GREECO
Territorial Potentials for a Greener Economy

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This basic report exists only in an electronic version.

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1. Assessing regional green economic performance

The analysis of the regional green economic performance aims to shed light on how the regions in Europe are doing from a green economic perspective. The analysis is based on GREECO's conceptualisation and operationalisation of the green economy and the indicator definition and collection. The objective of the analysis was to provide a quantitative profile of green economy at the regional level in Europe, i.e. it was attempted to give an answer to the question on how far we have already progressed towards a green economy in different parts of Europe. However, this objective can only be partly achieved due to fragmentation, gaps or non-availability of the necessary data as explained elsewhere in the report.

Basic approach

The analysis of green economy regional performance is based on two different but interrelated strands of research within GREECO, a bottom-up approach and a top-down approach.

- The bottom-up approach is built on the GREECO analyses of economic sectors. For each of the sectors under study, one key indicator has been selected at the end of the sector analysis task. The main requirements for those indicators are that they have a certain representativeness for the sector and that they are available at regional level.
- The top-down approach is more comprehensive across individual sectors. This part of the performance analysis is based on the "Core features of the green economy" as classified in Section 3.3. For each of the core features, environment, society, diverse territories, the economy and its production and consumption aspects and the econosphere, quantitative profiles of green economic performance are given.

The different indicators in the two strands of analysis are presented and analysed one by one, i.e. the green economy regional performance is analysed by economic sector in the first part and by green economy core features in the second.

Different approaches have been explored to aggregate from individual indicators to more abstract levels of analysis. A mulitcriteria evaluation based technique has turned out to be most suitable for the aggregation of individual indicators. The output from this step is a tentative assessment of regional green economic performance across Europe. Finally, the GE performance indicators have been related to non-GE indicators. Green economic performance is compared with the overall regional economic performance.

One of the theoretical aspects when considering the question of the regional level of the green economic performance is whether there is a knowledge gain when going down to lower spatial levels with the analysis. Probably, many aspects of the green economy would get already a value added in spatial terms, if NUTS-1 or even NUTS-0 data would be analysed. The topic of the green economy is so immature in every respect that an analysis at such aggregate spatial levels would bring huge new knowledge in spatial terms. This is supported by the fact that policies fostering the green economy are developed very often at national level or depending on the level of subsidiarity in different countries at NUTS-1 level, but not below.

However, more spatial detail is requested in ESPON and probably necessary for many aspects of the green economic performance. GREECO tries to go as deep as feasible in spatial terms. In GREECO, the analysis is first done at the spatial levels at which the data is available. This ranges from NUTS-0 down to NUTS-3. Only for the assessment of the regional green economic performance, data were transferred to a common territorial reference framework, i.e. NUTS-2. This harmonisation includes also the most simple form of data disaggregation, i.e. the use of NUTS-0 or NUTS-1 data (shares, indices etc.) at NUTS-2 level thus simply assuming that there is no spatial variation. harmonised .

From green economy concept to performance indicators

The analytical concept of GREECO to deal with the green economy is laid down in Section 3.3 of this report. The task of measuring regional green economic performance is closely related to the state of the core features of the green economy, namely the environmental sphere, the social sphere, the territorial sphere, the economic sphere and the econosphere. This section first reviews existing concepts from international sources in which an explicit indicator system for measuring the green economy was developed. It than proposes a set of headline indicators by which GREECO addresses the question of regional green economic performance.

Existing concepts to measure the Green Economy

The OECD (2011b) has proposed a concept for measuring the progress towards green growth which closely follows their working definition (see also Section 3.1): "Green growth is about fostering economic growth and development while ensuring that the natural assets continue to provide the resources and environmental services on which our well-being relies. To do this it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities." (OECD 2011b, p.16). The indicator system is considered as being pragmatic: "green growth indicators are seen as markers or milestones on a path of greening growth and of seizing new economic opportunities" (ibid.)

The indicator system is besides some background indicators organised in four main themes (in italic) reflecting the elements of the working definition of green economy:

- *Environmental and resource productivity:* CO_2 productivity, energy productivity, material productivity, water productivity, multi-factor productivity,
- *Natural asset base:* freshwater resources, forest resources, fish resources, mineral resources, land resources, soil resources, wildlife resources,
- *Environmental quality of life:* environmentally induced health problems and related costs, exposure to natural or industrial risks and related economic losses, access to sewage treatment and drinking water,
- *Economic opportunities and policy responses:* R&D of importance to GG, patents of importance to GG, environmental related innovation, production of environmental goods and services, international financial flows of importance to GG, environmentally related taxation, energy pricing, water pricing and cost recovery.

UNEP (2012) in a recent working paper has proposed an indicator system for measuring progress towards a green economy by closely following their definition of green economy that has to deliver improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities (see also Section 3.1). Based on UNEP's view that green economy is not as a goal as such but as a tool to achieve sustainable development and poverty reduction, the proposed indicator system is only partly focussed on the state of the green economy which is of interest here, but mostly on how green economy as an approach is applied in policymaking processes. However, the proposed indicator lists have the character of illustrative examples rather than that of a fixed indicator system.

For the environment, the following issues (in italic) and related indicators are given:

- *Climate change:* carbon emissions, renewable energy share, energy consumption per capita,
- *Ecosystem management:* forestland, water stress, land and maritime conservation area,
- *Resource efficiency:* energy productivity, material productivity, water productivity, CO_2 productivity,
- *Chemicals and waste management:* waste collection, waste recycling and reuse, waste generation or landfill area.

For policy interventions the following policies (in italic) and related indicators are given:

- *Green investment:* R&D investment, EGGS investment,
- *Fiscal reform:* Fossil fuel, water and fishery subsidies, fossil fuel taxation, renewable

energy incentive,

- *Pricing:* Carbon price: value of biodiversity, value of ecosystem services,
- *Green procurement:* expenditure in sustainable procurement, CO_2 and material productivity of government operations,
- *Training:* training expenditure, number of people trained.

Finally, indicators for issues (in italic) of well-being and equity are given:

- *Employment:* construction, operation and management, Gini coefficient,
- *EGSS performance:* value added, employment, CO_2 and material productivity,
- *Total wealth:* Value of natural resource stocks, net annual value addition/removed, literacy rate,
- *Access to resources:* access to modern energy, access to water, access to sanitation, access to health car,
- *Health:* number of people hospitalised due to air pollution, road traffic fatalities.

A somewhat different approach has been introduced by the Directorate General for Economic and Financial Affairs (ECFIN) of the European Commission. The iGrowGreen assessment framework is set up to "systematically compares EU Member States' environmental performance with macroeconomic and fiscal implications across 4 green policy domains and 9 policy areas, taking account of performance in levels and changes for more than 70 indicators" (ECFIN – GD Economic and Financial Affairs of the European Commission 2012). iGrowGreen contains quantitative scores for the 27 Member States, together with the underlying data and computations. It covers four domains, each reflecting a key link from environmental performance to macroeconomic and fiscal considerations:

- *Environmental tax reforms and fiscal consolidation:* indicators on the revenues side and the expenditure side,
- *Strengthening market functioning and competitiveness:* indicators on clean and efficient energy sector, sustainable use of resources, markets for green products,
- *Boosting new sources of growth:* indicators on green human capital and green technological progress
- *Climate change and biodiversity:* indicators on climate change and biodiversity.

The difference to the other indicator systems is that in iGrowGreen not only the individual indicators can be used, but that the main feature is the option to get one synthetic score per country for each of the four topics above. The weighting system is made transparent for the user.

Green economy regional performance measuring via headline indicators

The conclusions from the three examples on green economy or green growth indicator systems developed by international organisations are

- that indicator systems on green economy have to have a close relationship to the theoretical conceptualisation they are embedded in;
- that an indicator system on green economy should be organised in a hierarchical way, i.e. with major topics supported by headline indicators and a wider set of indicators in the background;
- that the indicator systems should deal with a wider range of topics than with the economy in a narrow sense only by addressing also aspects such as human well-being, environmental aspects and in particular all kinds of resource efficiency;
- that it is reasonable to work with indicators on green economy side by side, but also that it might be meaningful to aggregate indicators to synthetic indices;
- that none of the indicator systems explicitly addresses territorial differentiation and that none of the indicator systems goes spatially below the country level.

Against this background, the indicator system for measuring the regional green economic performance in GREECO is closely related to the conceptual base of the project. On the one hand, there is a strand of indicators for green economy directly derived from the bottom-up approach, i.e. the sectoral analysis. The second set of indicators is more comprehensive, i.e. does not necessarily address individual economic sectors, and is strictly derived from the core features of green economy as developed in Section 3.3.

Along these lines, both indicator sets on regional green economic performance of GREECO are organised along major topics which are either the economic sectors or the green economy core features. The economic sectors are each represented by one headline indicator. The green economy core features are decomposed each in some components which are represented by selected headline indicators and which again might be backed up by a series of corresponding indicators.

Table 1 presents the headline indicators for the bottom-up derived regional performance indicator set, i.e. the economic sectors analysed in GREECO. The headline indicators were proposed by the authors of the sectoral studies.

Economic Sector	Headline indicator
Agriculture	Organic area
Building and construction	Energy consumption in residential buildings
Energy production	Renewable energy
Green research and eco-innovation	Eco-innovation scoreboard
Manufacturing	Environmental protection expenditure
Tourism	Tourist overnight stay density
Transport	Motorisation rate
Waste management	Waste recycling
Water management	Waste water treatment

Table 1 Headline indicators for regional green economic performance of economic sectors

The indicators for the regional green economic performance based on the core features of the green economy are organised along the five core features defined in Section 3.3. Table 2 below lists the core features, their components and headline indicators.

- For the *environmental sphere*, the source function and the sink function are the two main components to be addressed. The first headline indicator is a comprehensive indicator developed by the EEA on environmental and natural assets, which describes what the current performance of the environment is in terms of availability of open space, biodiversity etc. The second headline indicator reflects how much the sink function of the environment is being exploited, an indicator of air pollution is used for this.
- For the *social sphere*, first the readiness of the society will be addressed by its willingness to adapt to a “greener way of living”. One ideal headline indicator would be the subscription rate of households to renewable energy. The second indicator reflects the impact of the economy on the well-being of population; life expectancy is used as a proxy for health. The third topic, environmental risk, can be expressed by the exposure of population to environmental risks such as air pollution.
- For the *territorial sphere*, the concept of territorial keys developed in the background document of the Polish Presidency (Böhme et al. 2011) are used. One important territorial key for green economy is "Territorial capacities/endowment assets" for

which one of the indicators of the document referred to above can be directly used, i.e. renewable energy production. A second indicator on land take per GDP unit can be seen as a proxy for the "Wise management of cultural and natural assets" or, more generally, as a proxy of “Spatial efficiency”.

- For the *economic sphere*, GREECO's intention was to address the “greenness of economic activities” as far as possible. How far green technology is being developed by the regional economies is reflected in the number of green patents submitted to the European Patent Office (EPO). This indicator can also be considered a green economy driver, as it is strongly related to the green technological development of a given region and thus with its future capacity for green growth. How far economic activities can be considered as being green is reflected in the EGGS share of employment.
- The *econosphere* is covered by environmental and resource productivity indicators. Headline indicator is energy productivity.

Core feature of Green Economy	Component	Headline indicator
Environmental sphere	Source function	Environmental and natural assets (EEA)
	Sink function	Emission of air pollutants
Social sphere	Health	Life expectancy
	Environmental risk	Exposure to air pollution
Territorial sphere	Territorial capacity	Renewable energy production
	Spatial efficiency	Land take per GDP unit
Economic sphere	Green technology	Green patents
	Green labour	Green jobs (EGGS)
Econosphere	Energy productivity	GDP per energy unit

Table 2 Headline indicators for regional green economic performance of core features of green economy

The presentation and analysis of the green economy regional performance indicators as outlined above gives a comprehensive picture on Europe, its countries and its regions. This comprehensive picture allows depicting several aspects of green economy for different economic sectors and for the core features of green economy as defined in the GREECO concept. This is a value as such as is allows to illustrate which regions are strong or weak in what aspect. However, this GE regional performance picture is not a single picture but a picture with numerous components, i.e. a set of individual pictures. A direct assessment of the overall GE performance of regions is not possible based on such a range of individual indicators. Therefore, different indicators were aggregated by multicriteria analysis techniques. This aggregation has first been done to the five core features of the green economy defined in GREECO and eventually to one single indicator of regional green economic performance of European regions. It has to be stated that this is a very explorative task based on limited availability of appropriate data, i.e. the results can only be interpreted as a first tentative assessment of regional green economic performance.

Headline indicators for regional green economic performance of economic sectors

This section presents for each economic sector analysed in GREECO one headline indicator representing the regional green economic performance of that sector. The headline indicators were proposed by the authors of the sector studies.

Agriculture

The headline indicator is the share of the total utilised agricultural area (UAA) under organic farming (see Figure 1). This share was 3.7 % of UAA of EU-15 in 2002, up from only 1.8 % in 1998. In 2008 the share increased to 4.3%. Organic production accounted for 2 % of EU-15 total production of milk and beef in 2001, but less than 1 % of total production of cereals and potatoes. From the report “An analysis of the EU organic sector” it is evident that the organic sector is developing at a fast pace in the EU. At farm level the rates of growth are rather impressive. Areas have increased by 6.5% per year on average in the EU-27 in the period 2000-2008, animal numbers have increased by the range of 6.1- 22.2% annually in the EU-15 depending on species groups. And in 2008 the organic sector represents a total area of 7.7 million ha with almost 190 000 farms. Italy has been for a long period the Member State with the largest organic area, exceeding one million ha since the beginning of the 2000s. However it is out performed by Spain in 2008 which reached an impressive 1.1 million ha. Some of the "pioneers" in the sector such as Denmark, Finland, Sweden and Italy seem to have reached a plateau or display only slow growth. Among Southern EU, Greece, Spain and Portugal which have grown fast in the last years.

Looking at the share of organic production in each country gives another picture of which countries are developing this type of farming. In countries such as Switzerland, Austria Finland, Italy, Denmark and Sweden the share of organic land area is between 6 and 10%. As a contrast in countries growing fast and showing a large amount of hectares, there is still only a low share of land devoted to organic farming; e.g. in Spain (2.4%) and France (1.8%). In large agricultural countries like Greece and Poland the share of certified organic production was only 0.4% in 2004, showing a great potential to increase in the coming years. This has taken place in Greece, where in many regions the share is now up to 5-10%. In Poland the picture is the same as in 2004 with many regions still below a share of 1%. In many regions in Germany and Austria, the share is clearly above 10%.

Building and construction

The headline indicator for the building and construction sector is the energy consumption in residential buildings. Given the high correlation between total residential energy consumption and population density, coupled with the lack of correlation between regional population density and per capita energy consumption, a simple but effective indicator of regional performance of the sector has been developed. Figure 2 shows totals for regional energy consumption of building based on national data on per capita energy consumption, which has been corrected for temperature variation and regionalized based on NUTS 2 regional population density. By default, this implies that agglomerations perform worse than their peripheral neighbors, simply because they have more people consuming energy in a greater number of buildings. Yet national trends are still apparent - for instance, countries with high overall consumption (i.e. Luxembourg, Germany, the Baltic States, etc.) are emphasized, but we also identify good performers. For example, Belgium and The Netherlands perform much better than their neighbors Luxembourg, The U.K., Germany and France.

In addition to the national variations, Figure 3 shows that there can be substantial differences in regional performance within countries as well. For example, apart from Bulgaria and Italy at the low and high ends, we see an average difference of 45% between per capita residential energy consumption in the lowest region and highest regions.

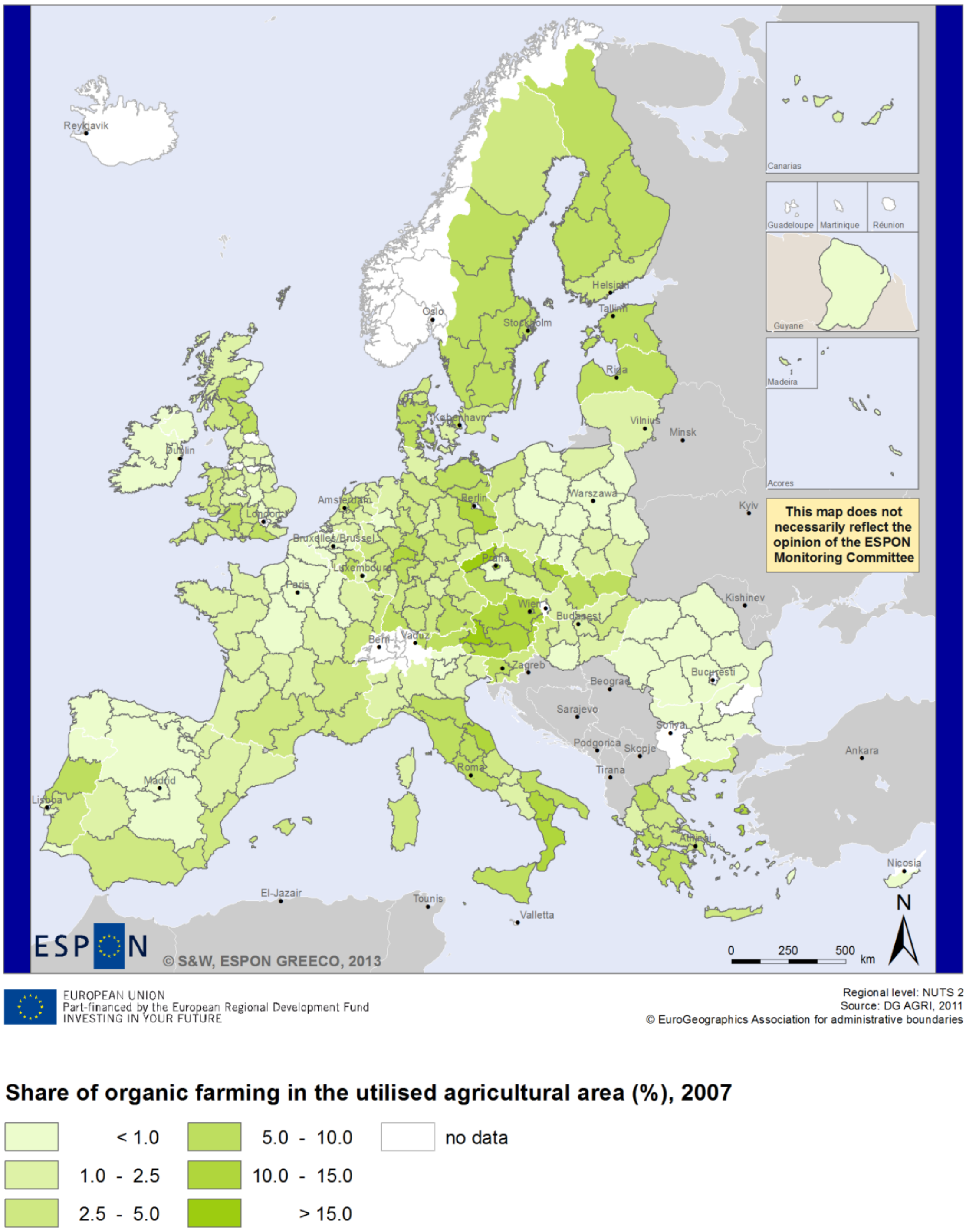


Figure 1. Share of organic farming in total utilised agricultural area in 2007 (Source: DG AGRI, 2011).

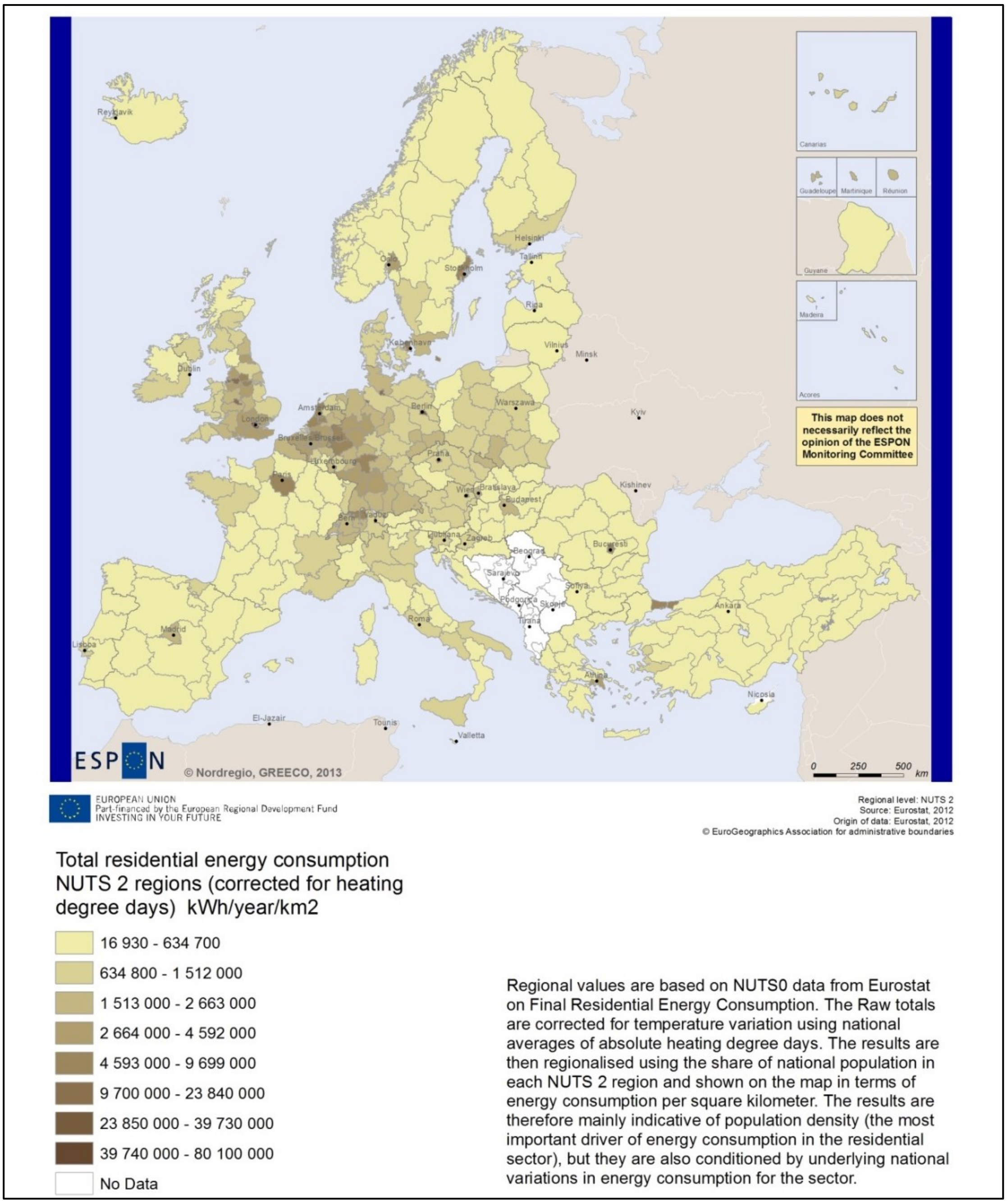


Figure 2. **T**otal energy consumption in residential buildings corrected to temperature variations (Source: GREECO Building and Construction Sector Study).

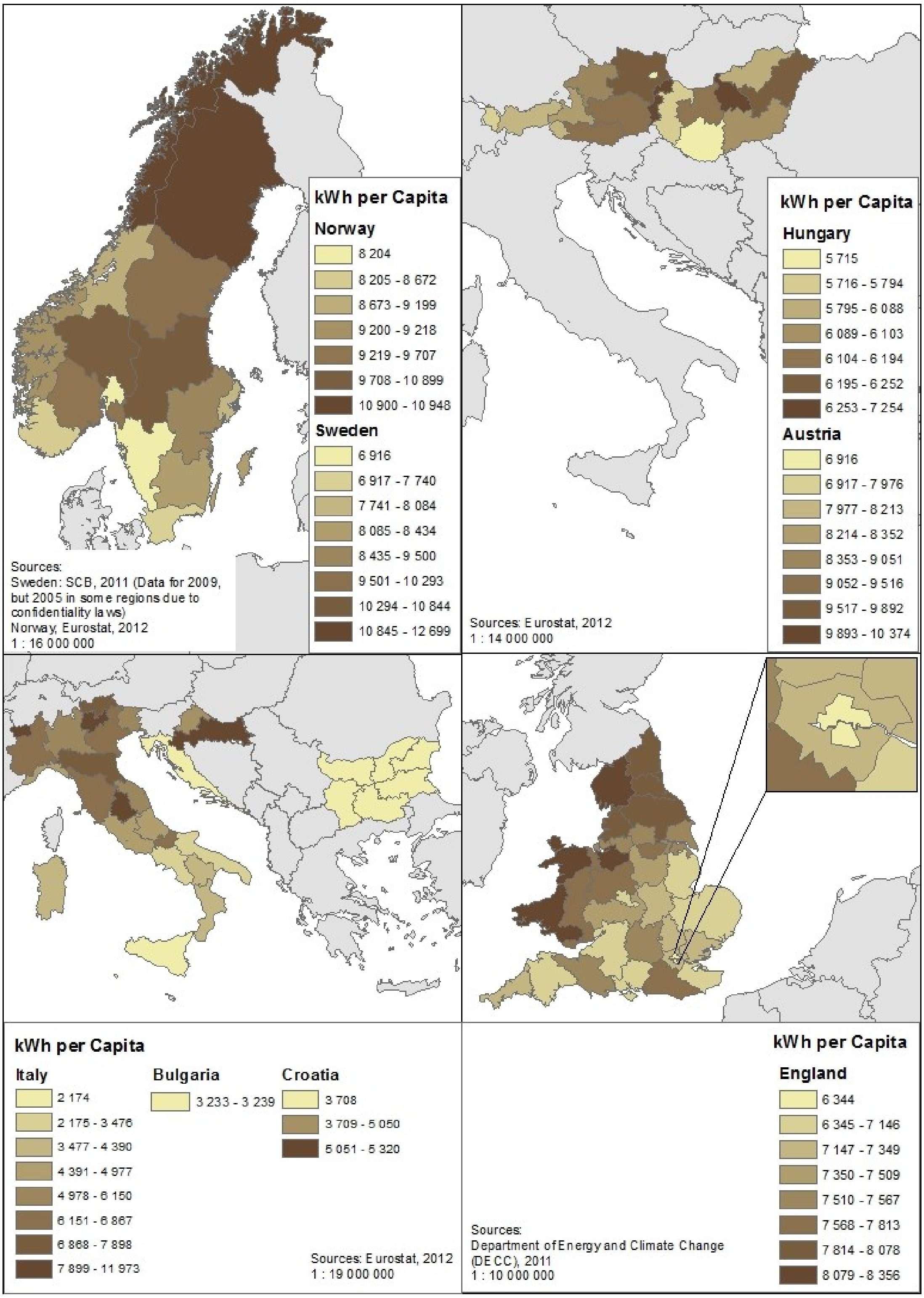


Figure 3. Energy consumption per capita in residential buildings 2009 (Source: GREECO Building and Construction Sector Study).

Energy production

The headline indicator for the energy sector is the amount of renewable energy produced. Figure 4 shows the share of renewable energy in gross final energy consumption for the EU member states. The figure clearly depicts the huge differences ranging from almost no current importance of renewable energies in countries such as the UK, the Netherlands or Belgium up to countries such as the Nordic countries, Latvia and Austria in which the share of renewable energy is already more than one third or even up to almost two thirds of final energy consumption.

The information in the figure provides also some indication of the progress towards the 2020 targets – showing countries such as Sweden, Estonia and Romania as seeming to be close to their targets while other countries have a long way to go. However, this very overarching view can be misleading. The recently published Renewable energy progress report COM(2013) 175 final is a key component of Energy 2020 and the RES directive as it serves to benchmark progress as the MS level. It mentions that the 2010 renewable energy shares of 20 Member States and the EU as a whole were at the level of or above 2010 commitments set out in their national plans and above the first interim target for 2011/2012. This is also shown in Figure 5.

Green research and eco-innovation

The headline indicator selected for the green research and eco-innovation sector is the so-called Eco-innovation Scorebord (ECO-IS) which is developed by the Eco-Innovation Observatory (EIO) an EU funded platform aimed at collecting and analysing eco-innovation information, across the EU. The Eco-IS is the first and only tool to evaluate and show eco-innovation performance across the 27 EU Member States in a systematic way. Eco-IS via its composite Eco-innovation index demonstrates the eco-innovation performance of a country compared with the EU average and with the EU top performers. The Eco-IS captures different aspects of eco-innovation in order to provide a holistic view of economic, environmental and social performance and hence, identify strengths and weakness of EU countries. The aim is to compare relative performance of Member States in key areas (dimensions) related to eco-innovation, including investments, company performance and economic and environmental outcomes. The Eco-IS ranks regions in four groups according to national overall eco-innovation performance (see Figure 5):

- EU Leaders (e.g. the Nordic countries, Ireland, Germany, Belgium, Spain or Slovenia)
- Good EI achievers (the UK, France, the Netherlands, Portugal, Italy, Austria and the Czech Republic,
- Average EI performers (Baltic States and south-eastern European countries)
- Countries catching up in EI (e.g. Poland, Slovakia or Greece).

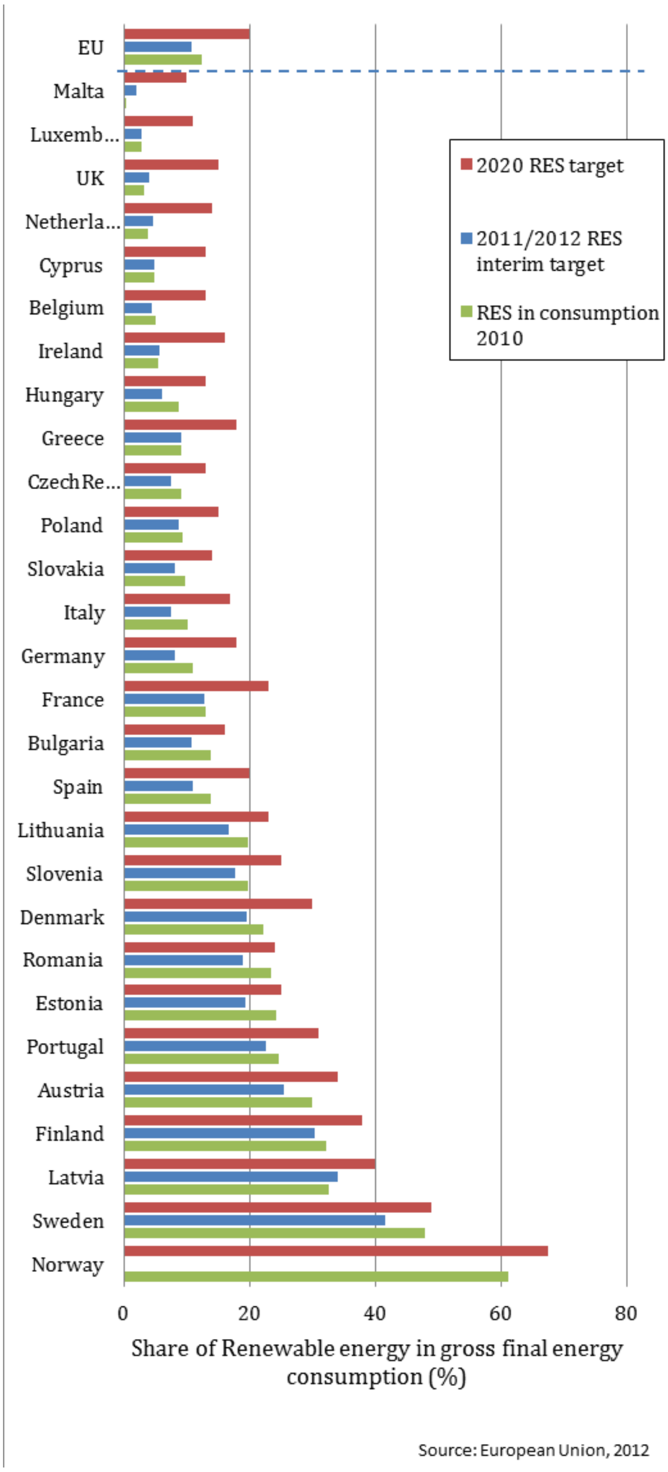


Figure 4. Share of Renewable Energy in final energy consumption,2010, compared to 2011/2012 interim targets and 2020 target for member states 2010 (Source: GREECO Energy Sector Study).

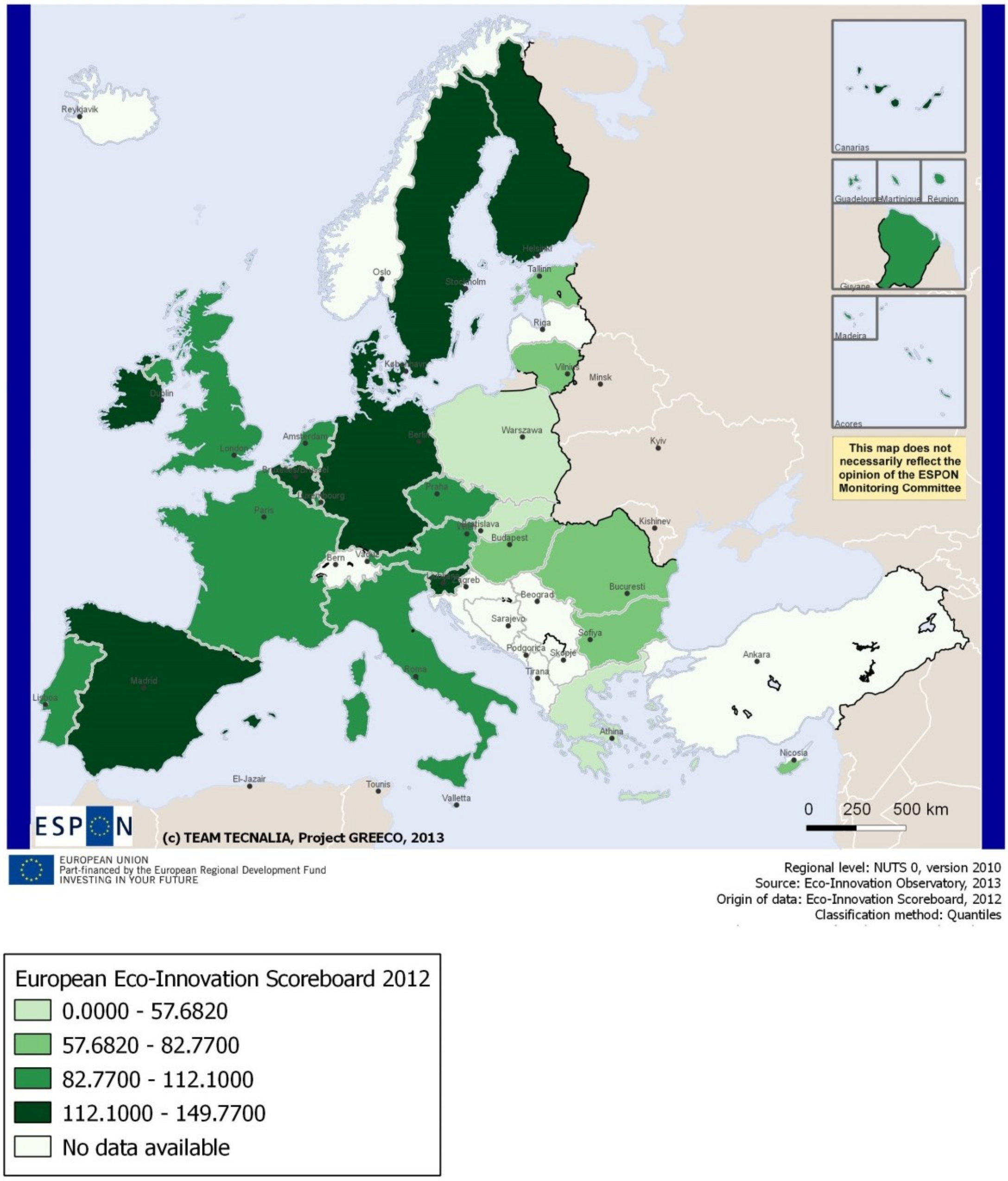
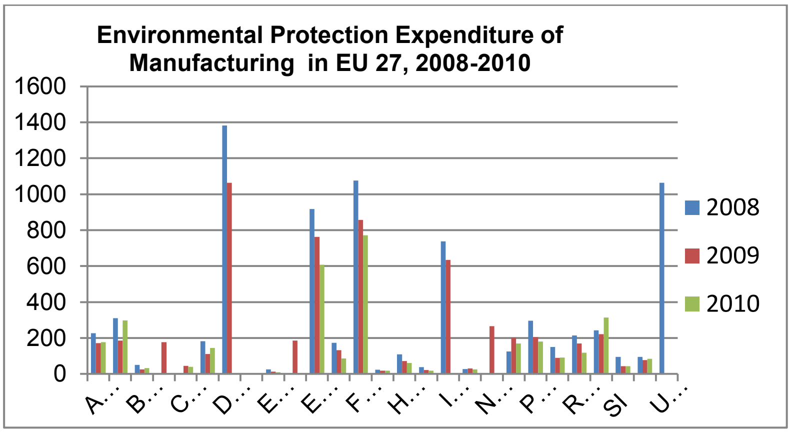


Figure 5. Overall eco-innovation performance in 2012. (*Source: GREECO Eco-Innovation Sector Study based on Eco-IS 2012).*

Manufacturing

The headline indicator chosen for the manufacturing sector is the environmental protection expenditure of that sector. Figure 6 shows data at national level; data at regional level are available only for very few countries (see Figure 7).



* 2010: Data gaps for CH, DE, DK, EL, IT, NL, UK

2009: Data gaps for DK, UK

2008: Data gaps for CH, EL, NL, BG, DK

Figure 6. Environmental protection expenditure of manufacturing sector, 2008-2010. *Source: GREECO Manufacturing Sector Study based on Eurostat data (sbs_env_dom_r2)*

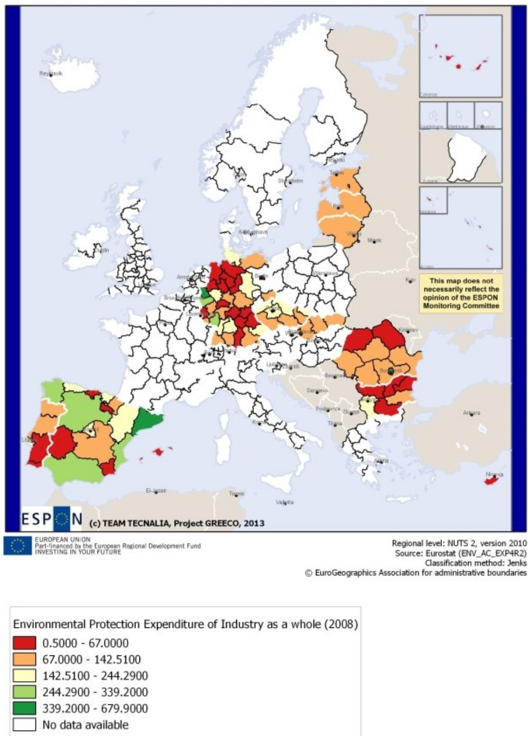


Figure 7. Environmental protection expenditure of industry as a whole in 2008. (*Source: GREECO Manufacturing Sector Study based on Eurostat ENV_AC_EXP4R2*)

Tourism

The headline indicator for the tourism sector is the tourist overnight stay density which reflects the tourism pressure on the European regions (Figure 8). Tourism is highly unevenly distributed across Europe. Tourism is concentrated in the Mediterranean regions, in the Alpine regions as well as along the Atlantic and North Sea coasts and in several capital cities. Many factors influence this pattern including accessibility, costs, and the attractiveness of the different regions. However, tourism is often concentrated even further locally below the NUTS 2 or 3 level shown in the map (e.g. along the coasts). As such the map only provides a general overview of high-pressure regions in a broad European context.

In a sustainability perspective, this spatial concentration of high number of tourists has economic, environmental and social impacts in the affected regions. The economic impacts include that tourism provides income and employment in the affected regions. Tourism causes a range of direct and indirect environmental impacts and is at the same time highly dependent on high environmental quality (e.g. bathing water qualities, availability of drinking water, clean air etc.). Generally, the impacts increase with the number of tourists in a region but also the treatment systems available play a significant role in reducing these environmental pressures and reducing the environmental “foot print” from tourism (as well as from local households). The social impacts of tourism are also diverse and both positive and negative. Generally, the impacts increase with the number of tourists in a region and is affected by the number of residents (and related infrastructure) to “absorb” the incoming tourist flows.

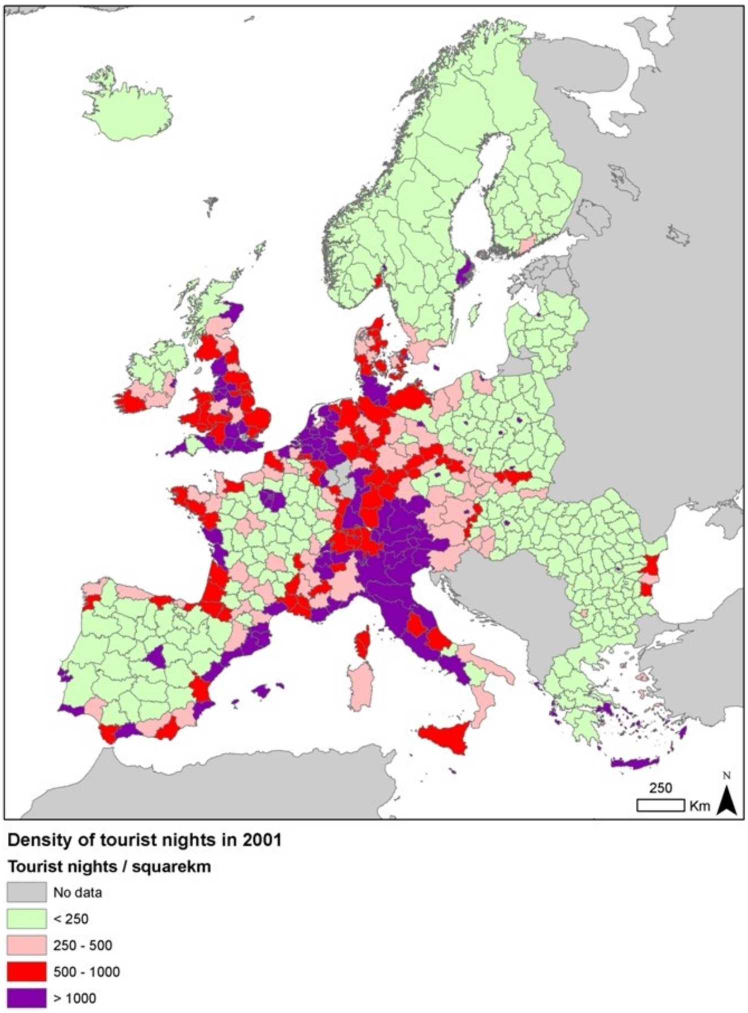


Figure 8: Tourists overnight stays per square kilometre in 2001 (Source: GREECO Tourism Sector Study).

Transport

The headline indicator for the transport sector is the motorisation rate (Figure 9). The amount of passenger cars reflects two different aspects of the greening of this sector. On the one hand high motorisation rate indicate often affluent societies that generate high demand for this economic sector. On the other hand, high motorisation rates might also be an indication for the lack of more environmental friendly transport options. Motorisation rates in 'Europe are highest in Italian and Austrian regions and lowest in south-eastern European regions.

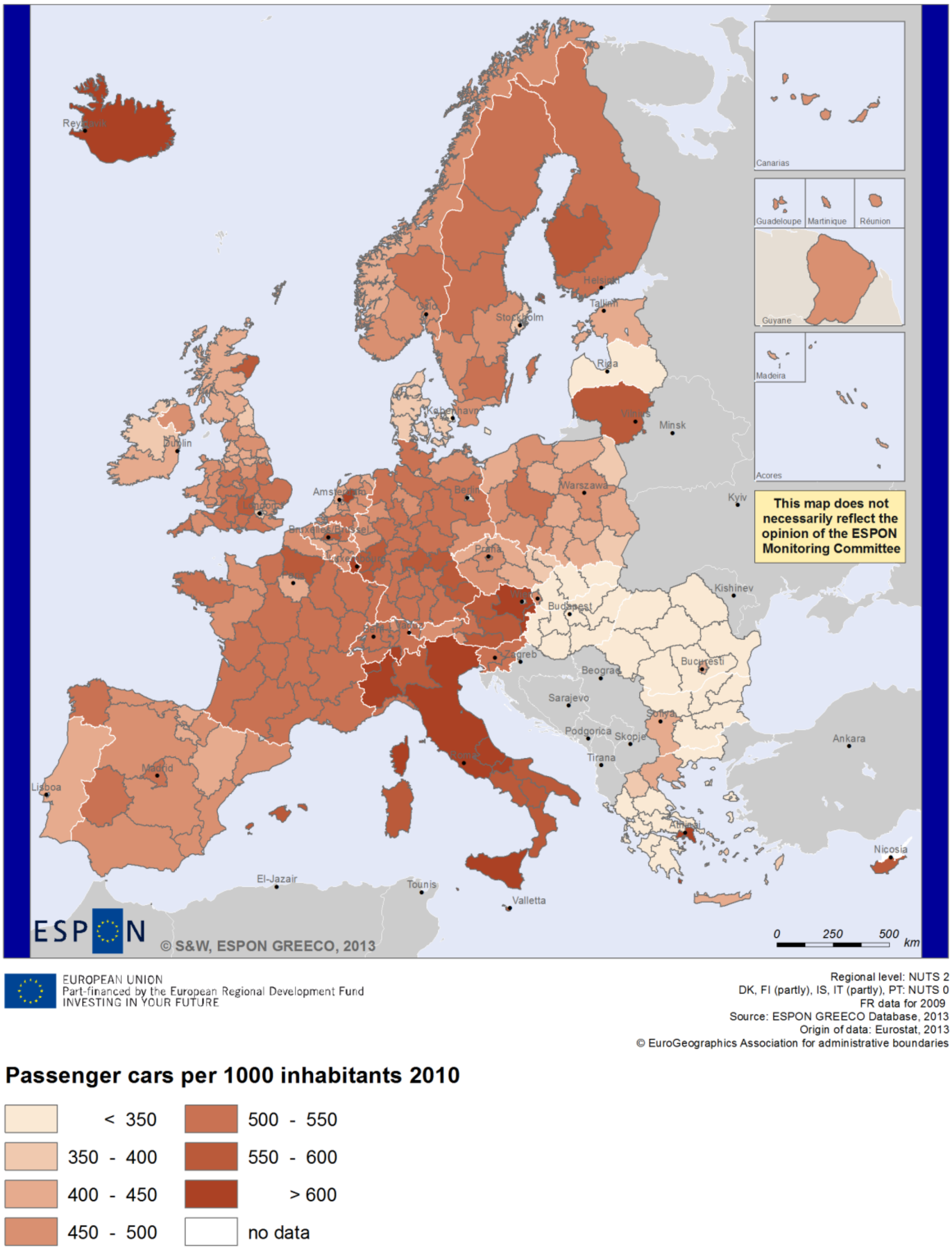


Figure 9. Motorisation rate 2010 (Source: GREECO Transport Sector Study).

Waste management

The headline indicator for the waste sector is the waste recycling ratio. After waste prevention recycling is the most preferred option in the waste hierarchy. Together with industrial ecology it is also the major direction of waste management. As waste prevention is extremely difficult to measure and monitor the level of recycling of different waste streams is the most relevant measure of the regional green performance in the waste sector. Recycling has been increasing through the years but still a small portion of our material consumption comes from recycled material. Depending on the material it is between 3% and 42%. Maximum waste recycling could cover between 6% and 61%. Figure 10 shows the huge differences between European regions in terms of municipal waste recycling rates ranging from almost no recycling at all in some eastern European countries up to recycling rates of almost 80 percent in countries such as the UK, Norway or Germany that have already a long-established waste recycling system.

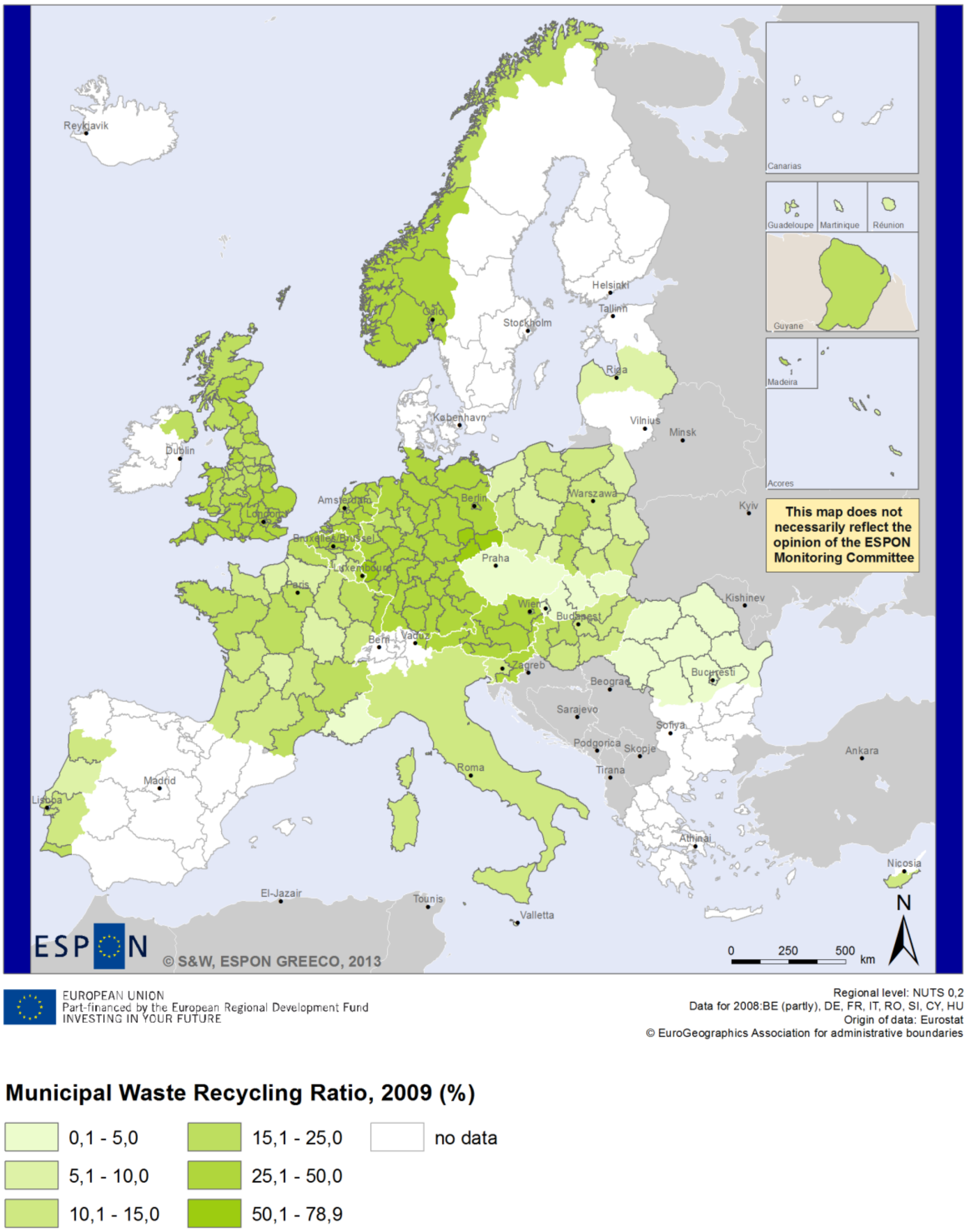


Figure 10. Municipal waste recycling ratio, 2009.

Water management

The headline indicator for the water sector is the degree of population connected to waste water treatment. Figure 11 shows the percentage of population connected to all types of urban waste water treatment at NUTS 2 level for some countries for which data exists and in the insert for NUTS 0 for a somewhat larger group of countries. In EU-15, the implementation of the Urban Wastewater Directive of the European Union is rather mixed. Significant investments have been made and key infrastructure is in place to a far extent. But there is still a number of agglomerations, for instance in Belgium, France, Greece, Italy and Spain, which completely lack waste water collecting systems and treatment facilities, although progress have been seen in latest years. Against this background it is however important to look at the amount of waste water that undergo at least secondary treatment. More than one third of the European countries for which data is available are connected to secondary waste water treatment.

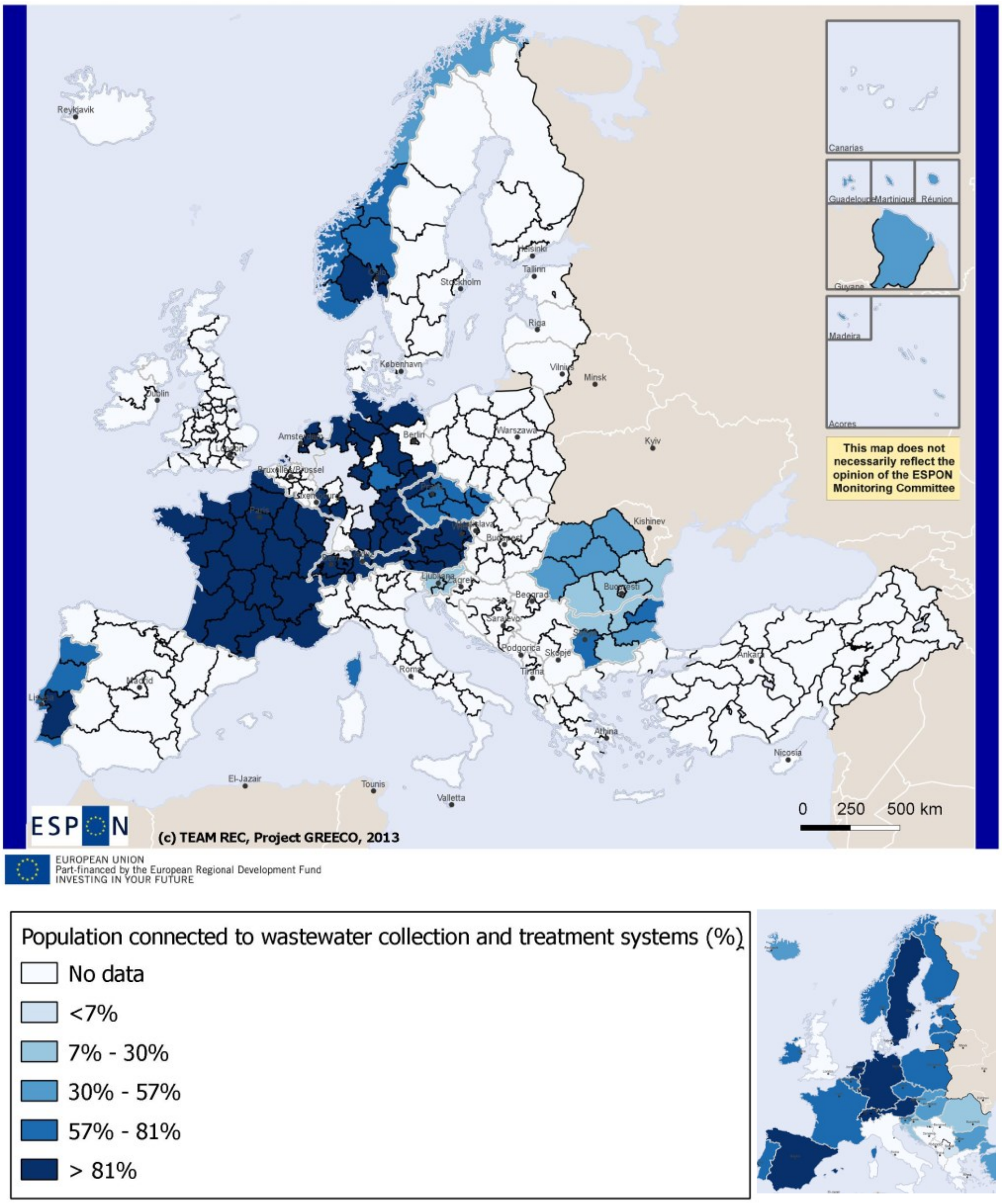


Figure 11. Population connected to wastewater collection and treatment systems 2010 (Source: GREECO Water Sector Study).

Headline indicators for regional green economic performance for core features of GE

This section presents the selected indicators for the five core features of the green economy as defined by GREECO.

Environmental sphere

For the environmental sphere, the source function and the sink function are the two main components to be addressed.

The first headline indicator is a comprehensive indicator developed by the EEA on environmental and natural assets, which describes what the current performance of the environment is in terms of availability of open space, biodiversity and other. The indicator is originally been calculated at raster cell level, Figure 12 shows an aggregation to NUTS 3 regions. Regions having the highest environmental and natural assets are located in the northern periphery (Finland, Sweden, Scotland), on islands (Crete, Sardegna, Corsica), in the Alps and in some coastal and non-coastal regions in Spain, Greece and the Baltic States. Regions with lowest assets are mostly the high-density urban agglomerations, their surroundings are mostly classified as second worst category.

The second headline indicator reflects how much the sink function of the environment is being exploited, an indicator of air pollution is used as a proxy for this. Figure 13 displays the density of NO_x emissions per km² which reflects mainly the density of residential and economic activities across Europe. A substantially different spatial pattern emerges if the emission is standardised by population (Figure 14). Now, the high-density areas perform much better, i.e. the emission per person is rather low, whereas rural regions and regions inbetween urban agglomerations have the highest emission rates per population.

Social sphere

For the social sphere, the headline indicator reflect the impact of the economy on the well-being of population; life expectancy is used as a proxy for health. the exposure of population to air pollution as an indication of environmental risks.

Figure 15 presents the life expectancy of males at birth in the year 2010 for NUTS 2 regions in Europe. Life expectancy has many causes, but can also be interpreted as an outcome of the regional health and economic conditions. A regional green economy would enable its population to live longer. However, as the map shows life expectancy is extremely different in European regions. Whereas regions in western Europe offer the highest life expectancy to their population, this dramatically goes down in regions of eastern Europe. Here, in some regions of Bulgaria, Romania or the Baltic States, life expectancy is more than ten years lower than in the best performing regions.

Environmental risks of the population expressed as exposure to air pollution is shown in Figures 16 and 17. The shares of regional population living in areas that exceeded O_3 and PM concentrations are used as demonstration indicators.

Territorial sphere

The concept of territorial keys (Böhme et al. 2011) is used for the territorial sphere. One important territorial key for green economy is "Territorial capacities/endowment assets" for which one of the indicators of the document referred to above can be directly used, i.e. renewable energy production. A second indicator on land take per GDP unit can be seen as a proxy for the "Wise management of cultural and natural assets" or, more generally, as a proxy of “Spatial efficiency”.

For Europe, information on renewable energy production is only available at country level (see Figure 18).

The economically efficient use of the territory is expressed as land take, i.e. artificial land use, per GDP (Figure 19). The regional variation ranges from less than 1 ha up to more than 5 ha artificial land per 1 million Euro GDP. High-density urban agglomerations in western Europa have lowest values meaning that relatively little settlement area is being used to produce the economic output. On the other hand, in more rural and peripheral areas in northern, eastern and south-western Europe, the amount of artificial land for the same amount of economic output is much higher, partly up to more than five-times higher.

Economic sphere

For the economic sphere, GREECO's intention was to address the “greenness of economic activities” as far as possible. As discussed elsewhere in the report, this was almost impossible due to the given data situation. However, some indication on regional differentiation in terms of the development of green technologies and on green jobs can be made, the latter only for one individual country.

How far green technology is being developed by the regional economies is reflected in the number of green patents submitted to the European Patent Office (EPO). This indicator can also be considered a green economy driver, as it is strongly related to the green technological development of a given region and thus with its future capacity for green growth. Figure 20 presents the number of green patents submitted in the decade 2001 to 2010. The map shows total numbers by region in order to highlight those areas in Europe with a high concentration of green economic innovation, namely the southern parts of the UK, Belgium and the Netherlands, Denmark and western Germany. There are also strong spatial clusters in northern Italy. Other green patent hotspots are the wider Paris and Lyon regions in France, Madrid and Barcelona, wider Gothenburg and Stockholm regions in Sweden and southern Finland. The number of green patents submitted from Portugal, other regions in Spain and France, from Greece and almost all eastern European countries is remarkably low. Figure 21 adds the information on the share of green patents of all patents in a region. It can be seen that the high-performing green patent areas are mostly also high-tech areas in general as the share of green patents is not remarkably high. However, some regions having lower numbers of green patents have a higher share in all patents meaning that green research might play a more important role for those regions.

The Environmental Goods and Service Statistics has not been developed as expected at the beginning of the project. Data is rather scare, even at the national level. However, a few countries have regionalized EGSS statistics. Figure 22 shows the share of green jobs (EGGS jobs) for NUTS-2 regions in Austria. It can be seen that in no Austrian region that share is beyond five percent of all jobs. However, it is remarkable that the lowest share is in Vienna, the capital and largest agglomeration of the country.

Econosphere

The econosphere links the environment with the economy. This is usually covered by environmental and resource productivity indicators. Headline indicator used here is energy productivity. Figure 23 shows the amount of economic output in terms of GVA being produced per unit of energy consumption. Apart from Norway for which the high energy productivity is based on the oil resources, the most productive areas are the high-density service oriented agglomerations (or countries in the case of Switzerland); Madrid, London, Paris, Rome or Stockholm have highest energy productivity. Less urbanised areas in western Europe, but also most regions in eastern Europe are producing much less economic output per energy unit. The gap between the most and the least efficient regions is enormous.

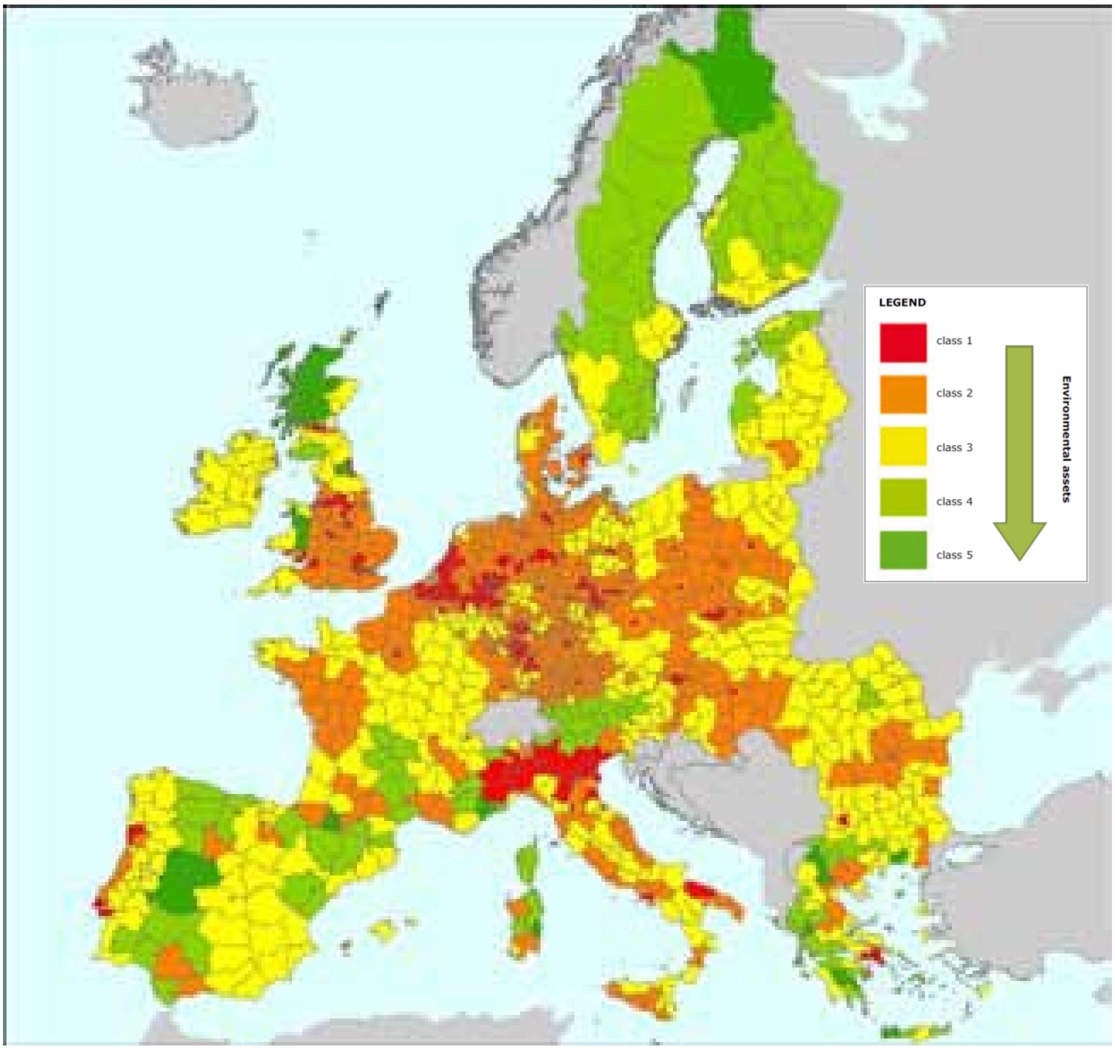
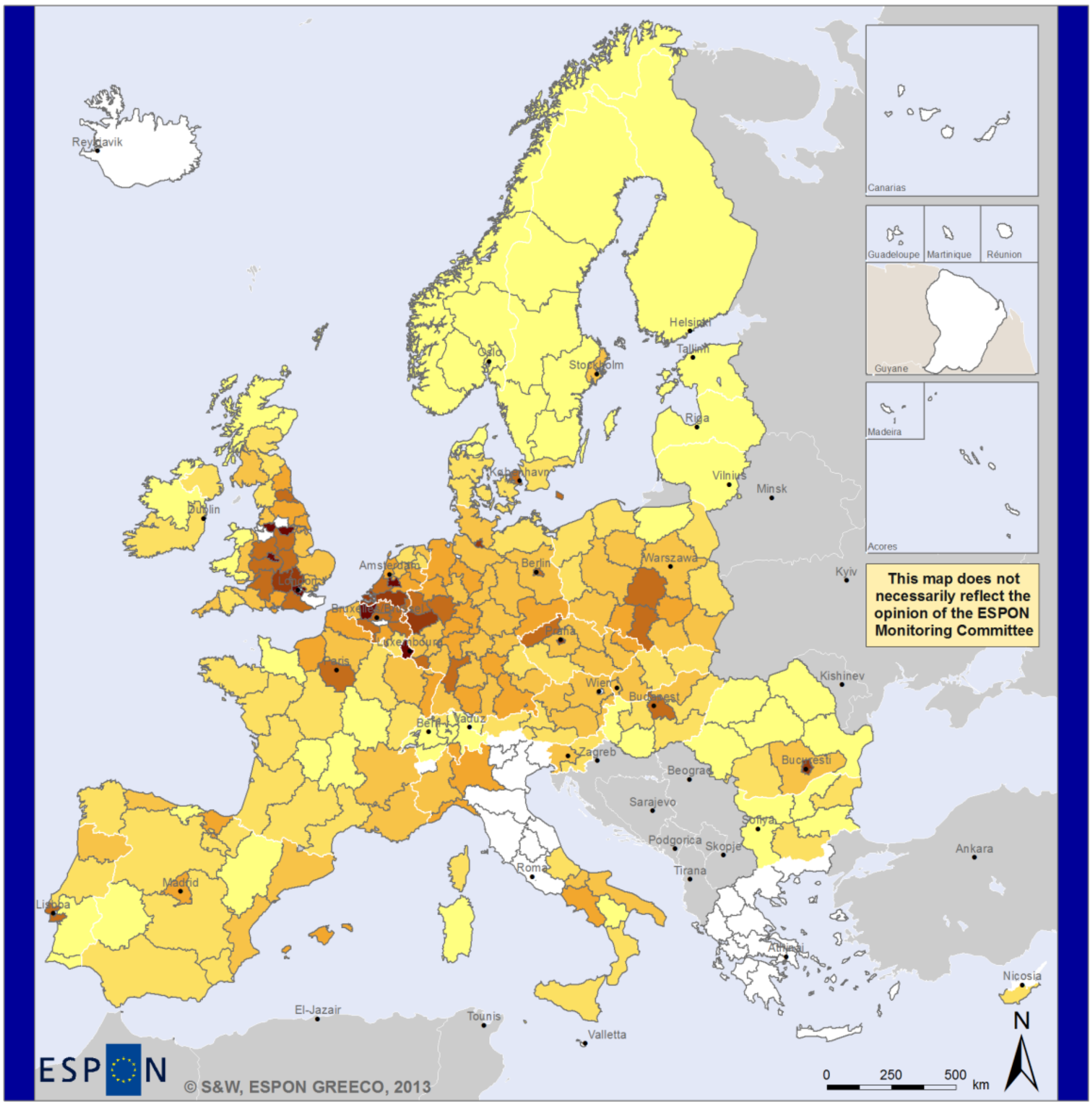


Figure 12. Environmental and natural assets (Source: EEA, 2010)



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Regional level: NUTS 2
NUTS 1: DE (partly), FI, NO (partly)
Source: GREECO database based on EMEP
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NO_x emission density 2010 (tons/sqkm)

< 1.0	5.0 - 10.0
1.0 - 2.0	10.0 - 15.0
2.0 - 3.5	> 15.0
3.5 - 5.0	no data

Figure 13. Air quality, NO_x emission density, 2010.

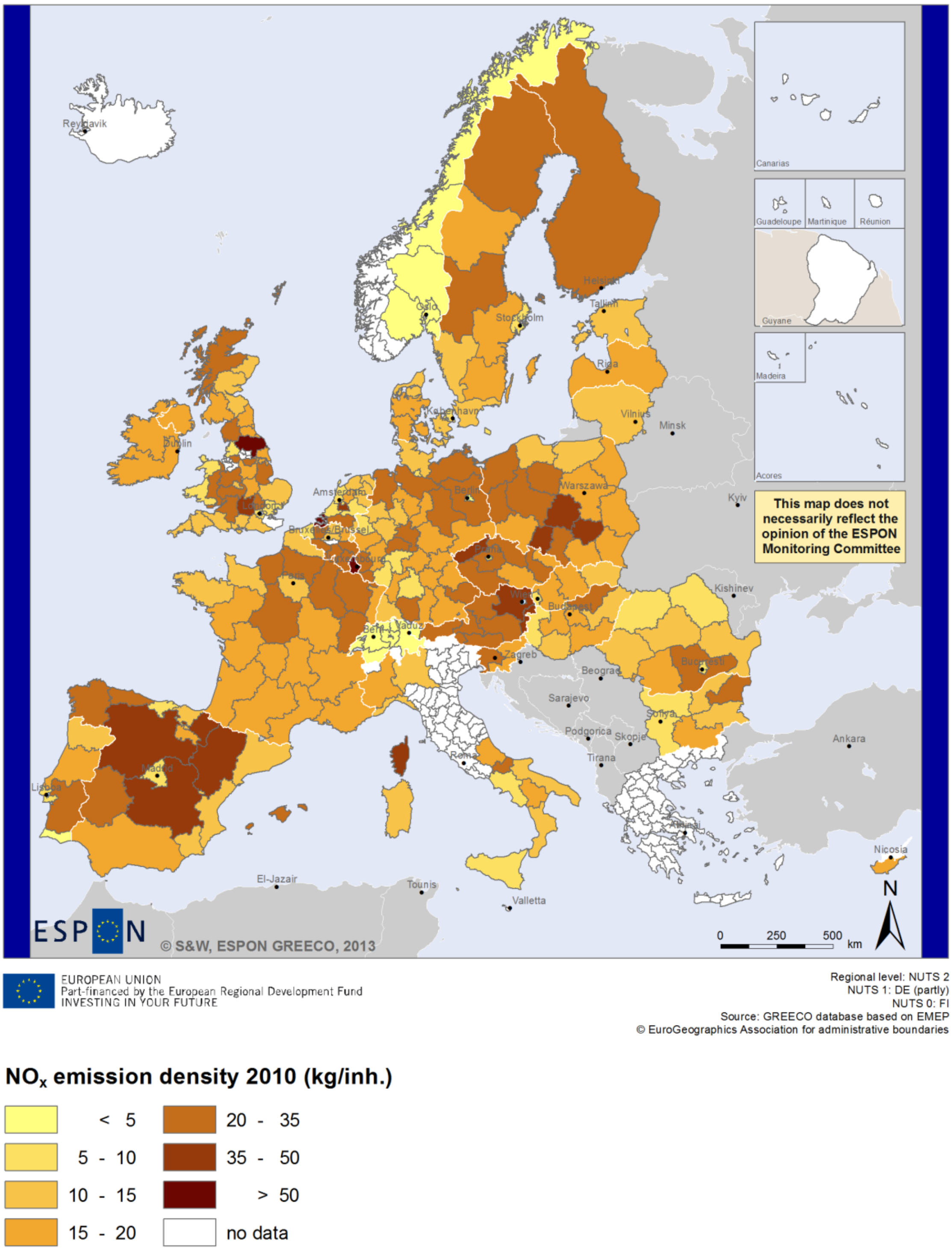


Figure 14. Air quality, NOx emission per inhabitant, 2010.

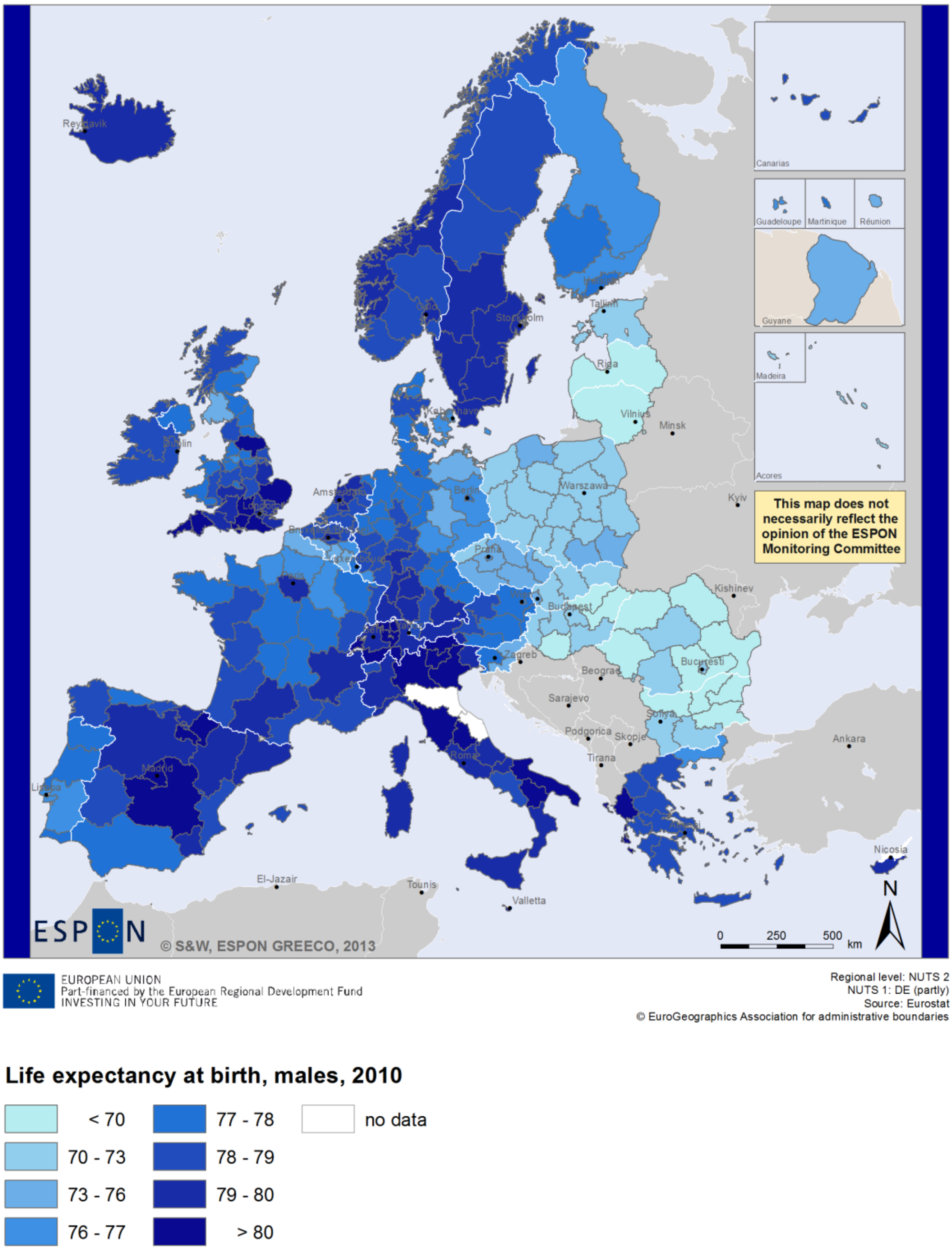


Figure 15. Life expectancy

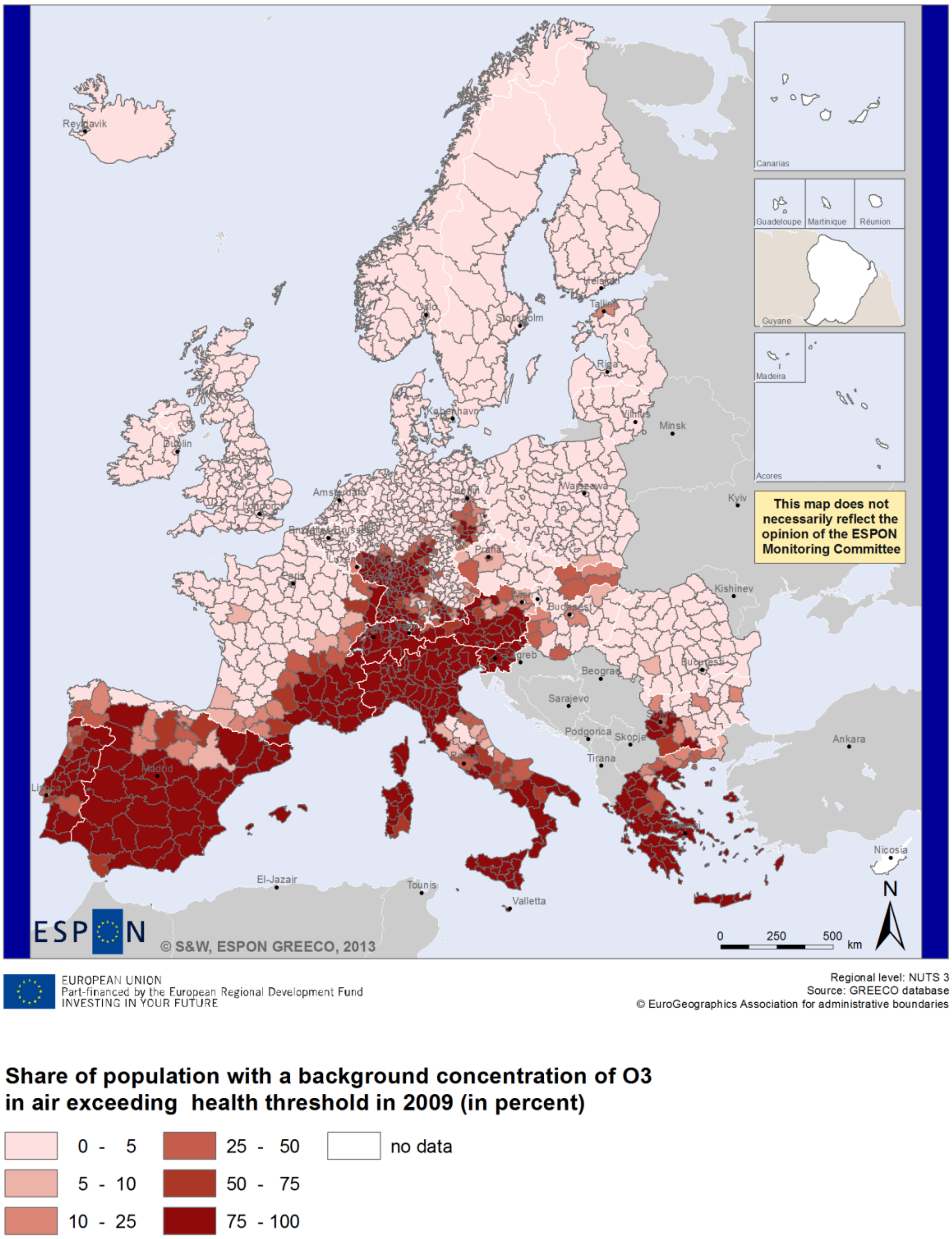
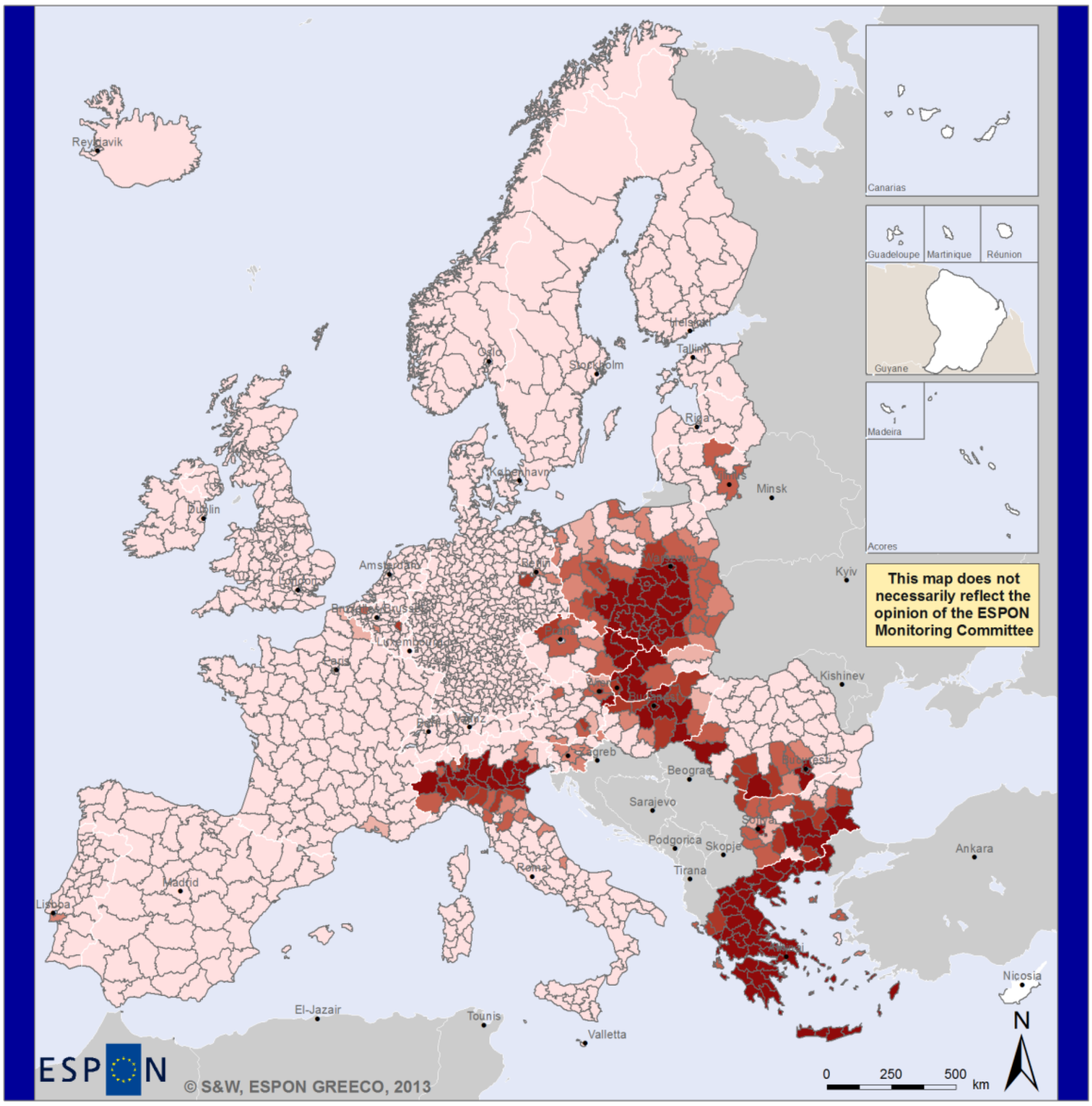


Figure 16. Exposure to air pollution (O_3)



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Regional level: NUTS 3
Source: GREECO database
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Share of population with a background concentration of PM in air exceeding health threshold in 2009 (in percent)

0 - 5
5 - 10
10 - 25
25 - 50
50 - 75
75 - 100
no data

Figure 17. Exposure to air pollution (PM)

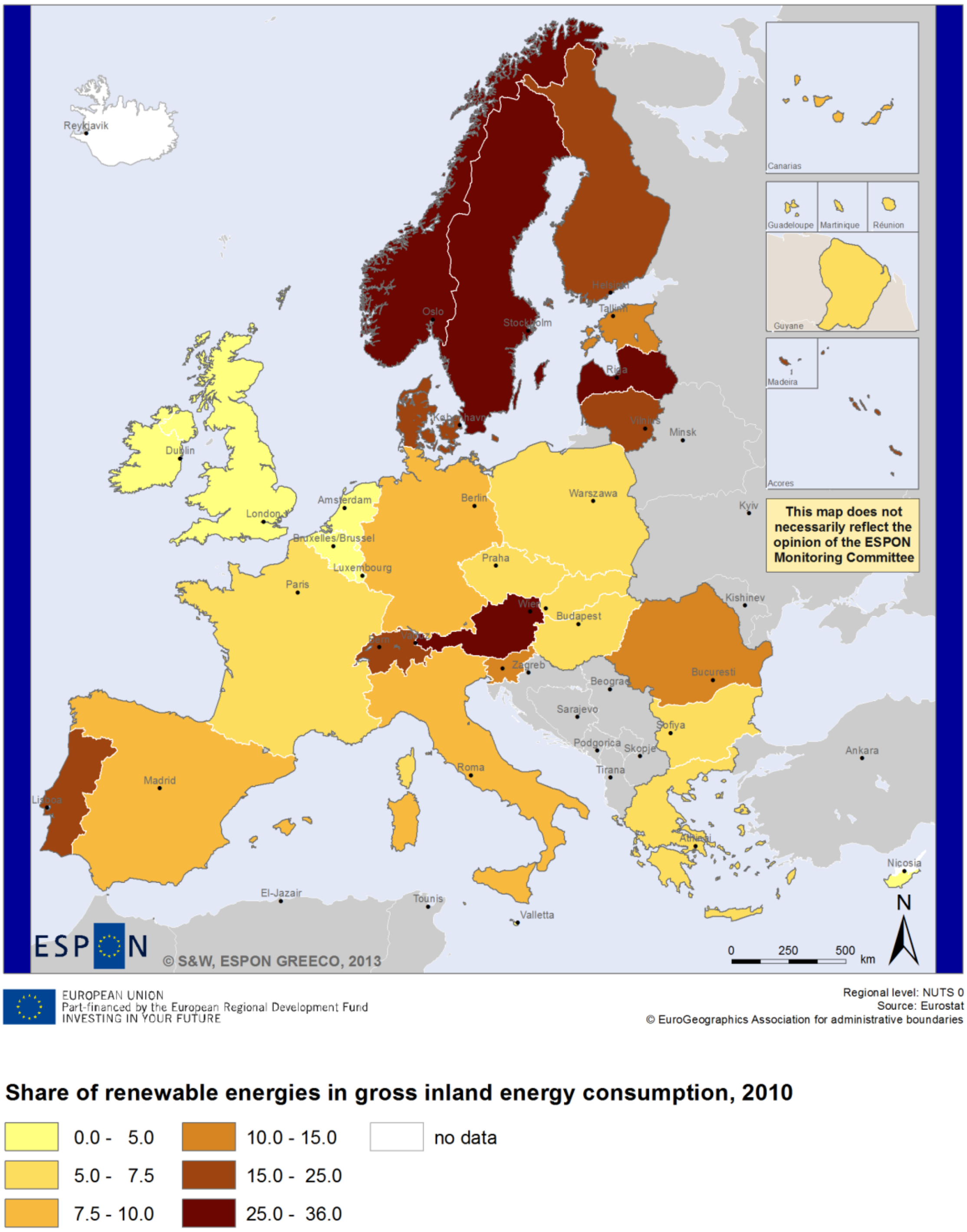
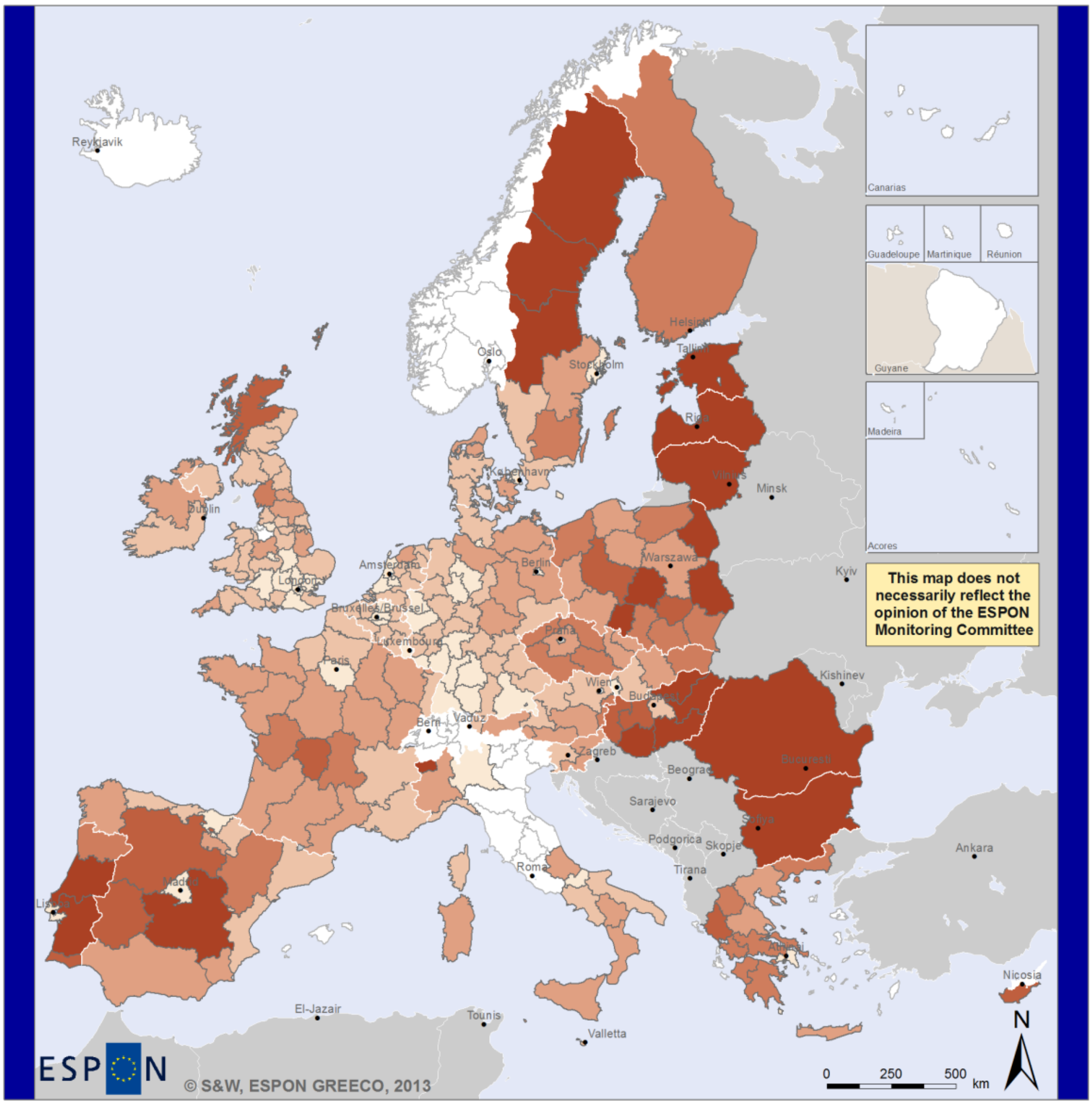


Figure 18. Share of renewable energy in gross inland energy consumption, 2010



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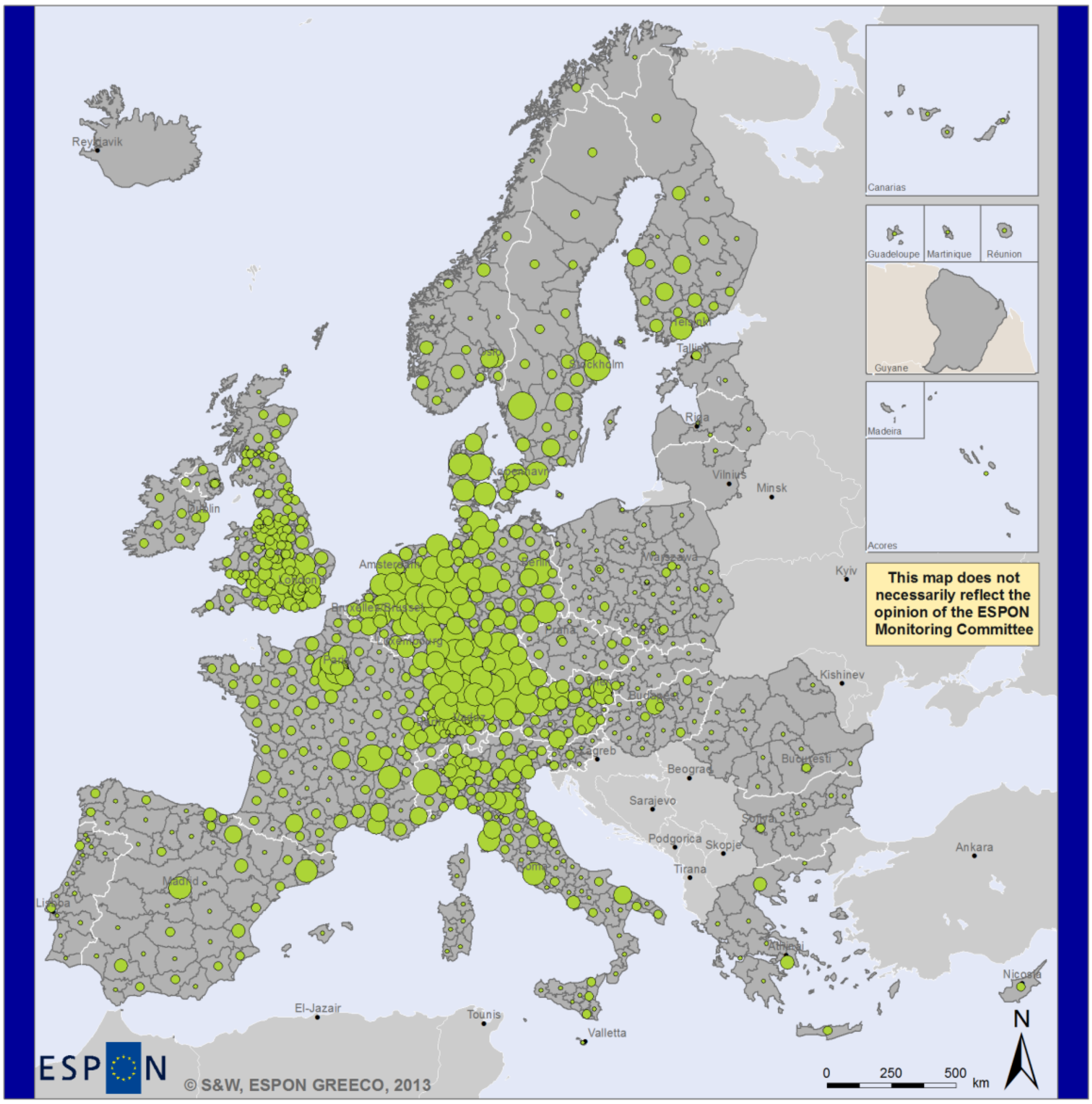
Regional level: NUTS 2
NUTS 1: DE (partly)
NUTS 0: BG, FI, CY, MT, RO
Source: Eurostat
© EuroGeographics Association for administrative boundaries

Artificial land area (ha) per GDP (million of euro), 2009

< 1	3 - 4	no data
1 - 2	4 - 5	
2 - 3	> 5	

Figure 19. Land take per GDP unit-



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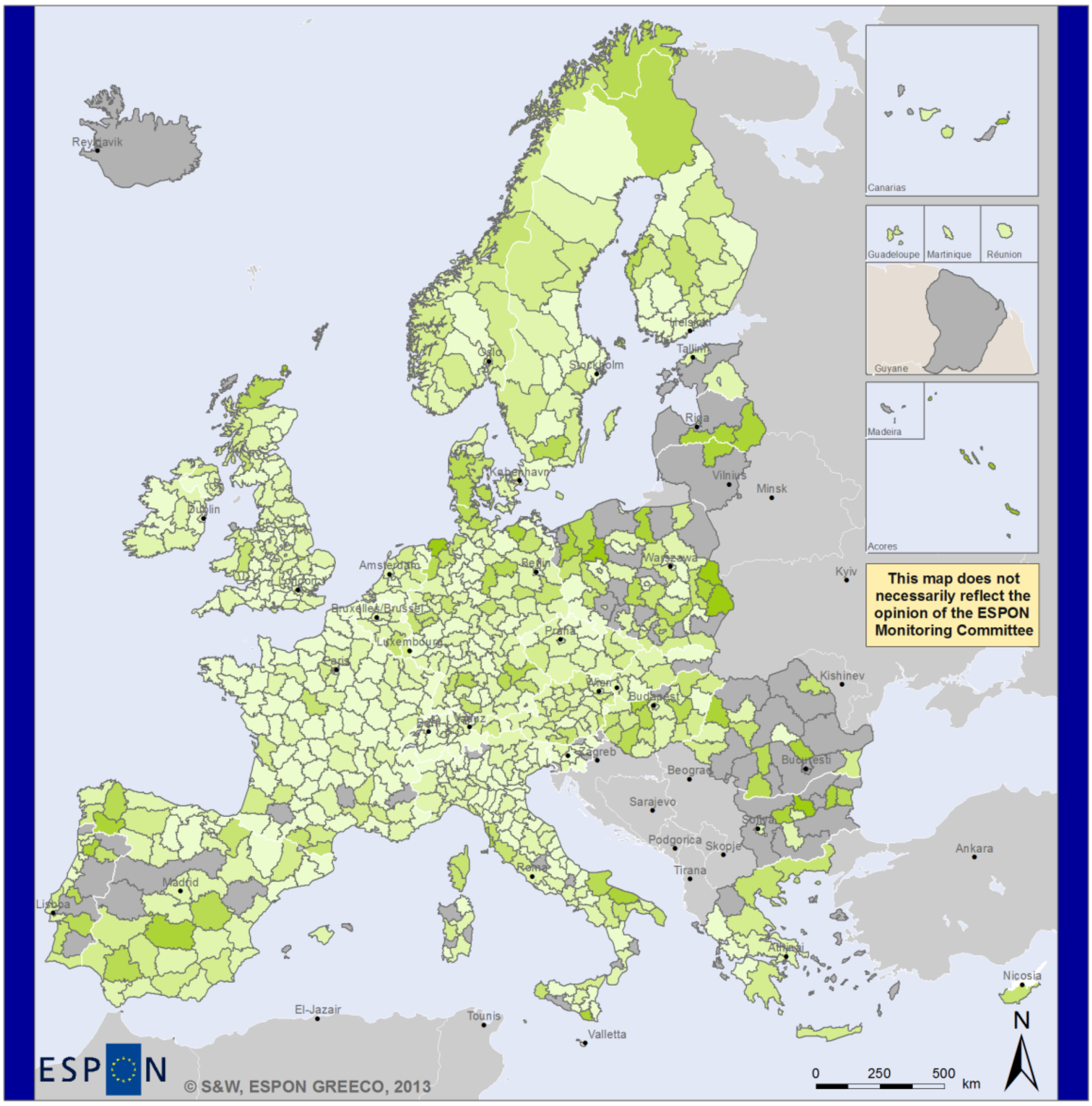
Regional level: NUTS 0,2,3
DE: OECD TL3
Source: OECD Statistics, 2011
Origin of data: European Patent Office (EPO)
© EuroGeographics Association for administrative boundaries

Green patents, 2001-2010

◦	< 5	●	100 - 250
●	5 - 25	●	250 - 500
●	25 - 50	●	500 - 1000
●	50 - 100	●	> 1000

Figure 20. Green patents, total by region.



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Regional level: NUTS 0,2,3
DE: OECD TL3
Source: OECD Statistics, 2011
Origin of data: European Patent Office (EPO)
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Green patents, 2001-2010
Share of green patents of total patents

< 5	20 - 30
5 - 10	30 - 50
10 - 15	> 50
15 - 20	no green patents
no data	

Figure 21. Green patents, share of total patents.

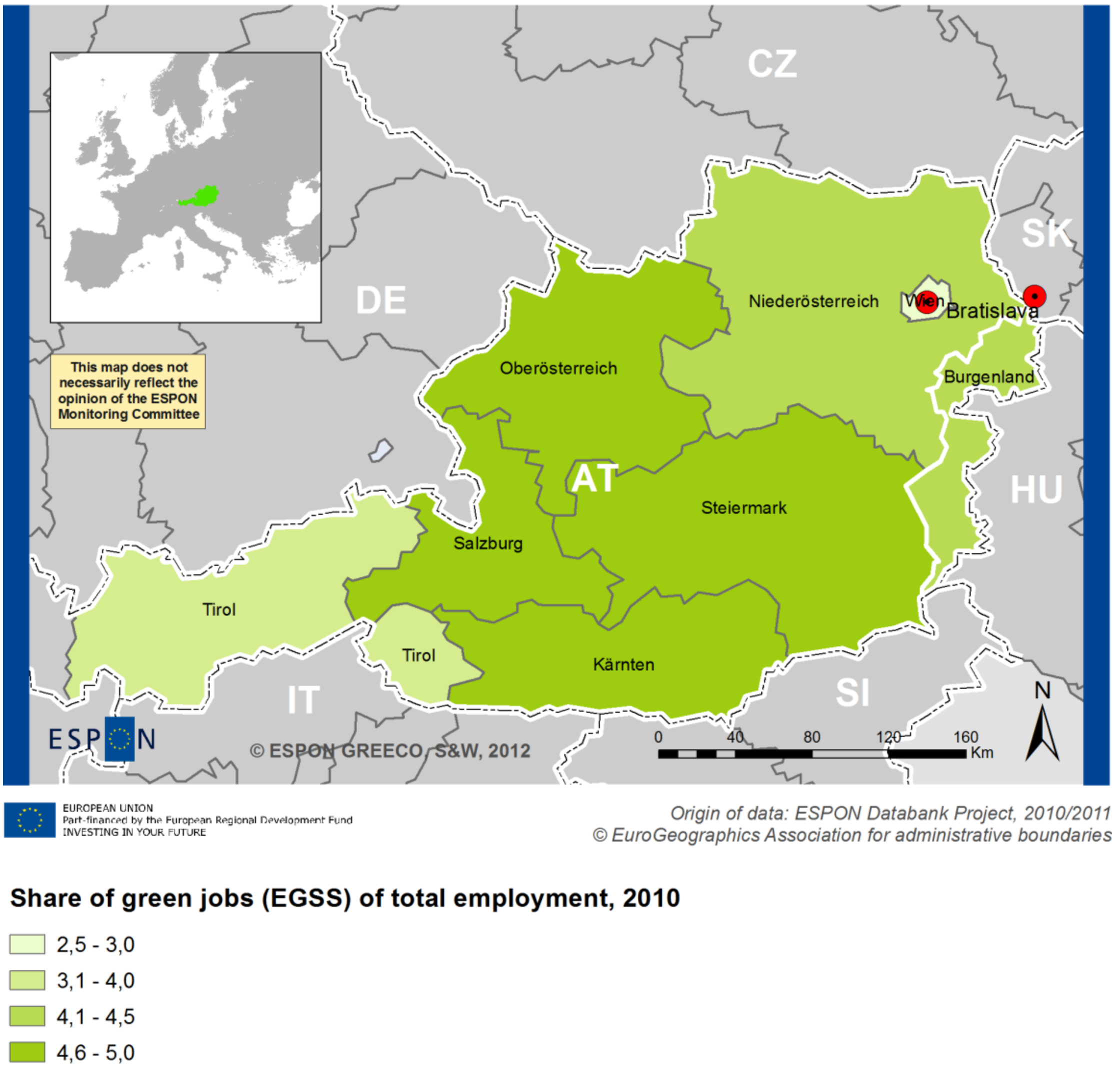
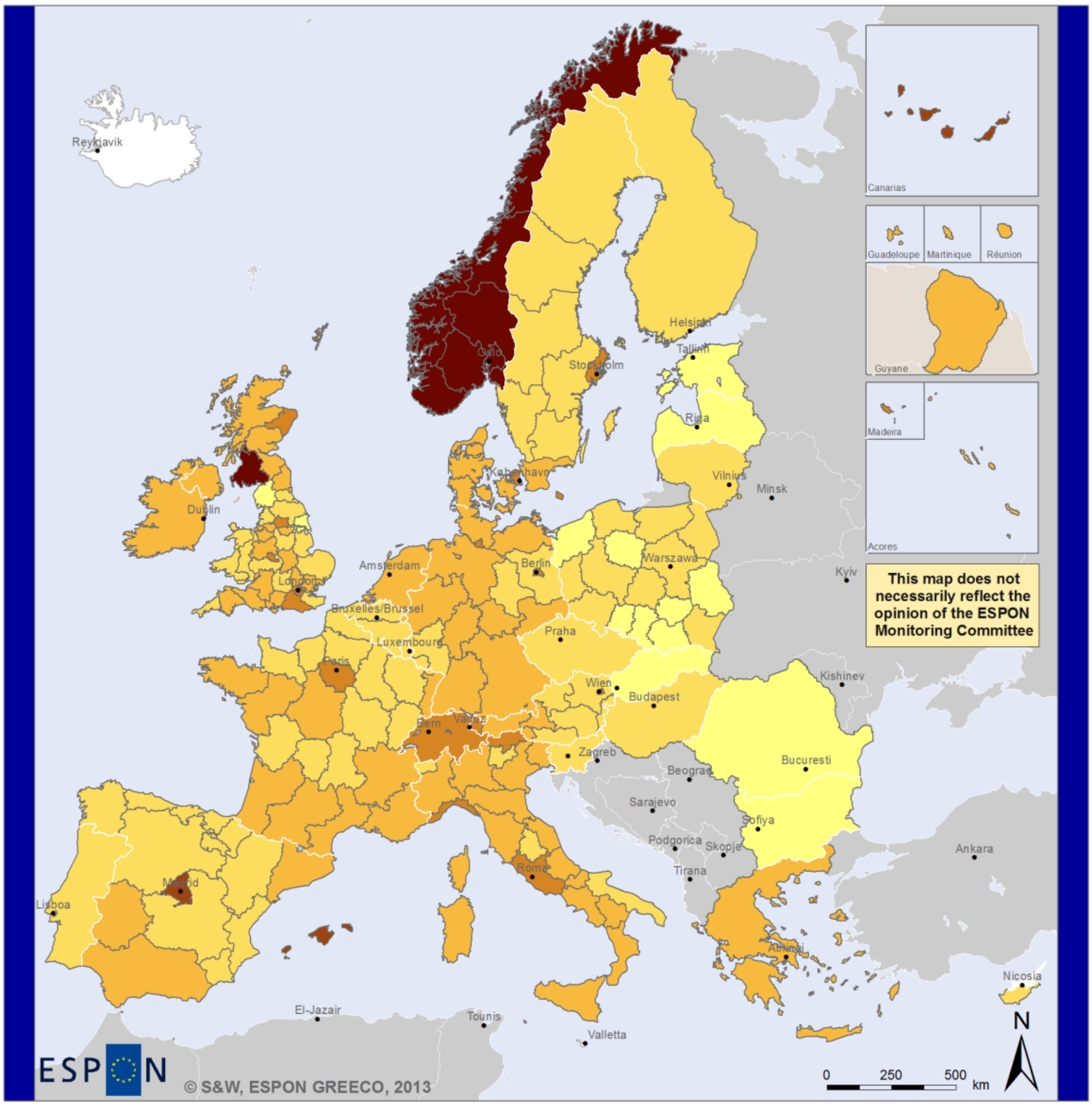


Figure 22. Green jobs (EGGS) in Austria, 2010.



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Regional level: NUTS 2
DE: NUTS 1
BG, CH, CZ, FI, GR, HU, IE, LU, NL, PT, RO, SK: NUTS 0
Source: GREECO database
© EuroGeographics Association for administrative boundaries

Final energy productivity (€ GVA/kJ)

< 100
100 - 200
200 - 300
300 - 500
500 - 1000
> 1000
no data

Figure 23. Energy productivity: GDP per energy unit.

Towards a comprehensive typology of regional green economic performance

This section presents the results of the aggregation of the different indicators for the five core features of the green economy. The objective of the aggregation is to allow some tentative and comprehensive statements about the regional green economic performance and thus allowing for a related typology of regions. The indicators used for this are the headline indicators presented in the previous section. The only indicator not included is the EGSS share as this data does not exist

The aggregation of single indicators into more comprehensive indices is done via techniques of multicriteria analysis. The territorial reference system is NUTS-2 (version 2010). That means that indicators available at NUTS-3 level are aggregated which is depending on the type of indicator done either by simply summing up or by weighted aggregation. For data that does exists only at NUTS-0 or NUTS-1 level, the disaggregation is simply done by using the standardised indicator values also at the lower level, i.e. for reasons of simplicity it is assumed that no spatial variation is existing for that indicator. Data gaps have been estimated by considering neighbouring or other regions which have comparable features. By this, it is guaranteed that all regions have all indicator values, i.e. no bias induced by missing data or indicator does exist.

The indicators are first transformed from their raw values into standardised green performance values which range from 0 to 100. The principle is that the range of raw indicator values should be mapped in a way that the full range of the standardised green performance values is utilised. This means that the green performance values are not oriented at certain objectives but that they should highlight the variety of regional performances. Table 3 shows the indicator system and the indicator raw values that are mapped to the extremes of 0 and 100. The values in between are transformed by a linear function. The table shows also the weights that are used to aggregate from single indicators to core features of the green economy and from there to a comprehensive green performance indicator.

The result of the regional green economic performance for the five core features are presented in Figure 24.

- The performance in the *environmental sphere* shows Nordic and Alpine regions doing best which is an outcome of high environmental and natural assets combined with low emission levels. Similar good is the situation in several coastal regions, the Baltic states and some regions in south-eastern Europe and Spain. Some urban agglomerations, in particular in the UK, Belgium, northern Italy, Poland and Greece do worst, but there are also some more rural regions in Spain and Germany in those lower classes.
- In the *social sphere*, most regions in a broad belt along the Atlantic from Portugal to the Nordic countries are doing fine based on low exposure to air pollution and relatively high life expectancy. Southern European regions suffer from high exposure to air pollution, eastern European regions from very low life expectancy.
- The *territorial sphere* sees Nordic and Alpine regions performing best, a combined result of high renewable energies and high land productivity. German and Italian regions do follow next. Low performance in the territorial sphere is mainly to be found in Eastern Europe, in particular in Bulgaria and Romania, and in some central parts of Spain.
- The *economic sphere* which is only based on the number of green patents per billion GDP sees the largest differences in Europe. Southern Germany, Denmark and some

individual regions in Spain, Belgium, the Netherlands, northern Germany, Austria, Sweden and Finland are doing best. In those parts of Europe, the development of green technologies plays a larger role in the regional economy than elsewhere. Then, a large gap exists to most other regions in which the performance is rather low.

Core feature of Green Economy	Headline indicator definition	Unit	Transformation function	Weights for aggregation to	
				Core feature index	Comprehensive GD index
Environmental sphere	Environmental and natural assets	Classes 1-5	0.5 -> 0 5.5 -> 100	0.5	0.2
	Emission of air pollutants	kg NO_x per inhabitant	<50 -> 0 0 -> 100	0.5	
Social sphere	Life expectancy	years at birth 2010, males	<67 -> 0 >82 -> 100	0.5	0.2
	Exposure to air pollution	% population above O3 health threshold	100 -> 0 0 -> 100	0.25	
	Exposure to air pollution	% population above PM health threshold	100 -> 0 0 -> 100	0.25	
Territorial sphere	Renewable energy production	% of gross inland energy consumption	0 -> 0 >35 -> 100	0.5	0.2
	Land take per GDP unit	ha artificial land per million € of GDP	0 -> 0 >10 -> 100	0.5	
Economic sphere	Green patents	Green patents per 1 billion GDP	0 -> 0 >10 -> 100	1.0	0.2
Econosphere	GVA per energy unit	€ GVA per kJoule	0 -> 0 >500 -> 100	1.0	0.2

Table 3 Headline indicators used for comprehensive typology of regional green economic performance.

- In the *econosphere*, Norway, some UK regions, Stockholm, Madrid and Paris and some individual regions in those countries, regions in southern Germany, Switzerland and Austria, Italy and Denmark are doing best, i.e. having a high economic output per energy unit used. Most regions in Eastern Europe, Finland and Sweden, Spain and good parts of the UK, France and Belgium are at the other end of the spectrum.

The aggregation of the performance of the five core features to one single regional green economic performance index is presented in Figure 25. Each core feature contributes 20 percent to the overall performance of a region. The map classes are composed of five quantiles which can be considered as an aggregate typology of regions with respect to regional green economic performance. Regions with high and very high performance are mainly located in the Nordic Countries, Iceland, UK and Ireland, the Netherlands, Germany, Austria and Switzerland and Italy, and also Paris and Madrid. On the other hand, most eastern European regions belong to the type of very low green economic performance because the performance in most of the five different spheres is clearly low.

The diagram in Figure 26 ranks the regions according to their overall green economic performances and decomposes this by the five core features. The environmental spheres varies a lot in all performance types of regions, i.e. there are good performing regions that have only a moderate environmental performance, but also low performing regions with high environmental performance. The main differences between top and poor performing regions can be found in the economic sphere and in the econosphere. Low performing regions do not have green innovation capacity and at the same time the energy productivity is rather poor. Remarkably, that some of the best performing regions do have a rather low contribution to their position from the economic sphere, i.e. green innovation is not the base for success.

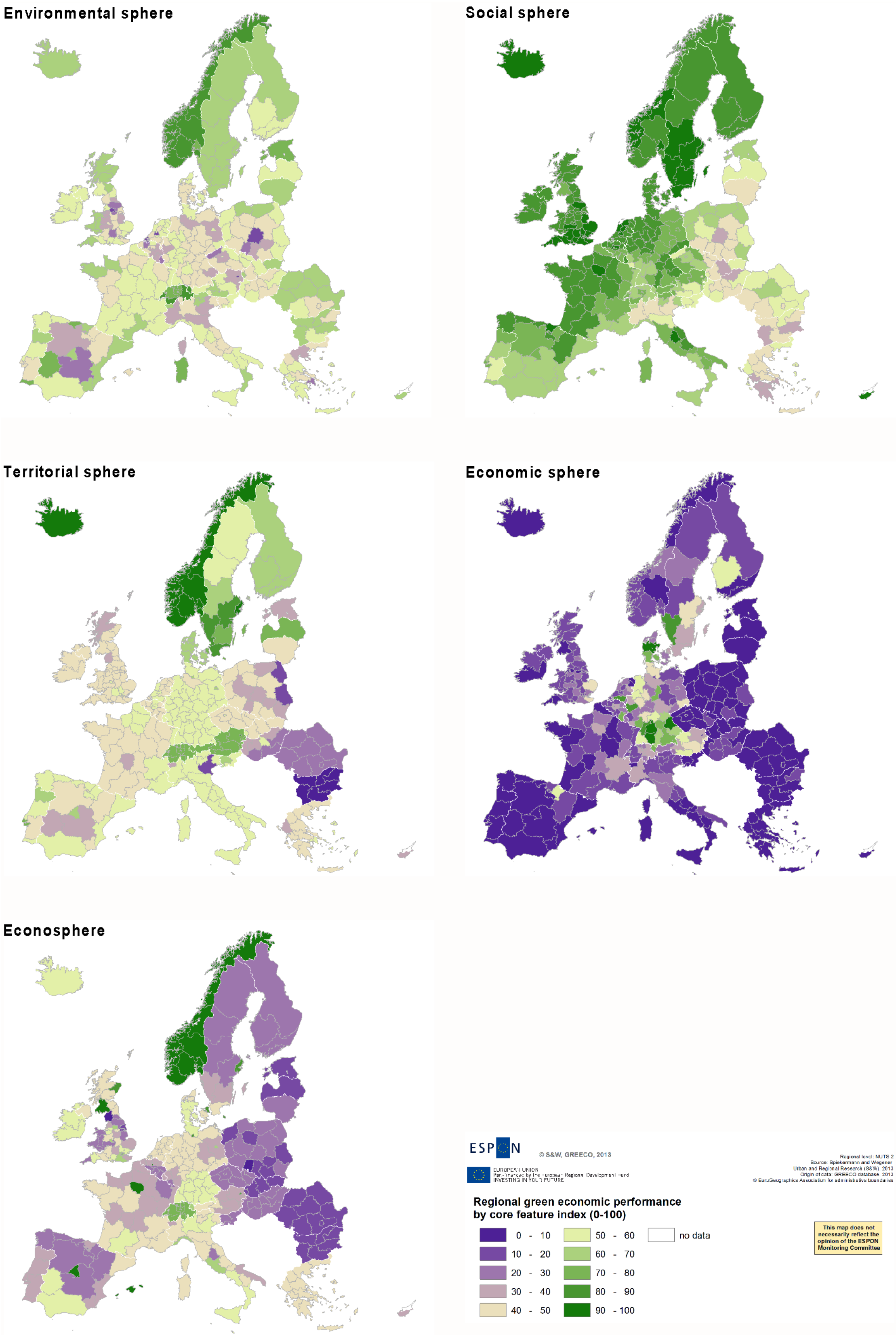
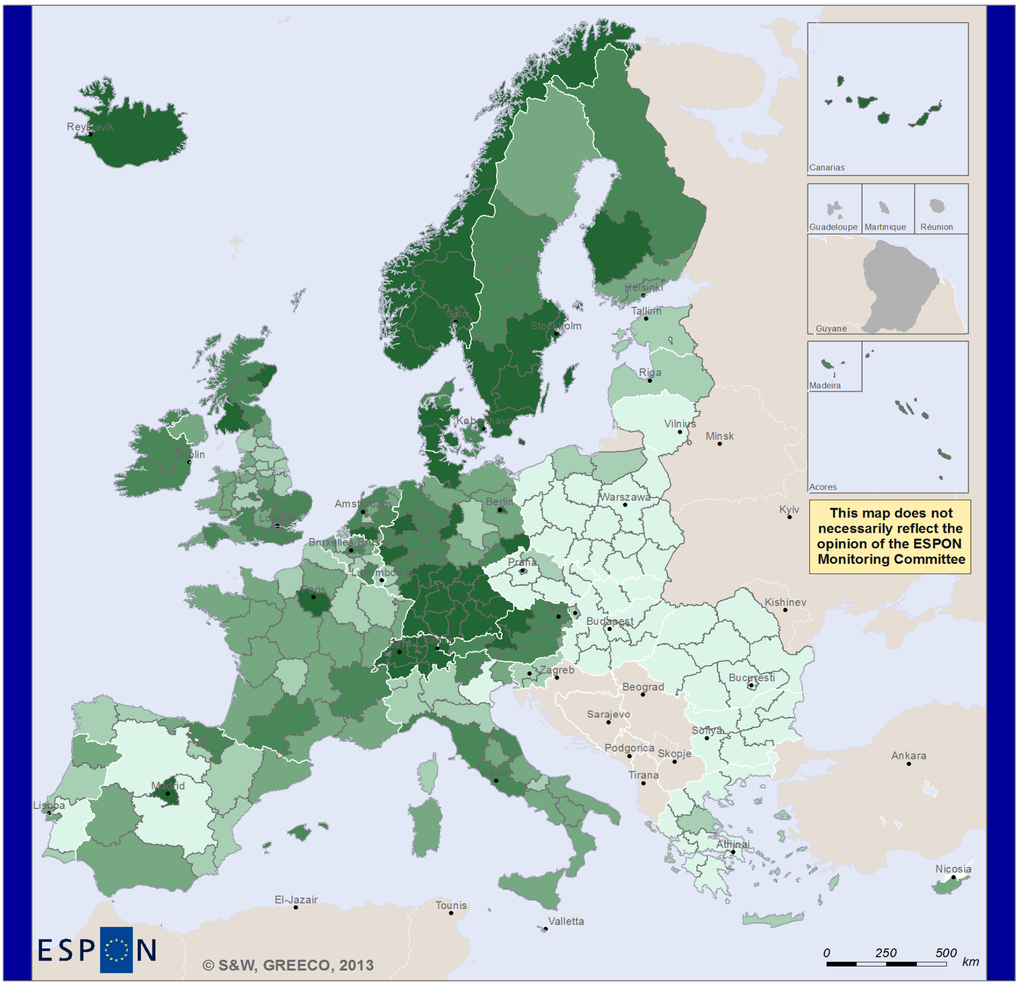


Figure 24. Standardised regional green economic performance for core features of green economy.



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Regional level: NUTS 2
Source: Spiekermann and Wegener
Urban and Regional Research (S&W), 2013
Origin of data: GREECO database, 2013
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Regional green economic performance
Aggregate typology (quantils)

- 21,4 - 37,9 (very low GE performance)
- 38,0 - 45,8 (low GE performance)
- 45,9 - 49,8 (average GE performance)
- 49,9 - 56,8 (high GE performance)
- 56,9 - 77,8 (very high GE performance)
- no data

Figure 25. Typology of regional green economic performance.

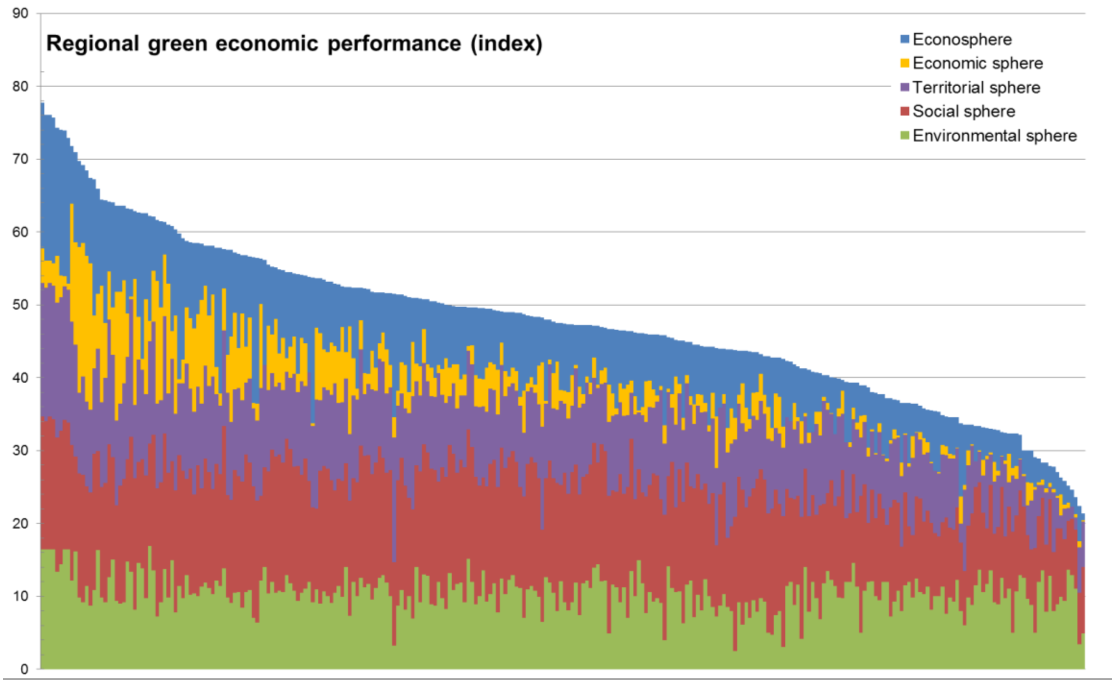

Figure 26. Decomposition of the typology of regional green economic performance.

Regional green economic performance vs. regional economic performance

Does it pay for a region to have a good green economic performance? Is there a correspondence between this and overall regional economic performance. . Figure 27 relates the standardised regional green economic performance of the five core features against GDP per capita. At this level of analysis, the relationship is rather weak for the environmental sphere (R^2 = 0.08), moderate for the social sphere (R^2 = 0.47) and the economic sphere (R^2 = 0.32), but fairly good for the territorial sphere (R^2 = 0.62) and the econosphere (R^2 = 0.65).

Figure 27. Standardised regional green economic performance of core features vs. regional economic performance.

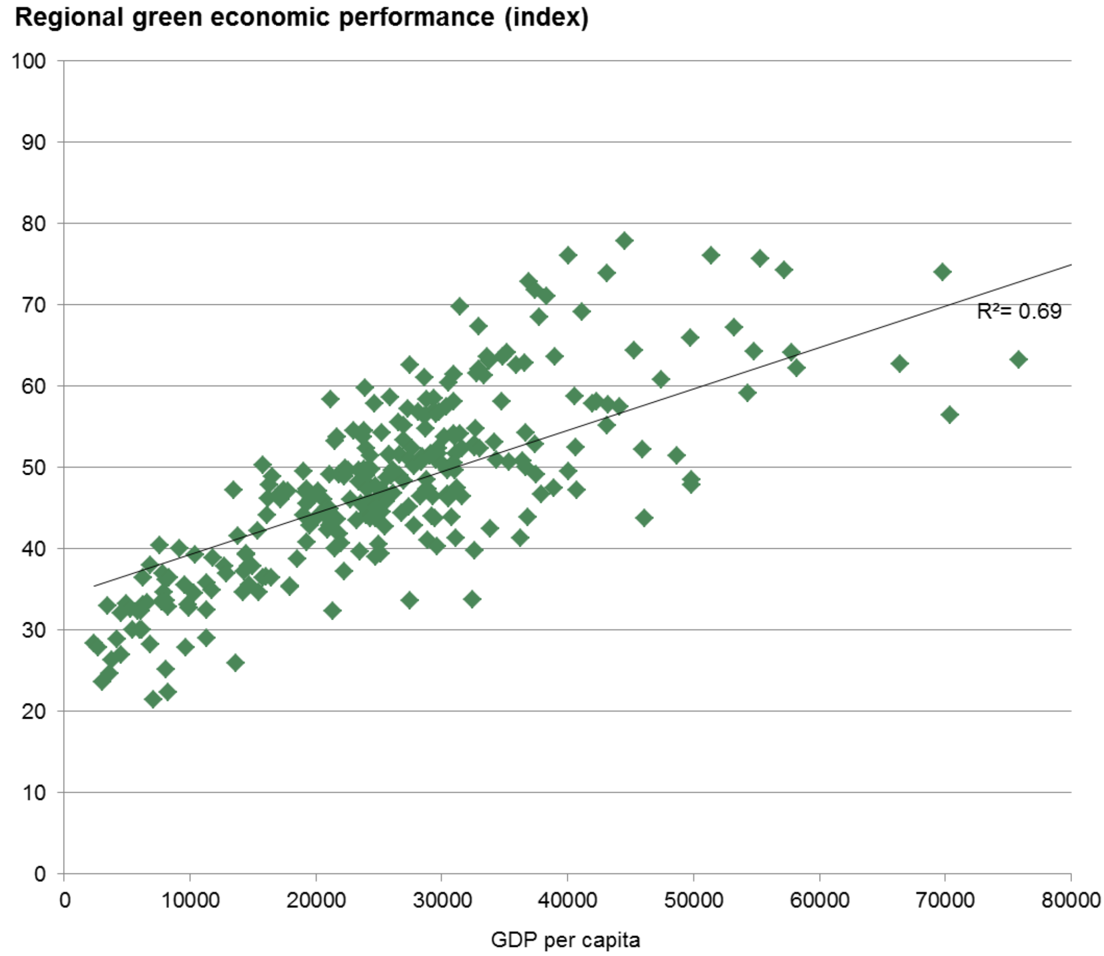

Figure 28. Typology of regional green economic performance vs. regional economic performance.

However, the aggregation of the performance of the five core features of the green economy to the single comprehensive typology of regional green economic performance shows an even higher degree of relationship with the economic output of regions in Europe (Figure 28). The distribution of the regions in the diagram gives a clear message supported by the correlation coefficient ($R^2 = 0.69$): Lagging regions are also low performing in green economic aspects, prosperous regions do display a high degree of green economic performance. This relationship can be seen from two sides. On the one hand, one might argue that it requires a certain degree of economic output to be able to put also an emphasis on green issues. On the other hand, one might consider that investments in greening the regional economy in a broad sense as understood in GREECO will also help in improvements in overall economic performance of those regions.

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ISBN