016) Slovenia's Second Biennial Report Under the United Nations Framework Convention on Climate Change
	http://aip.scitation.org/doi/abs/10.1063/1.4811283?journalCode=rse	Obrecht, M and Denac, M (2013) A sustainable energy policy for Slovenia: Considering the potential of renewables and investment costs, Journal of Renewable and Sustainable Energy, 5(3): DOI. 10.1063/1.4811283
Spain	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-spain.pdf	report providing overview of Spain's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Spain	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Spain/Country_Report_Spain_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.sciencedirect.com/science/article/pii/S1364032107001165	De Alegria Mancisidor, IM et al. (2009) European Union's renewable energy sources and energy efficiency policy review: The Spanish perspective, *Renewable and Sustainable Energy Reviews*, 13(1): 100-114
	http://www.sciencedirect.com/science/article/pii/S1876610213017086	Tolon-Becerra et al. (2013) Opportunities in Spanish Energy Efficiency. Current Situation, Trends and Potential in the Building Sector, *Energy Procedia*, 42: 63-72;
	http://awsassets.wwf.es/downloads/challenges_and_funding_opportunities_for_the_energy_efficient_renovation_of_spain_s_resi.pdf	WWF (2012) Challenges and Funding Opportunities for the Energy Efficient Renovation of Spain's Residential Building Stock
Sweden	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-sweden.pdf	report providing overview of Sweden's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Sweden	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/Sweden/Country_Report_Sweden_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.sciencedirect.com/science/article/pii/S0301421506000383	Rohdin, P; Thollander, P and Solding, P (2006) Barriers to and drivers for energy efficiency in the Swedish foundry industry, *Energy Policy*, 35(1): 672-677.
	http://link.springer.com/article/10.1007/s12053-016-9446-7	Xylia, M., Silveira, S. and Morfeldt, J (2016) Implications of an energy efficiency obligation scheme for the Swedish energy-intensive industries: an evaluation of costs and benefits, Journal of Energy Efficiency, doi:10.1007/s12053-016-9446-7

Country	Links to documents	Nature of document
	http://fourfact.se/images/uploads/5-055-12_Backlund.pdf	Backlund, S et al (2012) Energy efficiency potentials and energy management practices in Swedish firms, ECEEE, Summer Study on Energy Efficiency in Industry
UK	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-united-kingdom.pdf	report providing overview of UK's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=United%20Kingdom	Policies and measures database from the International Energy Agency
	http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Country_Reports_EEW3/United_Kingdom/Country_Report_United_Kingdom_FINAL.pdf	Country report published within the Energy Efficiency Watch project, assessing ambition and quality of EU Member States energy efficiency action plans and policy
	https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans	National Energy Efficiency Action Plans and Annual reports
	http://www.sciencedirect.com/science/article/pii/S1462901104000371	Boardman, B (2004) Achieving energy efficiency through product policy: the UK experience, *Environmental Science & Policy*, 7(3): 165-176
	http://s3.amazonaws.com/academia.edu.documents/46273428/j.eneco.2006.12.0082016 0606-7895-lblk8w.pdf?AWSAccessKeyId=AKIAJ56TQJRTWSMTNPEA&Expires=1483628951&Signature=IobZUtewIWP2K671Rz0poOOaDuI%3D&response-content-disposition=inline%3B%20filename%3DMacroeconomic_effects_of_efficiency_poli.pdf	Barker, T; Ekins, P and Foxon, T (2007) Macroeconomic effects of efficiency policies for energy-intensive industries: The case of the UK Climate Change Agreements, 2000–2010, *Energy Economics*, 29: 760-778
	http://aoatools.aua.gr/pilotec/files/bibliography/EP_houseUK_boardman-3986158080/EP_houseUK_boardman.pdf	Boardman, B (2004) New directions for household energy efficiency: evidence from the UK, *Energy Policy*, 32: 1921-1933
	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy--the-energy-efficiency.pdf	Department of Energy and Climate Change (2012) The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK
	https://www.gov.uk/government/policies/energy-efficiency-in-buildings	Department for Communities and Local Government
	http://www.publications.parliament.uk/pa/cm201516/cmselect/cmenergy/552/552.pdf	House of Commons Energy and Climate Change Committee, Home energy efficiency and demand reduction, Fourth Report of Session 2015–16
	http://www.publications.parliament.uk/pa/cm201516/cmselect/cmenergy/552/55202.htm	Parliament UK (2015) Home energy efficiency and demand reduction, Parliamentary copyright
Partner States		
Iceland	http://www.sciencedirect.com/science/article/pii/S0301421504002472	Solomon, BD and Banerjee, A (2006) A global survey of hydrogen energy research, development and policy, Energy Policy, 34(7): 781-792
	http://www.energycharter.org/fileadmin/DocumentsMedia/EERR/EERR-Iceland_2005_en.pdf	Energy Charter (2005) Iceland, Regular Review of Energy Efficiency Policies
	https://ec.europa.eu/energy/sites/ener/files/documents/dir_2009_0028_action_plan_iceland__nreap.pdf	Ministry of Industries and Innovation, The Icelandic National Renewable Energy Action Plan for the promotion of the use of energy from renewable sources in accordance with Directive 2009/28/EC and the Commission Decision of 30 June 2009 on a template for the national renewable energy action plans.
	http://www.nea.is/	National Energy Authority
	http://www.nordicenergy.org/indicators/country/iceland/	Nordic Energy Research

Country	Links to documents	Nature of document
Liechtenstein	www.eea.europa.eu/publications/energy-support-measures/case-study-Liechtenstein	European Environment Agency (2011) 2011 Survey of resource efficiency policies in EEA member and cooperating countries COUNTRY PROFILE: Liechtenstein
	http://www.arhiv.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/prostor/pdf/alpska_konvencijateziscni1_li_climate_policy.pdf	Liechtenstein Climate Policy – Office of Forests and Nature. Republic of Liechtenstein
	http://www.aeeprn.com/countries/europe/rest-of-europe/liechtenstein	Asia Europe Energy policy research network
Norway	http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-norway.pdf	report providing overview of Norway's energy efficiency trends and policies
	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Norway	Policies and measures database from the International Energy Agency
	http://www.sciencedirect.com/science/article/pii/S0301421508006629	Ryghaug, M and Sorensen, KH (2009) How energy efficiency fails in the building industry, *Energy Policy*, 37(3): 984-991
	https://www.ssb.no/en/energi-og-industri/artikler-og-publikasjoner/konsekvenser-av-energieffektiviseringsdirektivet-i-norge	Statistics Norway (2013) Consequences of the Energy Efficiency Directive in Norway: Energy efficiency obligation schemes and power balance
	https://www.ife.no/en/publications/2012/ensys/energy-efficiency-policies-and-measures-in-norway	Institute for Energy Technology (2012) Energy efficiency policies and measures in Norway
	https://henrikkarlstrom.files.wordpress.com/2012/11/paper_-towards-new-national-policy-instruments-for-promoting-energy-efficiency_final.pdf	Karlstrom, H; Ryghaug, M and Sorensen, KH (2012) Towards new national policy instruments for promoting energy efficiency
	https://www.researchgate.net/publication/276853193_The_ethos_of_energy_efficiency_Framing_consumer_considerations_in_Norway	Godbolt, A (2015) The ethos of energy efficiency: Framing consumer considerations in Norway, *Energy Research & Social Science*, DOI: 10.1016/j.erss.2015.04.005
Switzerland	https://www.iea.org/policiesandmeasures/energyefficiency/?country=Switzerland	Policies and measures database from the International Energy Agency
	http://www.bfe.admin.ch/themen/00507/?lang=en	Swiss Federal Office of Energy SFOE
	www.eea.europa.eu/publications/energy-support-measures/case-study-switzerland	European Environment Agency (2011) 2011 Survey of resource efficiency policies in EEA member and cooperating countries COUNTRY PROFILE: Switzerland
	http://www.off4firms.ethz.ch/wp-content/uploads/2013/01/Off4Firms-Working-Paper-D1-3.pdf	Gerigk, J et al. (2012) The Current Climate and Energy Policy in the EU and in Switzerland, ETH Zurich

Table A.5: Full Cluster Matrix showing distribution of regions

	Good Progress Score		Medium Progress Score		Poor Progress Score	
High RAI score	**AT11**	Burgenland	**AT21**	Kärnten	**CH03**	Nordwestschweiz
	AT12	Niederösterreich	**AT22**	Steiermark	**CH07**	Ticino
	BE21	Prov. Antwerpen	**AT31**	Oberösterreich	**DE30**	Berlin
	BE22	Prov. Limburg (BE)	**AT32**	Salzburg	**DE60**	Hamburg
	BE23	Prov. Oost-Vlaanderen	**AT33**	Tirol	**ES11**	Galicia
	BE25	Prov. West-Vlaanderen	**AT34**	Vorarlberg	**ES12**	Principado de Asturias
	BE32	Prov. Hainaut	**BE24**	Prov. Vlaams-Brabant	**ES13**	Cantabria
	BE33	Prov. Liège	**CH01**	Région lémanique	**ES21**	País Vasco
	BE34	Prov. Luxembourg (BE)	**CH02**	Espace Mittelland	**ES30**	Comunidad de Madrid
	BE35	Prov. Namur	**CH04**	Zürich	**ES70**	Canarias
	DE11	Stuttgart	**CH05**	Ostschweiz	**FI20**	Åland
	DE13	Freiburg	**CH06**	Zentralschweiz		
	DE14	Tübingen	**DE12**	Karlsruhe		
	DE23	Oberpfalz	**DE21**	Oberbayern		
	DE24	Oberfranken	**DE22**	Niederbayern		
	DE25	Mittelfranken	**DE71**	Darmstadt		
	DE26	Unterfranken	**ES24**	Aragón		
	DE27	Schwaben	**ES41**	Castilla y León		
	DE40	Brandenburg	**ES53**	Illes Balears		
	DE50	Bremen	**ES61**	Andalucía		
	DE72	Gießen	**ES62**	Región de Murcia		
	DE73	Kassel	**PT20**	Região Autónoma dos Açores		
	DE80	Mecklenburg-Vor-pommern	**PT30**	Região Autónoma da Madeira		
	DE91	Braunschweig				
	DE92	Hannover				
	DE93	Lüneburg				
	DE94	Weser-Ems				
	DEA1	Düsseldorf				
	DEA2	Köln				
	DEA3	Münster				
	DEA4	Detmold				
	DEA5	Arnsberg				
	DEB1	Koblenz				
	DEB2	Trier				
	DEB3	Rheinhessen-Pfalz				
	DEC0	Saarland				
	DED2	Dresden				
	DED4	Chemnitz				
	DED5	Leipzig				
	DEE0	Sachsen-Anhalt				
	DEF0	Schleswig-Holstein				
	DEG0	Thüringen				
	ES22	Comunidad Foral de Navarra				
	ES23	La Rioja				
	ES42	Castilla-La Mancha				
	UKM2	Eastern Scotland				
	UKM3	South Western Scot-land				
	UKM5	North Eastern Scot-land				
	UKM6	Highlands and Islands				
Medium RAI score	**BE31**	Prov. Brabant Wallon	**BE10**	Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest	**EL30**	Αττική (Attiki)
	ES52	Comunidad Valenci-ana	**ES51**	Cataluña	**ES43**	Extremadura
	FR21	Champagne-Ardenne	**FR26**	Bourgogne	**FR10**	Île de France
	FR22	Picardie			**FR42**	Alsace
					FR61	Aquitaine

	Good Progress Score		Medium Progress Score		Poor Progress Score	
	FR23	Haute-Normandie	**FR30**	Nord – Pas-de-Calais	**ITC1**	Piemonte
	FR24	Centre	**FR43**	Franche-Comté	**ITC2**	Valle d'Aosta/Vallée d'Aoste
	FR25	Basse-Normandie	**FR51**	Pays de la Loire	**ITC4**	Lombardia
	FR41	Lorraine	**FR52**	Bretagne	**ITH1**	Provincia Autonoma di Bolzano/Bozen
	FR53	Poitou-Charentes	**FR62**	Midi-Pyrénées	**ITH2**	Provincia Autonoma di Trento
	FR81	Languedoc-Roussillon	**FR63**	Limousin	**ITH3**	Veneto
	ITF2	Molise	**FR71**	Rhône-Alpes	**ITH4**	Friuli-Venezia Giulia
	ITG2	Sardegna	**FR72**	Auvergne	**ITH5**	Emilia-Romagna
	NO06	Trøndelag	**FR82**	Provence-Alpes-Côte d'Azur	**ITI2**	Umbria
	SE12	Östra Mellansverige	**FR83**	Corse	**ITI4**	Lazio
	SE21	Småland med öarna	**ITC3**	Liguria	**NL12**	Friesland (NL)
	SE22	Sydsverige	**ITF1**	Abruzzo	**NL13**	Drenthe
	SE23	Västsverige	**ITF3**	Campania	**NO01**	Oslo og Akershus
	SE33	Övre Norrland	**ITF4**	Puglia	**NO03**	Sør-Østlandet
	UKI3	Inner London – West	**ITF5**	Basilicata	**NO05**	Vestlandet
	UKI4	Inner London – East	**ITF6**	Calabria		
	UKI7	Outer London – West and North West	**ITG1**	Sicilia		
	UKN0	Northern Ireland	**ITI1**	Toscana		
			ITI3	Marche		
			NL11	Groningen		
			NL21	Overijssel		
			NL22	Gelderland		
			NL23	Flevoland		
			NL31	Utrecht		
			NL32	Noord-Holland		
			NL33	Zuid-Holland		
			NL34	Zeeland		
			NL41	Noord-Brabant		
			NL42	Limburg (NL)		
			NO04	Agder og Rogaland		
			NO07	Nord-Norge		
			SE11	Stockholm		
			SE31	Norra Mellansverige		
			SE32	Mellersta Norrland		
			UKI5	Outer London – East and North East		
			UKI6	Outer London – South		
			UKL1	West Wales and The Valleys		
			UKL2	East Wales		
Low RAI score	**CZ01**	Praha	**BG33**	Североизточен (Severoiztochen)	**BG31**	Северозападен (Severozapaden)
	CZ04	Severozápad	**CZ02**	Střední Čechy	**BG32**	Северен централен (Severen tsentralen)
	CZ07	Střední Morava	**CZ03**	Jihozápad	**BG34**	Югоизточен (Yugoiz-tochen)
	DK03	Syddanmark	**CZ05**	Severovýchod	**BG41**	Югозападен (Yugo-zapaden)
	EL41	Βόρειο Αιγαίο (Voreio Aigaio)	**CZ06**	Jihovýchod	**BG42**	Южен централен (Yuzhen tsentralen)
	EL42	Νότιο Αιγαίο (Notio Aigaio)	**CZ08**	Moravskoslezsko	**DK02**	Sjælland
	EL43	Κρήτη (Kriti)	**DK01**	Hovedstaden	**FI19**	Länsi-Suomi
	EL51	Ανατολική Μακεδονία, Θράκη (Anatoliki Makedonia, Thraki)	**DK04**	Midtjylland	**FI1B**	Helsinki-Uusimaa
	EL54	Ήπειρος (Ipeiros)	**DK05**	Nordjylland	**FI1C**	Etelä-Suomi
	EL64	Στερεά Ελλάδα (Sterea Ellada)	**EL52**	Κεντρική Μακεδονία (Kentriki Makedonia)	**FI1D**	Pohjois- ja Itä-Suomi
	EL65	Πελοπόννησος (Pelo-ponnisos)	**EL53**	Δυτική Μακεδονία (Dytiki Makedonia)	**HU10**	Közép-Magyarország
	IE01	Border, Midland and Western	**EL61**	Θεσσαλία (Thessalia)	**HU23**	Dél-Dunántúl
	IE02	Southern and Eastern	**EL62**	Ιόνια Νησιά (Ionia Nisia)	**HU31**	Észak-Magyarország
	LU00	Luxembourg	**EL63**	Δυτική Ελλάδα (Dytiki Ellada)	**HU32**	Észak-Alföld
	PT11	Norte	**HU21**	Közép-Dunántúl	**HU33**	Dél-Alföld
	PT15	Algarve	**HU22**	Nyugat-Dunántúl	**IS00**	Iceland
			PT17	Área Metropolitana de Lisboa	**LT00**	Lietuva
					LV00	Latvija

Good Progress Score		Medium Progress Score		Poor Progress Score	
PT16	Centro (PT)	**PT18**	Alentejo	**PL11**	Łódzkie
SK02	Západné Slovensko	**SI03**	Vzhodna Slovenija	**PL12**	Mazowieckie
SK03	Stredné Slovensko	**SI04**	Zahodna Slovenija	**PL21**	Małopolskie
SK04	Východné Slovensko	**UKC1**	Tees Valley and Durham	**PL22**	Śląskie
UKD3	Greater Manchester	**UKC2**	Northumberland and Tyne and Wear	**PL31**	Lubelskie
UKH1	East Anglia	**UKD1**	Cumbria	**PL32**	Podkarpackie
UKJ2	Surrey, East and West Sussex	**UKD4**	Lancashire	**PL33**	Świętokrzyskie
		UKD6	Cheshire	**PL34**	Podlaskie
		UKE1	East Yorkshire and Northern Lincolnshire	**PL41**	Wielkopolskie
		UKE2	North Yorkshire	**PL42**	Zachodniopomorskie
		UKE3	South Yorkshire	**PL43**	Lubuskie
		UKF1	Derbyshire and Nottinghamshire	**PL51**	Dolnośląskie
		UKF2	Leicestershire, Rutland and Northamptonshire	**PL52**	Opolskie
		UKF3	Lincolnshire	**PL61**	Kujawsko-pomorskie
		UKH2	Bedfordshire and Hertfordshire	**PL62**	Warmińsko-mazurskie
		UKH3	Essex	**PL63**	Pomorskie
		UKJ3	Hampshire and Isle of Wight	**RO11**	Nord-Vest
		UKJ4	Kent	**RO12**	Centru
		UKK4	Devon	**RO21**	Nord-Est
				RO22	Sud-Est
				RO31	Sud – Muntenia
				RO32	Bucureşti – Ilfov
				RO41	Sud-Vest Oltenia
				RO42	Vest
				SK01	Bratislavský kraj
				UKD7	Merseyside
				UKE4	West Yorkshire
				UKG1	Herefordshire, Worcestershire and Warwickshire
				UKG2	Shropshire and Staffordshire
				UKG3	West Midlands
				UKJ1	Berkshire, Buckinghamshire and Oxfordshire
				UKK1	Gloucestershire, Wiltshire and Bristol/Bath area
				UKK2	Dorset and Somerset
				UKK3	Cornwall and Isles of Scilly

ESPON 2020 – More information

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