ReRisk
Regions at Risk of Energy Poverty

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This report presents the final results of an Applied Research Project conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

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This basic report exists only in an electronic version.

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Foreword

"EU urged to prioritise tackling energy poverty"[1]. The NGO network INFORSE raised the voice of alarm at the end of December 2009, as it became obvious that more and more European households face difficulties paying their energy bills. The NGOs' concern is shared by the European Parliament, which, in June 2008, called on Member States to "to set up National Energy Action Plans addressing energy poverty" and to "invest as a priority in comprehensive energy efficiency measures for low-income households, thereby addressing in a strategic manner both the problem of fuel poverty and the '20 % by 2020' energy efficiency target" [EP 2008].

While the Parliament is concerned by the impact of rising energy prices and diminishing incomes on household level, the Commission is presently analysing the possible consequences of carbon taxes (and higher energy costs) on the European companies. Political pressure to fight energy poverty is mounting, but policy initiatives in this field are hampered by the lack of basic data on how energy is used in Europe. This report tries to fill this gap by presenting the findings of the ReRisk project on the implications of energy poverty for economic competitiveness and social cohesion in the regions of the European Union.

Instead of focussing on energy infrastructure, which is mostly at the heart of studies in the energy field (including one earlier ESPON report), this project looks to a large extent on the consumption side of energy. It is the economic and transport structure, as well as the social situation and the climate conditions, which makes certain regions in Europe more vulnerable to energy poverty than others. But, as shown in the report, increasing prices for fossil fuels also open up opportunities for the development of renewable energy resources and the creation of new sources of income and employment.

The authors of this report want to thank all those who have provided valuable comments to improve this work, participated in the workshops or made contributions as interview partners, helping us to gather evidence on the present realities and future challenges of regional policy making in the energy field.

[1] January 2010, http://www.euractiv.com/en/energy/eu-urged-prioritise-tackling-energy-poverty/article-188554

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A. Executive Summary

A.1. Key Messages and Findings

Key Messages

1. Urgent measures are needed to help the most vulnerable regional economies, mainly located in the Eastern part of Europe, to cope with the challenges of rising energy prices. Competitiveness is not only at stake in Eastern regions with industrial background or strong dependence on food processing, but also in the highly industrialized Northern periphery.
2. Remote regions in general have to prepare for higher prices for long-distance travel and air transport, with negative impact on overall price levels and tourism, which is often an important source of employment in these regions.
3. By analysing the exposure to energy poverty on regional, rather than on country level, a much clearer image of social disparities in Europe emerges. People living in the poorest region in Bulgaria (Severozapaden) earn less than 12% of the average income in Inner London - measured in power purchase standards (pps), which take into account different price levels -, but Bulgarians pay on average 17.07 pps for 100 kWh of electricity, while the British pay 15.37 pps. Even in the pre-crisis situation of 2005, the South–North and East-West divide in social terms persisted in the European Union and has most probably worsened since then.
4. The main challenge from the policy point of view is that of mobilizing the considerable potential for renewable energy sources in regions that lack the financial resources to do so and to coordinate a large set of policy instruments on local, regional, national and EU level to enhance access to energy efficiency measures, both for industries and households.

A.1.1. Features of Energy Poverty in the EU Regions

The project started out by measuring the regions’ vulnerability to rising energy prices in three dimensions:

- **Economic vulnerability**, mainly due to regional specialization in industries with high energy spending.
- The regions’ **dependence** on (motorized) **transport**, both in terms of employment and transport uses.
- **Social vulnerability**, which refers to the segments of the population that may have problems paying their energy bills.

The three dimensions discussed here (industry, transport and households) account for 84% of energy consumption in the European Union. The focus is set on energy demand, because price developments have shown that oil price hikes spill through the entire economy, independently from the fuel mix used for electricity generation. Differences in regional vulnerability derive mainly from climate conditions, the economic and transport structure and the social situation in regions and cities.

On the demand side, responses to increasing energy prices in the short term have proven to be very limited. Price increases in the past have generally been too minor and too slow to have provoked changes in consumption patterns. However, adjustments in demand in the medium and longer term can be accelerated with the right policy measures and with investments in energy efficiency, thus mitigating the expected negative impact of rising energy prices on the main economic variables and the most vulnerable population.

So, what do we know presently about the possible impacts of rising energy prices in the regions? The impacts in economic terms can be estimated by identifying the industries with highest energy spending and by determining, which regions are specialized in these economic activities. Specialization means that a considerable part of employment and / or wealth creation in the region depends on these industries. The analysis carried out here shows that negative effects on regional economies are not limited to industries which are known to be energy-intensive, such as paper or aluminium, but also affect other sectors, for example the food processing industry.

There are important differences between the EU countries with regard to industrial energy spending. Most of the Eastern countries have rather high expenses for energy purchases in a number of industrial sectors, and so does Luxemburg. These differences cannot be explained entirely by the levels of energy prices or general price indexes, so it must be assumed that energy is not efficiently used in some industrial processes.

The available data on industrial energy consumption seems to confirm this hypothesis. We find that, after Bulgaria, Romania is the country that employs the largest amount of energy per million € of industrial gross value added (16.06 TJ), followed by Latvia (12.46 TJ), Luxembourg (10.10 TJ), Estonia (9.17 TJ) and Cyprus (5.80 TJ).

The question is if these findings on **national** industrial energy consumption can be extended to the **regional** level. The analysis of industrial energy consumption in regions in France, Germany, Italy and the UK confirms that there is a positive correlation between the regional specialization in industries with high energy costs and their actual energy consumption.

The regions with the most unfavourable position in terms of economic vulnerability (> 10% of employment in industries with high energy spending) are located in the Czech Republic and in Italy. In the latter case, the highly vulnerable regions combined represent more than 50% of industrial employment. However, the Italian industries do not perform badly in the EU comparison with regard to energy spending, despite of the relatively high energy prices in the country. In the second group of regions, in which 7 – 10 % of employment depends on industries with high energy purchases, we find some belonging to countries that fare worse in the EU comparison of industrial energy purchases: Romania (Centru), and Hungary (Észak-Magyarország and Dél-Alföld), as well as Estonia and Latvia.

By combining the results on industrial energy spending and regional wealth creation and employment, it is possible to identify those industrial processes, which should be subject to an in-depth analysis on regional level because they seem to be making an inefficient use of energy. Some suggestions can be given for the regions with the most unfavourable industry structure in Italy, the Czech Republic and Hungary.

In the Italian regions of Emilia-Romagna, Lombardia, and Veneto, special attention should be paid to the *manufacture of cement*, since energy purchases in this sector represent more than 30% of total purchases and energy spending is almost 10% higher than the EU average. A second critical sector is the *manufacture of glass fibres,* in which more than 18% of purchases are dedicated to energy, and energy spending is 8.6% above the average level of spending in the EU. The sector of *manufacture of other non-metallic mineral products*, to which both cement production and manufacture of glass fibres belong, employs more than 30,000 people in Lombardia and Veneto and more than 46,000 in Emilia-Romagna. Although cement production is regionally oriented and is therefore less exposed to international competition, improving efficiency would help to reduce the elevated level of industrial energy consumption in these regions.

In the Czech region of Severovýchod production processes in the sector of *other non-metallic mineral products* should be analyzed, since energy spending in this sector is 10% above EU average on national level and local companies in this branch employ 21,564 persons. Moravskoslezsko also has a very high level of employment (28,388 persons) in the basic metals industry. Special attention should be paid to processes related to *forging, pressing, stamping and roll forming of metal; powder metallurgy*, for which energy spending is about 5% higher than the EU average and represents 7.65% of total purchases. Additionally, Moravskoslezsko ranks first with regard to wealth creation in sectors with high energy-spending, with more than 25% of regional GVA (Gross Value Added) proceeding from these industries.

All of the mentioned regions in the Czech Republic (Moravskoslezsko, Strední Morava, Severovýchod, Severozápad and Jihovýchod) should analyze the performance of one branch subsector of the chemical industry, *manufacture of industrial gases*, since energy spending is 10% above EU average and energy represents close to 20% of total purchases. Employment levels in the chemical sector range from 4,225 in Moravskoslezsko to 7,943 in Severozápad.

In the case of Hungary, decision-makers from Észak-Magyarország should take a close look at the *manufacture of fertilizers and nitrogen compounds*, since, on national level, this industry spends 40% more on energy purchases than the industry on EU average and energy purchases amount to almost 60% of total purchases. Észak-Magyarorszá ranks second among the Hungarian regions in employment in the chemical sector (6,215 employees), after Közép-Magyarország with 15,073 employees. Differences in energy spending with regard to Europe are also considerable in the *manufacture of starches* and this may especially affect the region of Dél-Alföld, where 25,444 persons work in the food-processing industry.

The data collected here therefore makes it possible to identify potential weaknesses in regional economies derived from higher than average levels of energy spending and thus sheds some light on the hitherto obscure question of industrial energy use in the European regions.

The methodology can also be employed to add information on the “risk of carbon leakage”, i.e. the possibility that companies decide to transfer activities to countries outside the EU if production costs rise as a result of carbon taxes [EC 2009b].

“Carbon leakage” seems to be a major threat to the Belgian provinces of Brabant Wallon and Antwerpen, which should analyse the situation in the subsectors *manufacture of other organic basic chemicals* as well as *fertilizers and nitrogen compounds*, since these spend more than the EU average on energy purchases. The British regions of East Yorkshire and Northern Lincolnshire might be exposed to the risk of carbon leakage by companies dedicated to *manufacture of other inorganic basic chemicals*, which do not perform well with regard to the subsector’s average spending on energy.

Within the two countries most affected by the risk of carbon leakage, Poland and Finland, two specific problem regions can be identified: Swietokrzyskie, with 21.24% of industrial employment in sectors with risk of carbon leakage and Pohjois-Suomi (34% of industrial employment is in the critical sectors).

In order to measure **transport dependence**, several attributes have to be taken into account such as employment in the transport sector, commuting, the cost of freight transport and the need for air travel in remote regions and islands.

Differences among EU regions are considerable in each of the above-mentioned categories. The combination of transport indicators reveals that the most vulnerable regions are the large logistics centres, peripheral and island regions, but also some rural regions dependent on working opportunities in nearby urban poles or agricultural regions with high export levels.

The costs of commuting or those associated to other car uses directly affect the budget of households, while increased costs for freight in the region will affect the general price level of goods, with further negative effects on available income.

Additionally, households will have to face higher heating and electricity bills, so that the total energy expense may become a serious burden for families, which already struggle to make ends meet. This is the third dimension of “energy poverty” that was analysed in the ReRisk project.

The present economic crisis is already showing its effect in the energy sector. Electricity company Enel in Italy, for example, informs that the number of customers who can not pay their bills increased during 2008, to 600,000 (up 30% since 2007). Presently, this is not so much caused by rising energy prices, but by diminishing income, but the effects are similar.

Social vulnerability is obviously strongly related to the levels of poverty in the regions. Despite of the importance of this problem, no indicators are available to measure the risk of poverty in the regions directly. People slide into poverty in different types of circumstances and long-term unemployment and low rates of economic activity are considered to be the main reasons for it. In 2007, 16 regions in Europe, plus the French overseas territories, had a long-term unemployment rate above 60%. The list comprises a number of regions in Eastern Germany, as well as three regions in Bulgaria and two of the four Slovakian regions: Stredné Slovensko and Západné Slovensko. Activity rates below 50% are frequent in the Southern regions in Italy, and in four regions in Hungary: Észak-Magyarország, Észak-Alföld, Dél-Alföld and Dél-Dunántúl. Severozapaden in Bulgaria also belongs to the group of regions with the lowest level of economic activity (less than 43%) and another three regions from this country (Severen tsentralen, Severen tsentralen and Yuzhen tsentralen) follow closely.

Rising energy prices are bound to become a serious social problem in an area, which extends from Eastern Germany to the New Member States, especially those with a very low disposable income, such as Bulgaria, Romania, Hungary and Poland. Energy costs represent a much greater strain on household budgets in these regions, which additionally have a high demand for heating in the winter time.

A.1.2. Regional Typologies

The original indicators used to measure economic and social vulnerability, as well as dependence on (motorized) transport were completed with data on the climate characteristics in the regions (important for heating and cooling demand), and the potential to develop renewable energy resources (solar and wind).

The combined data was then processed further in a clustering process in order to identify groups of regions with similar characteristics, which may be addressed by a common set of policies. The 9 indicators selected for the clustering were weighed with regard to their policy relevance, based on expert judgement. The k-means algorithm applied allowed to identify five typologies of regions, as indicated in table 1:

Table 1 Characteristics of the Regional Typologies

Mean Values	1a "With problems and potential"	1b "Well-off, with trouble ahead"	2 "Struggling, looking for jobs and a brighter future"	3 "Wealthy and commuting"	4 "Cool and windy, but working"
Maximum temperature July	32.36	30.66	33.70	30.46	26.17
Minimum temperature January	-6.21	-7.55	-11.80	-6.81	-17.59
% employment in industries with high energy purchases	3.41	5.22	5.28	3.60	6.14
Fuel costs of freight transport	1.93	1.89	5.23	1.73	2.37
% workers commuting	4.28	13.71	3.54	48.70	3.67
Long-term unemployment rate	39.15	37.00	48.44	36.51	18.75
Disposable income in households	14,176.55	15,968.78	7,144.57	16,917.15	12,631.45
Wind power potential	108,004.23	69,263.38	153,859.09	65,568.82	843,163.27
PV potential	1065.27	896.13	1041.70	857.19	833.83
Total Nº of regions	91	73	47	15	11

Typologies 1 a and b depict the most common regional profiles in Europe, while typologies 2 to 4 group regions with markedly different features of energy poverty. Taking into account the information elaborated in the ReRisk project on the regions' vulnerability to rising energy prices, as well as data from previous ESPON typologies, the ReRisk categories can be described as follows:

Typology 1 a "with problems and potential" contains two groups of regions with low exposure to rising energy prices for industry: the service oriented urban centres – the hearts of the Pentagon - and semi-rural, often tourist-oriented coastal and island regions in the South of Europe. The high photovoltaic (PV) potential of many of the regions in this latter group is an important asset for the future and could help to ease the strain of high demand for cooling in the summer time. However, the capital areas must be prepared for possible changes in transport patterns as a result of rising energy prices, both in terms of commuting (incoming labour) and loss of traffic volumes in the transport hubs. Also, the higher than average unemployment rates in 2007 are an indicator for possible social problems both in the semi-rural and capital areas.

Typology 1 b "Well-off, with trouble ahead" is made up of central, industrialized regions, including the more industrial coastal (harbour) and Pentagon areas, with low potential for developing wind and solar energy. The competitiveness of these regions could be severely affected by rising energy prices if efforts to improve energy efficiency in industry and transport fail, but their starting position is much more favourable than that of regions grouped in typology 2.

Typology 2 "Struggling, looking for jobs and a brighter future" is composed of the most vulnerable regions in terms of social cohesion, located mainly in the East of Europe, with high energy demand both for heating and cooling. These mostly peripheral regions do have potential to develop renewable energy systems, but lack the resources to do so. The number of regions grouped in this typology is smaller than those considered lagging, according to data from 2005 – 2007, but may have increased considerably in the wake of the economic recession.

Typology 3 "Wealthy and commuting" is mostly made up of regions belonging to the Pentagon "hinterland", in which wealth creation is dependent on accessing near-by centres of economic growth. The main challenge related to rising energy prices in these regions is that of guaranteeing affordable mobility. There is a high potential for polycentric development in these regions, but fewer possibilities for using wind and solar power.

Typology 4 "Cool and windy, but working" is very special in terms of features of energy poverty. The greatest concern is the heavy industrial base, combined with extreme peripheral location on the coastline and the high energy demand for heating in these, mostly Nordic, regions. However, opportunities for the further development of wind energy are considerable and the risk of energy poverty in households is low as long as the job situation remains as it was in 2007.

A.1.3. Long-term Scenarios

The cluster analysis shows that different sets of policies are needed to cope with the challenge of rising energy prices on regional level. However, as the survey to regional administrations has shown, energy policies are to a large extent determined by national policies and are embedded in a long-term planning framework. Energy - like spatial - planning requires the development of infrastructure and therefore operates with a time horizon of 30 to 60 years. The energy sector is presently undergoing a far-reaching transition process, and the political and investment decisions that are now being made will shape the framework for regional competitiveness for time to come. It is for this reason that the policy recommendations presented in this report use information obtained from scenario building. Energy policies are still highly diverse in Europe, and the policy recommendations must be "robust", meaning that they must help the regions to reduce their vulnerability in the short term and improve their adaptive capacity in the longer term under different framework conditions.

The four ReRisk scenarios, which were elaborated with the help of external experts, are based on the common hypothesis that, by 2030, energy prices still remain at a high level, but that the political response to this challenge will be different. Scenario 1 "**Green High-tech**" assumes a quick development of renewable energy sources, both large and small-scale, a situation in which the regions gain greater influence on energy policy. In this scenario, regions can specialize in certain types of renewable energy production and will gain from cooperation and shared networks.

The second scenario "**Energy-efficient Europe**" assumes a greater use of natural gas by 2030, while trying to keep Europe's energy dependency within limits through important efficiency gains in all sectors and a move towards more regionalized economies. In this situation, regions that depend on gas supplies from only one producer region will have to deal with a higher risk of supply interruptions, but economic development will probably follow a fairly balanced and more sustainable path.

In the case that present plans to expand the use of nuclear energy are actually implemented in a large number of Member States, as assumed in "**Nuclear Energy for Big Regions**", it should be expected that the power sector will remain highly centralized, since few players are able to carry out the needed investment. The logical consequence would be to "go electric" both in industry and transport, but these decisions will be little influenced by local and regional policy makers.

Choosing (clean) coal to fill the gap of dwindling oil reserves, as described in "**Business as Usual?**", would obviously benefit the mining and some harbour regions and fits well into certain protectionist ideas in Europe. However, in most parts of Europe, (imported) coal is a preferred option not because of price, but because of availability of reserves. Production from coal power plants will become even more expensive when technologies for carbon capture and storage are widely deployed. This could lead to a situation, in which high energy prices provoke continued backlashes in a world economy that is not able to function "as usual". In this case, a large number of regions, and especially urban areas, will face severe social problems over longer periods of time, due to increases in consumer prices.

A.1.4. Options for Policy Development

Within this context of national energy policy, regions do have scope to act, especially with regard to policies promoting energy efficiency and the setting of environmental standards, which can go beyond European or national norms. According to the survey of policy makers, regional involvement is comparatively higher in the field of renewable energy and natural gas projects, while their influence regarding coal use and nuclear plants is more limited.

Evidence from the survey of 41 regional energy agencies and from the case studies carried out in the project suggests that there is a strong relation between the governance model and the performance of regions in terms of economic specialization, as well as the development of renewable energy sources. Nationally guided energy strategies tend to give higher priority to security of supply, while regions are generally in charge of policies related to awareness-raising, especially in the residential sector. Regions with a greater scope of action and lower dependence on energy-intensive industries tend to be more active in promoting renewable energy sources and these characteristics determine to some extent their exposure to the risk of energy poverty.

Regional competences also vary with regard to energy research, since in only six Member States, plus Norway, regions are carrying out their own R&D programmes in the energy field. Experts in the field argue that there is a greater need for regional participation in energy research to promote the use of renewable energy sources: “Sustainable energy supply structures based completely on the importation of knowledge and technology do not seem to be favourable for countries and regions. Local or regional R&D constitutes a good basis to optimise energy systems and to reduce vulnerability. Besides, the yield of renewable energy sources and the types of optimal technologies depend, in part, on local (climatic) conditions. Thus, specific technologies have to be developed – mostly by means of local or regional R&D” [Luther 2004].

Taking into account the limitations of regional competences in the energy field, policy recommendations focus on the intersections with other policy domains, in which regions and municipalities do have a decisive influence and can be supported by EU actions, namely:

1. Governance models and regional cooperation
2. Spatial and urban planning
3. Environmental protection and risk prevention
4. Deployment of renewable energy sources
5. Promotion of energy efficiency
6. Social policies

With regard to good governance, the main attention should be paid to policies promoting energy solidarity between regions, in line with the Territorial Agenda, through different actions, including the extension of regional and local networks. The modernization of transport and energy networks is one of the actions to be reinforced by the “EU 2020 Strategy”. This is a central issue for reducing the vulnerability of regions with a high level of commuting and for the development of complementary portfolios of renewable energy sources in neighbouring regions.

Spatial and urban planning provides innovative tools for promoting the integral development of solar energy use, for understanding how energy and other resources are being used in urban environments (“urban metabolism”), and for the promotion of cooperation between regional actors, for example in the form of “industrial symbiosis”.

In the field of environmental protection and risk prevention, the most pressing problems are related to possible climate change impacts on the regional energy infrastructure. These impacts are likely to be most severe in the Southern regions belonging to Spain, Greece, Portugal and France, both in terms of energy production and demand. In these regions, summers are going to be complicated for energy companies, due to diminishing water reserves, higher average temperatures and heat waves, and consequently, forest fires. The supply problems will coincide in time with higher peaks of electricity demand, derived from a more extended use of air-conditioning.

These issues could be addressed when implementing the national emergency plans for the prevention of heat waves, which have already been approved by some European governments.

Regional “maps of untapped energy reserves” could be of great use for developing longer-term plans in the regions. The data on PV and wind potential should be completed at the regional level with an evaluation of the feasible potential of other technologies, including concentrated solar, geothermal, wave / tidal technologies, biomass, and hybrid solutions.

Action is also urgently needed to reduce the vulnerability of those regions which rely heavily on air transport (i.e. peripheral territories and the big European transport hubs). The aviation industry is expected to face serious supply problems in the coming decades and alternative energy sources must be developed quickly. Unfortunately, in the opinion of the regional policy makers, the transport sector as a whole is the most problematic field of transition while actions promoting energy efficiency in the residential sector seem to be easier to implement.

In order to achieve greater efficiency in energy use, some basic steps need to be taken at the European level. Data on energy use and efficiency is collected in 61% of EU regions, but it must be harmonized in order to measure and monitor progress in this area. Benchmarks are needed to determine companies’ performance with regard to energy efficiency on detailed subsector levels. Companies can furthermore contribute to reducing regional energy consumption with new arrangements of space and working times, which would reduce the need for commuting.

Through pilot projects, regions can support the development of markets for energy efficiency on the basis of, for example, white certificates. Along with municipalities, the regional level is decisive for including energy end-users, including SMEs, into European research and demonstration projects, as well as for the implementation of energy efficiency strategies in general.

User information, transparency and comparability of energy bills are considered key elements for fighting energy poverty at the household level. Little is known, however, on how this problem is being addressed in social policies. Therefore, much work still needs to be done before the “European Charter on the Rights of Energy Consumers” can be implemented.

All the policy measures proposed in this report are considered important to fight the different forms of energy poverty in the regions, but some have a higher priority for certain typologies and under different scenario assumptions.

Typology 2, for example, groups the regions with the most unfavourable economic structure, so that industrial diversification strategies are vital to conserve competitiveness. Since this typology is also characterized by high demand for heating and cooling, the construction of efficient networks is another priority. Likewise, regions with high levels of commuting (typology 3) or at the periphery (typology 1a, 2 and 4), with an important dependence on air travel, have a greater need for action in the field of mobility and freight transport.

Social policies play a crucial role for regions type 1a and 2 under the assumptions of the “Business as Usual?” scenario and could be combined with innovative financing measures on the municipal level, for example “Pay

As You Save" schemes. For regions with low disposable income, but considerable PV potential, urban solar planning tools may provide the information necessary to achieve the greatest deployment of these technologies at the lowest cost possible. In Member States that opt primarily for building new nuclear plants and will therefore have a large base load capacity, overall energy efficiency may not be the determining aspect in the corresponding policies, but rather the shift from fossil fuel use to the constant consumption of electricity. A critical question in this context is the influence of consumer preferences, for example for "green tariffs".

European initiatives are especially important where benchmarks are needed, for example in industries with high energy spending, and for promoting regional cooperation through network extension, energy research and the development of a joint and more reliable renewable portfolio. The European framework will furthermore be decisive where major transition processes need to be implemented, mainly with regard to air and freight transport.

Maps of all indicators of energy poverty, explanations on their relevance and data gaps, as well as the statistical data are presented in Annex 1 and 2 of this report. The different research strings applied in this project are discussed in detail in the Scientific Report.

A.1.5. Need for Further Research

The main limitation of the analysis carried out in the ReRisk project is related to the fact that it is based on 2005, i.e. pre-crisis data. Some of the indicators elaborated in this project are appropriate to measure the economic and social impacts of the present recession and should be recalculated when more recent data becomes available. This will make it possible to draw a pre- and after-crisis profile for the NUTS II regions.

Issues that should be explored in more depth through focussed research on NUTS 3 level, using data from regional and national sources, are the actual extent of poverty and the transport modes used for commuting. The regional profiles elaborated in this project could be completed as comparable data on renewable energy resources other than solar and wind becomes available.

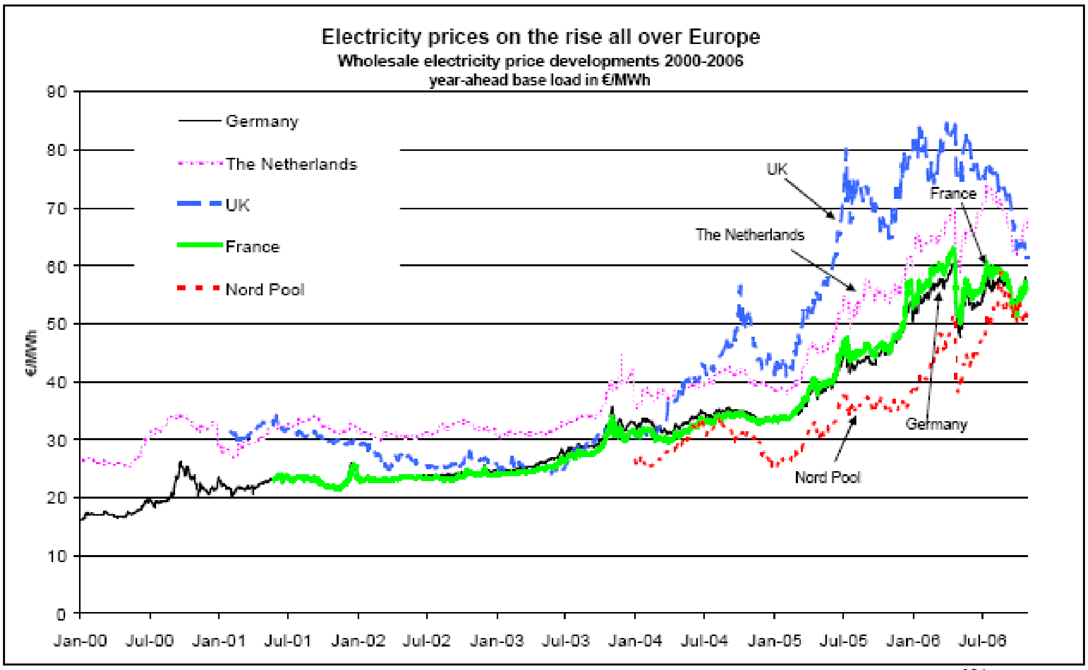
B. Main Report

B.1. Methodology

The ESPON project ReRisk concentrated on the different uses of energy in the regions, rather than looking into infrastructure or production issues, which are often at the heart of energy studies. This approach was chosen, because an earlier ESPON project had already analysed the production side, concluding that "When dealing with energy policy indicators we have to take into account that most of them only have sense at national or EU level" [CEEETA 2005]. Furthermore, the initial market analysis showed that price developments were similar in countries with very different fuel mixes for electricity generation, since most energy markets follow common rules:

Figure 1 Electricity Price Development in Selected EU Countries 2000 - 2006

Figure 38



Source: information received within the scope of the Sector Inquiry from Argus Media, Platts[184], and Nord Pool.

Source: DG Competition Report 2007

Due to the high dependence on oil for transport in all EU countries, fuel price increases spread into the economy and are passed on to the final customer, when possible. All regions in the EU operate in this general framework, but there are differences on how energy is being used in the regions, depending on the regions' economic specialization and their spatial and climate characteristics. Also, the households' capacity to absorb higher energy price increases varies considerably between richer and poorer regions, so these were considered to be the most important research question from the point of view of regional policy making.

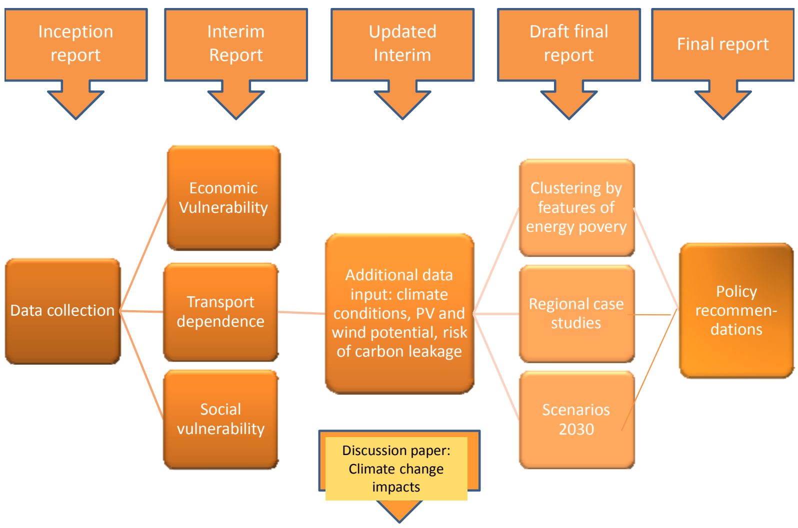
B.1.1. Overall Research Approach

The research carried out in this project was divided in four consecutive phases:

1. The regions' vulnerability was analyzed with regard to industrial competitiveness and employment, their dependence on motorized transport and the main causes for poverty, using a set of indicators for each of these three categories, all based on harmonized Eurostat data. Data on wind and PV potential, as well as temperature data for the last 15 years could be obtained from GIS data provided by the Joint Research Centre and the European Environmental Agency, although some of this data had to be converted to NUTS II level.
2. A clustering process was applied to identify groups of regions with similar levels of vulnerability and development potential. The resulting groups of regions were then compared to earlier ESPON typologies, such as lagging regions, the motors of growth (Pentagon regions) or urban regions with potential for polycentric development.
3. Possible long-term developments in the energy sector were condensed in four scenarios, in order to take into account how the different types of regions might be affected by national and European policy objectives and energy strategies. This scenario exercise was enriched by information obtained from four case studies and a survey of 41 regional energy agencies, which gave insights on the influence that regional administrations have in the energy field, as well as their priorities in this area.
4. Conclusions were then drawn in the form of policy recommendations for actions to be taken on local, regional, national en European level to reduce the vulnerability of regions and grasp the opportunities that are likely to arise from increasing prices for energy from fossil fuel sources.

The research steps carried out in the project are displayed in figure 2.

Figure 2 Overall Research Approach



Source: Own elaboration

B.1.2. Selection of Indicators

However, by putting the focus on energy consumption, the project immediately ran into the problem that there is no comparable data available for the EU regions, so that other indicators had to be used (and sometimes built) in order to measure the regions' vulnerability to rising energy prices indirectly.

The following five factors are especially relevant when identifying regions that are potentially at risk of energy poverty:

1. Regions that have important temperature extremes, i.e., hot climates that need cooling systems and cold climates that have high heating needs (See Map 12 and Map 13 in Annex AN1.)

2. Regional economies, in which wealth creation depends heavily on industries that spend a considerable part of their total production cost on energy purchases. Further, if these industries are an important source of employment for the region, the effect is multiplied. The basic assumption is that if energy is an important cost item, an increase in prices will leave companies with lower net margins, and hence their competitiveness is at risk. And this could affect negatively the economic development and stability of the region itself. (See Map 14 and Map 15)

3. Regions with population bases that have low levels of income at their disposal to affront and absorb increases in their energy costs. This problem is quite like that in the second factor, but at the microeconomic level, where the unit is an individual family, instead of a company. However, the underlying issue is the same: there are economies (in this case family economies), which have less ability to respond to and absorb increases in energy costs. (See Map 23 , Map 24, Map 25, Map 26)

4. The role of transport in a region's economy is also a critical factor. On the one hand, if the transport industry represents an important part of a region's gross domestic product (GDP), a threat to the transport sector's profitability and survival due to increasing fuel costs will have a clear effect on the economic development of a region. And on the other hand, regions where residents have to travel large distances to work, and as a result, transport represents an important cost in the family budget, will also be more affected. Furthermore, increases in the cost of freight transport get passed on to consumers and businesses – the transport company does not accept lower net margins and is not willing to absorb all of these increased costs. Therefore, an increase in fuel prices affects the family not only as they fill up their own car, but also as they purchase any good that had to be transported. (See Map 16, Map 17, Map 20, Map 21)

   An example of a key good that is affected by increased transport costs is coal. When transport costs to ship the coal from the mine to the power plant increase, these costs end up getting passed along to the consumer through higher electricity prices – be it an industrial or household consumer.

5. One last factor that should be included in the analysis for determining the vulnerability of regions with regard to rising energy prices is the potential for generating electricity from renewable resources, which is not necessarily fed into the general electricity grid. Examples of this can include solar-thermal, small wind, biomass, geothermal or PV plants,

which deliver energy for direct consumption. The reason for this is that grid access has costs associated, such as transport and distribution costs as well as taxes. If the production stays off the grid and is consumed directly, these additional costs are avoided by the consumer. As a result, the higher the total price of electricity sourced from the grid, the more competitive installations of renewables for end-use become. (See Map 27, Map 28)

The indicators finally selected, their graphic presentation in maps, the source or mode of calculations, as well as gaps in the data sets are described in detail in Annex 1 of this report. Annex 2 contains the complete data set used in the project.

B.1.3. Methodological Aspects of K-means Clustering

For the purpose of defining appropriate sets of policies for groups of regions with similar features of energy poverty, a clustering process was applied. The calculations were carried out using the cluster algorithm called k-means procedure, which attempts to identify relatively homogeneous groups of cases based on selected characteristics. It is a quick algorithm and the results of the analysis can be easily mapped. The four typologies so identified were further analysed, with the result of splitting the largest typology 1 of “average” regions in two subgroups. The methodology applied is extensively documented in the scientific report.

B.1.4. Methodology Used for Scenario-Building

The scenario building activity in ReRisk was based on explorative prospective that aims to shed light on multiple images of possible futures, which are constructed on the notion of past and present conditions of the studied system. Therefore, the four scenarios created in this exercise are not prognoses or forecasts, but instead they are plausible visions of the future that shed light on the implications of different development trends on a system.

This exercise complies with the four key principles of prospective scenario building: relevancy, consistency, likelihood and transparency [Ritchey, 2007-2009]. The approaches applied for the scenario building process are:

- Exploratory; by using past and present trends leading to the description of likely futures. This includes using data analysis and the case studies carried out within the ReRisk project as point of departure for building the scenarios.
- Anticipatory; by analysing predetermined visions of the future. In this case, four distinct hypothetical visions of the future under high energy prices for year 2030.

The method behind the scenario building exercise is mainly based on the General Morphological Analysis (MA) originally developed by Fritz Zwicky, which is a qualitative method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable problem complexes by using the technique of Cross Consistency Assessment (CCA) [Ritchey 2007-2009]. Accordingly, the scenario building exercise is comprised of two phases: the construction of the scenario bases, which consists of the identification of the drivers, the actors and trends in the studied system; and setting out the four scenarios, which consists of the definition of the hypotheses, CCA and the selection and validation of the scenarios by experts.

B.1.5. Regional Case Studies and Survey

Four case studies on regional energy initiatives, as well as a survey of 41 regional energy agencies and expert interviews added valuable information on the scope of action and the priorities of regional policy makers in the field of energy. The survey, completed in mid-2009, addressed evolving governance structures in response to present and future energy concerns of Europe. The analysis focussed on four key aspects:

(1) the distinctions in policy approach between centralised and decentralised public authorities;

(2) key differences between mechanisms used to implement policies derived from different political scales;

(3) sectoral implications of these varying policy perspectives and implementation mechanisms – in terms of what tends to get governed locally; and

(4) how these conditions effect the mode of decentralised governance for implementing green energy initiatives in practice.

B.2. Main Results

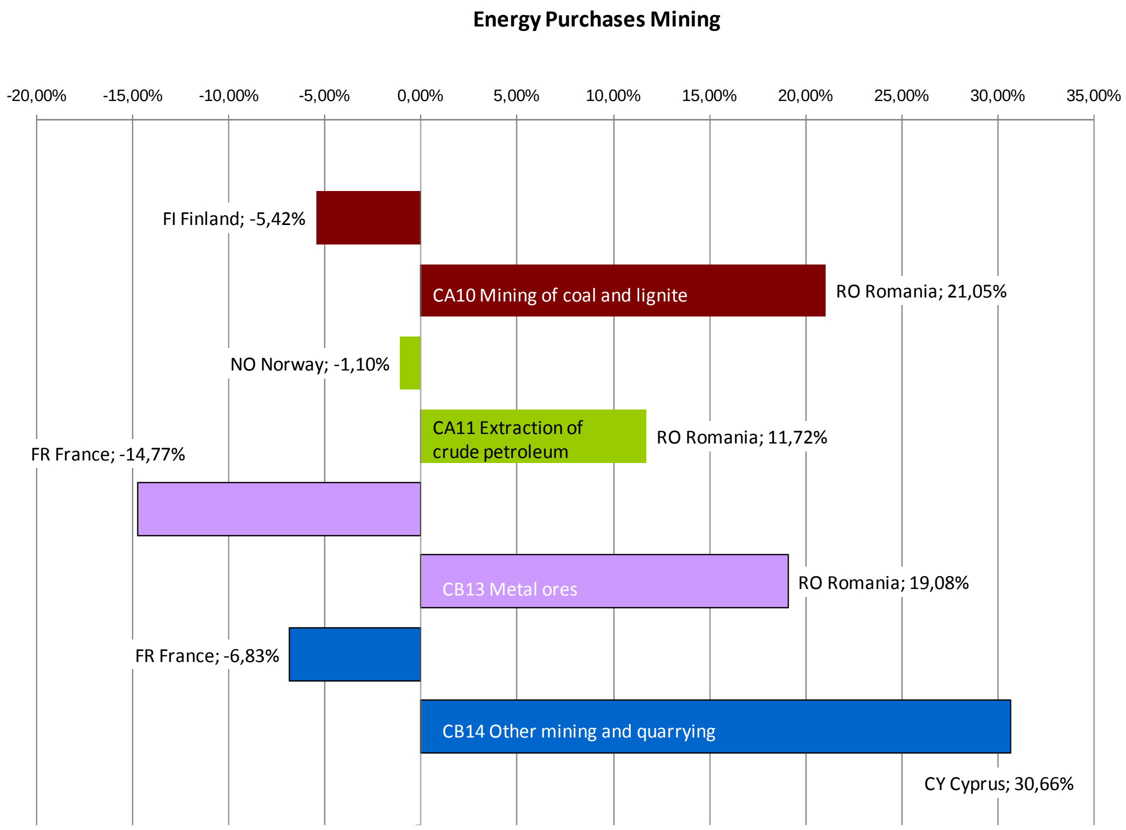
B.2.1. Analysis of Regional Vulnerability

B.2.1.1. Impacts of Rising Energy Prices on Competitiveness of Industries

In terms of competitiveness, it is important for companies to know if their energy costs are higher than those of their competitors. For this reason, energy costs (as percentage of total purchases of industries) were calculated for a large number of sectors and subsectors and compared to the average EU spending. As shown below, differences between the EU countries are considerable.

Divergence in energy spending are especially great in the mining industry, with Romania spending up to 20% more on energy purchases than the sector on EU average, while France and Finland fare considerably better than the rest of EU countries with mining activities:

Figure 3 Country Comparison: Energy Purchases in the Mining Sector
(as % of total purchases, EU average = 0)



Source: Own elaboration based on Structural Business Statistics

Differences in energy spending are also considerable in industry. For example, the chemical industry in Luxemburg spends almost 40% more on energy purchases than the EU average, but the country performs much better in the manufacture of basic metals.

However, in order to obtain a full understanding of how important these differences are for the competitiveness of regions, it is necessary to take into account how much the industries in questions contribute to wealth creation in the region and how many workplaces depend on their performance. The location of industries with high energy costs can be determined by associating regional data on employment and wealth creation (GVA) on NACE 2-digit to the sectors identified in the national comparison. Table 2 shows the region with the highest rate of employment in industries that may be seriously affected by rising energy prices.

Table 2 Regions with more than 10% of Total Employment in Sectors with High Energy Spending

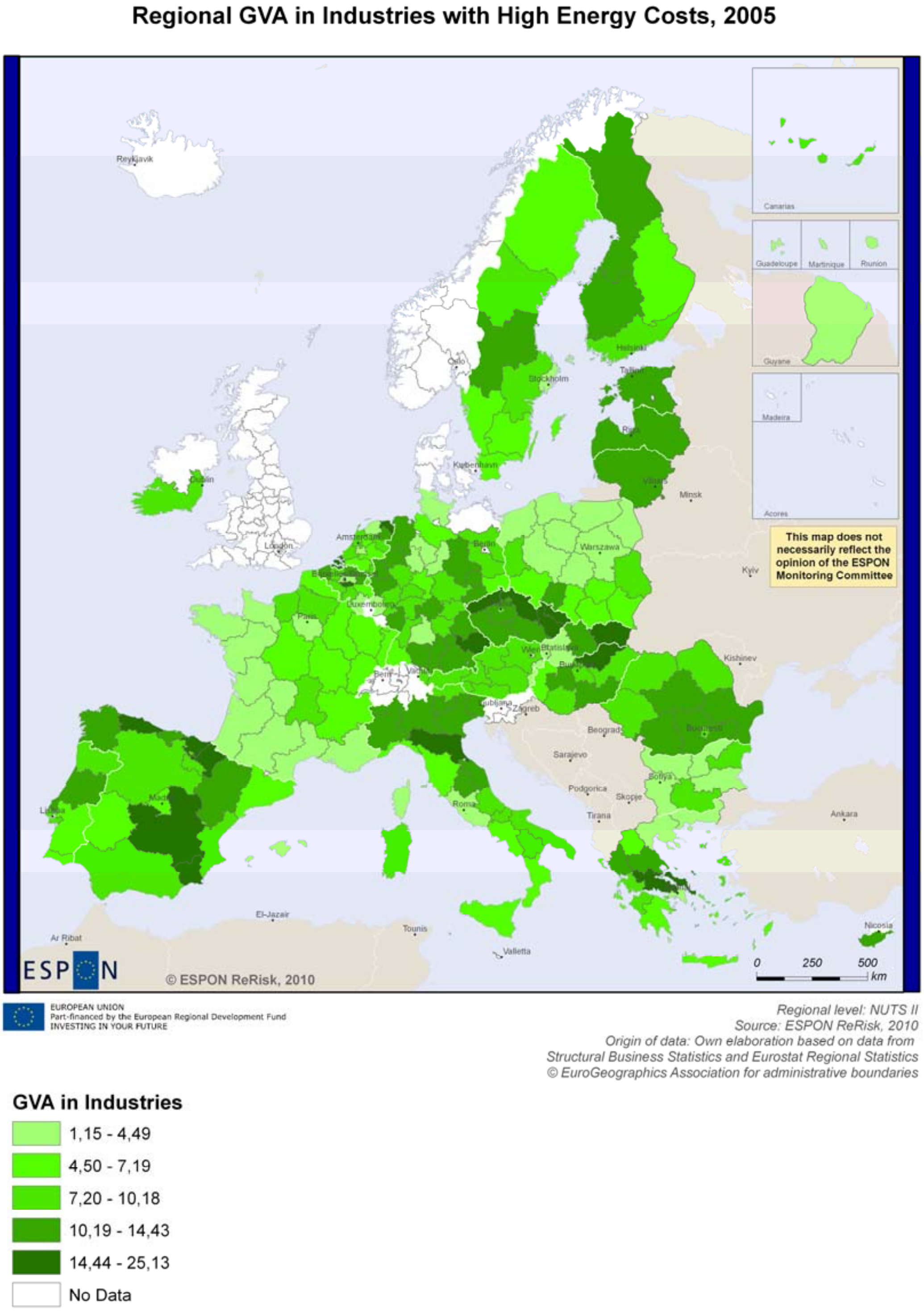
NUTS Code	Region	Employment in industries with high energy purchases / total employment (%)	Total employment 2005
CZ08	Moravskoslezsko	14.23%	535600,00
ITD5	Emilia-Romagna	13.91%	1872400,00
CZ07	Stredni Morava	12.75%	545400,00
CZ05	Severovýchod	12.52%	693900,00
ITD4	Friuli-Venezia Giulia	12.50%	503600,00
ITC4	Lombardia	12.37%	4193900,00
SE31	Norra Mellansverige	12.14%	376200,00
ITD3	Veneto	12.09%	2063200,00
CZ04	Severozápad	11.49%	502200,00
CZ06	Jihovýchod	11.33%	750600,00
ITC1	Piemonte	10.95%	1828800,00
ITE3	Marche	10.41%	634600,00

Source: Own elaboration based on Eurostat data

It should be noted that 5 of the 8 existing regions in the Czech Republic have unfavourable industrial structures in terms of energy purchases. When taking a closer look on how the Czech industries perform with regard to the EU average spending on energy purchases in each of the sectors, we find that even though the divergence is minor, special attention should be paid to the “Manufacture of other non-metallic mineral products”, since energy purchases represent a considerable cost factor in this industry and the value of purchases is slightly higher than the EU median value.

A second relevant aspect of regional competitiveness is the capacity of wealth creation, measured as Gross Value Added (GVA). By comparing the GVA produced in the five sectors with highest energy spending with the total GVA, we can identify a set of regions, which depend heavily on these industries.

Map 1 Regional GVA in Industries with High Energy Costs



In the fourteen regions listed in table 3, more than 15% of GVA proceeds from sectors with high energy spending:

Table 3 Ranking of Regions by Gross-Added Value in Industries with High Energy Spending

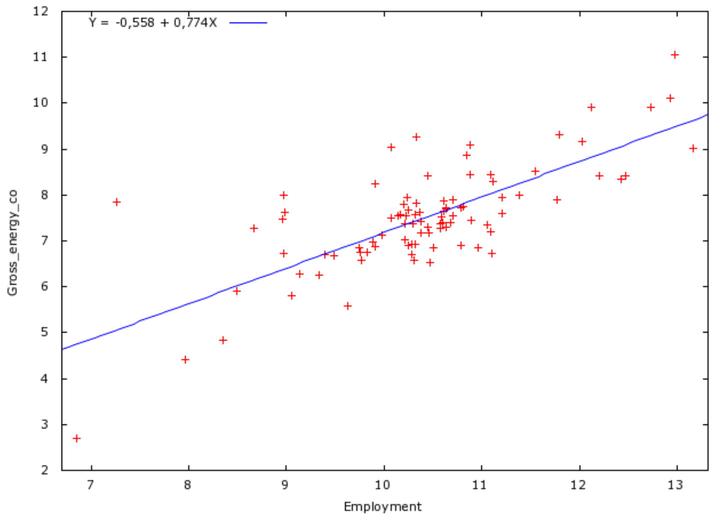
NUTS2_2006	Region	GVA of industries with high energy spending / total regional GVA (%)
CZ08	Moravskoslezsko	25.13%
NL11	Groningen	22.36%
ES12	Principado de Asturias	21.02%
CZ04	Severozápad	20.37%
ES21	Pais Vasco	18.40%
ES22	Comunidad Foral de Navarra	17.82%
DE22	Niederbayern	16.84%
ES42	Castilla-la Mancha	16.76%
BE31	Prov. Brabant Wallon	16.44%
ITD5	Emilia-Romagna	16.25%
CZ07	Strední Morava	16.04%
GR24	Sterea Ellada	15.79%
NL34	Zeeland	15.71%
CZ05	Severovýchod	15.64%

Source: Own elaboration based on Eurostat data

There are some differences to the results on industrial employment, since in this case, three Spanish regions, which had not been identified in the employment analysis, reveal to depend heavily on industries with high energy spending: Asturias, the Basque Country and Navarre. Also, the Dutch provinces of Groningen and Zeeland, Niederbayern in Germany and the Greek Sterea Ellada show a high level of vulnerability to rising energy prices, due to their industrial structure.

For further interpretation of the results, it is important to understand if high levels of industrial energy spending can be used as an indicator for actual industrial energy consumption in the regions and this was checked by carrying out a statistical correlation analysis with consumption data for four countries, for which this information was available in a comparable format and on NUTS II or NUTS 1 level: Germany, UK, France and Italy.

Figure 4 Correlation Analysis between Regional Energy Consumption and Employment in Industries with High Energy Spending



Source: Own elaboration based on national statistics

Further analysis carried out on consumption data for Slovakia, the Czech Republic, Belgium and Greece confirmed that:

- Where detailed information on industrial energy consumption is available, the ReRisk estimates of the regional industrial energy spending can largely be confirmed. Some slight distortion with regard to the actual industrial energy demand in the region may occur in countries with large price differences for the fuels used by industry.
- As a consequence of market liberalization, comparable data on prices and consumption on regional level is even more difficult to obtain than before, which constitutes a serious problem for sectoral and regional policy initiatives aimed at reducing energy demand.

B.2.1.2. Usefulness of Results for Regional Policy-Making

By combining the results of this sequence of analysis on industrial energy spending, wealth creation and regional employment, it is possible to identify those industrial processes, which should be subject to an in-depth analysis on regional level, with the objective of reducing energy consumption and, therewith, the industry's vulnerability to rising energy prices. Some examples can be given for the regions with the most unfavourable industry structure in Italy, the Czech Republic and Hungary.

In the above-mentioned Italian regions of Emilia-Romagna, Lombardia, and Veneto, special attention should be paid to the manufacture of cement (NACE class DI2651), since in this branch, energy purchases represent more than 30% of total purchases and energy spending is almost 10% higher than the EU average. A second critical sector is the "Manufacture of glass fibres" (DI2614), in which more than 18% of purchases are dedicated to energy and energy spending is 8.6% above the average level of spending in the EU. The sector of "Manufacture of other non-metallic mineral products", to which both cement production and manufactured of glass fibres belong, employs more than 30,000 people in Lombardia and Veneto and more than 46,000 in Emilia-Romagna. Although cement production is regionally oriented and is therefore not exposed to international competition, analysing energy use in this industry may help to reduce the elevated level of industrial consumption in these regions.

Table 4 Employment and Industrial Energy Consumption in Italian Regions

Region	Employment in Sectors with High Energy Spending (nº of persons)					Industrial Energy consumption 2004 (in toe)
	DG24 - Manufacture of chemicals and chemical products	DI26 - Manufacture of other non-metallic mineral products	DJ27 - Manufacture of basic metals	DJ28 - Manufacture of fabricated metal products, except machinery and equipment	DK29 - Manufacture of machinery and equipment n.e.c.	
ITC1 Piemonte	13,307	13,947	13,192	78,140	67,035	4.544,2
ITC4 Lombardia	95,949	32,600	48,690	20,2514	16,2037	8.140,7
ITD3 Veneto	13,178	32,731	13,023	97,064	81,240	4.226,6
ITD 4 Friuli-Venezia Giulia	1,967	6,369	5,083	20,450	26,439	1.563,9
ITD 5 Emilia-Romagna	13,532	46,227	7,645	84,930	102,532	4.572,3
ITE 3 Marche	3,397	6,300	2,242	24,109	24,220	838,5

ITF 4 Puglia	1,503	10,763		23,922	10,993	4.621,9

Source: Own elaboration based on Eurostat data and national statistics

In the Czech region of Severovýchod, processes in the "Manufacture of other non-metallic mineral products" should be analyzed, since energy spending in this sector is 10% above EU average on national level and companies in this branch employs 21,564 persons in Severovýchod. Moravskoslezsko has a very high level of employment (28,388 persons) in the basic metals industry and should pay special attention to processes related to "Forging, pressing, stamping and roll forming of metal; powder metallurgy" (DJ284), for which energy spending is about 5% higher than the EU average and represents 7.65% of total purchases. The region consumes 88% of all hard coal used in the Czech Republic and also ranks high in electricity consumption, confirming again the correlation between regional energy spending and consumption2. Additionally, Moravskoslezsko ranks first with regard to wealth creation in sectors with high energy-spending, with more than 25% of regional GVA proceeding from these industries.

All of the above-mentioned regions in the Czech Republic (Moravskoslezsko, Strední Morava, Severovýchod, Severozápad and Jihovýchod) should analyze the performance of one branch of the chemical industry (DG2411 Manufacture of industrial gases), since energy spending in this sector is 10% above EU average and energy represents close to 20% of total purchases. Employment levels in the chemical sector range from 4,225 in Moravskoslezsko to 7,943 in Severozápad.

In the case of Hungary, decision-makers from Észak-Magyarország should take a close look at the "Manufacture of fertilizers and nitrogen compounds" (DG2415), since, on national level, this industry spends 40% more on energy purchases than the industry on EU average and energy purchases amount to almost 60% of total purchases. Észak-Magyarorszá ranks second among the Hungarian regions in employment in the chemical sector (6,215 employees), after Közép-Magyarország with 15,073 employees. Differences in energy spending with regard to Europe are also considerable in the "Manufacture of starches and starch products" (DA1562; >12%) and this may especially affect the region of Dél-Alföld, where 25,444 persons work in the food-processing industry.

The data collected here therefore permits to identify potential weaknesses in regional economies derived from higher than average levels of energy spending and therefore may shed some light on the hitherto obscure question of industrial energy use in the European regions.

[2] The Czech data on regional energy consumption is organized by fuel consumed, not by uses (industrial, household, etc.)

B.2.1.3. Regional Dependence on Transport

Transport is a critical factor in a region's economy. On the one hand, if the transport industry represents an important part of a region's gross domestic product (GDP), a threat to the transport sector's profitability and survival due to increasing fuel costs will have a clear effect on the economic development of a region. And on the other hand, regions where residents have to travel large distances to work, and as a result, transport represents an important cost in the family budget, will also be more affected. Furthermore, increases in the cost of freight transport get passed on to consumers and businesses – the transport company does not accept lower net margins and is not willing to absorb all of these increased costs. Therefore, an increase in fuel prices affects the family not only as they fill up their own car, but also as they purchase any good that had to be transported. These aspects of transport dependency can be documented on the basis of indicators provided by Eurostat and DG Regio.

Table 5 Ranking of Regions by Transport Dependence

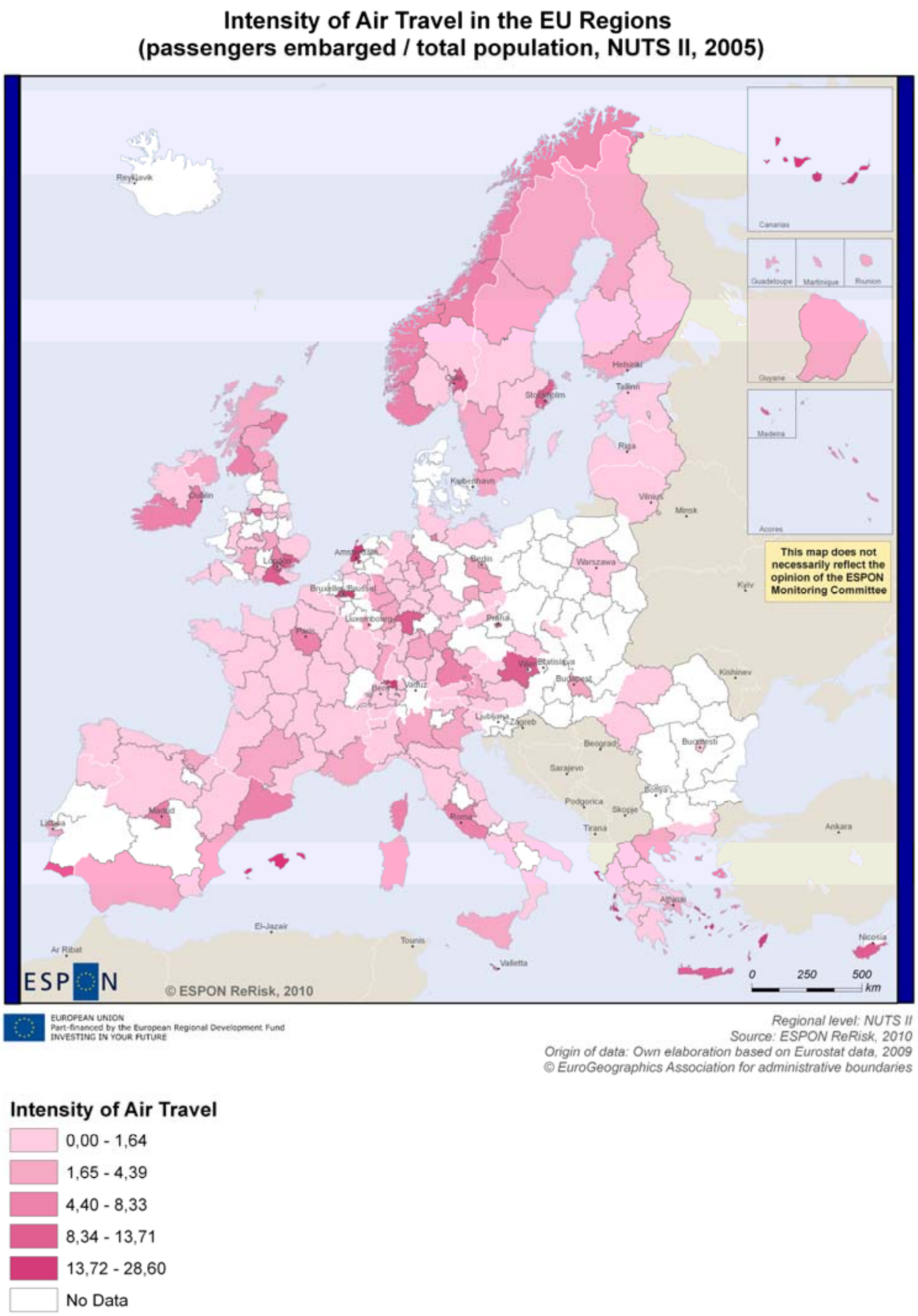
Transport employment / total employment		Fuel costs for freight as % of GDP		Commuting (persons working outside the region / inside the region)		Nº of passengers in air travel / total population (%)	
Region	%	Region	%	Region	%	Region	%
FI20 Åland	60.26	BG32 Severen tsentralen	14.22	BE31 Prov. Brabant Wallon	98.22	ES53 Illes Balears	28.60
DEA2 Köln	45.78	BG34 Yugoiztochen	8.18	UKI2 Outer London	77.29	GR42 Notio Aigaio	19.44
SK01 Bratislavský kraj	38.22	PL33 Swietokrzyskie	7.99	BE24 Prov. Vlaams Brabant	72.92	CH03 Nordwestsch weiz	17.54
FR10 Île de France	27.69	BG33 Severoiztochen	7.16	NL23 Flevoland	60.62	NL32 Noord-Holland	16.93
BE10 Région de Bruxelles-Capitale	26.07	BG42 Yuzhen tsentralen	6.72	AT11 Burgenland (A)	50.66	ES70 Canarias (ES)	15.78
ES30 Comunidad de Madrid	25.45	PL43 Lubuskie	6.67	DE93 Lüneburg	48.34	BE24 Prov. Vlaams Brabant	15.32
DE50 Bremen	25.25	PL34 Podlaskie	6.59	BE35 Prov. Namur	45.16	UKI Outer London	15.00
DE71 Darmstadt	24.20	BG31 Severozapaden	6.39	BE34 Prov. Luxembour g (B)	45.14	GR2 Ionia Nisia	14.85
PL12Mazowi eckie	24.09	CZ02 Strední Cechy	6.27	UKH2 Bedfordshir e Hertfordshir e	37.17	DE7 Darmstadt	13.71

Source: Own elaboration based on data from Eurostat and DG Regio

Differences in transport dependence are considerable between the EU regions in each of the above categories. The combination of transport indicators reveals that the most vulnerable regions are the large logistic centres, peripheral and island regions, but also some rural regions dependent on working opportunities in nearby urban poles or agricultural regions with high export levels.

Map 2 highlights the regions with the highest intensity of air travel, which are likely to suffer important impacts on competitiveness and employment as a consequence of rising prices for aviation fuel:

Map 2 Intensity of Air Travel in the EU Regions

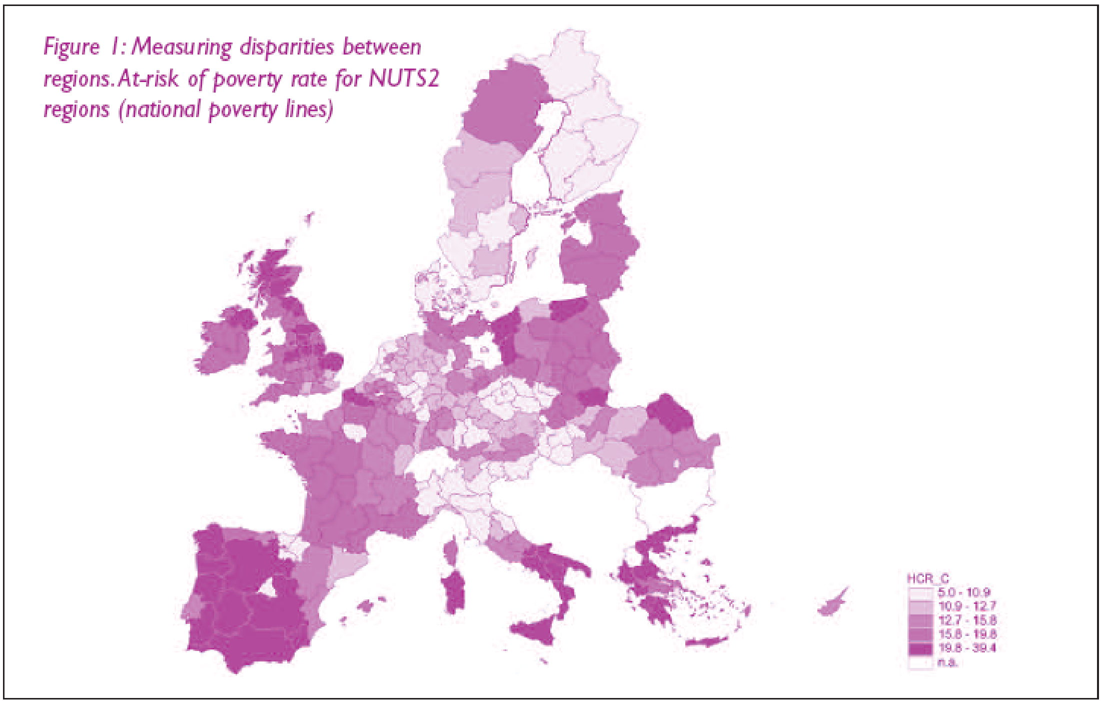


B.2.1.4. Social Vulnerability

Since the main European indicator for poverty, the “at-risk-of poverty rate”, is presently not compiled for the regions, is has been necessary to measure the vulnerability of households to rising energy prices using a set of indicators, which are the cause of poverty [EC 2005], according to research carried out on national level.

Some pioneering work for defining the right indicators for measuring poverty on **regional level** has been done for the *Community Action Programme on Social Exclusion* [Lemmi 2003] showing that there is a need for measuring poverty not only with respect to the national poverty lines, but also within the NUTS II regions.

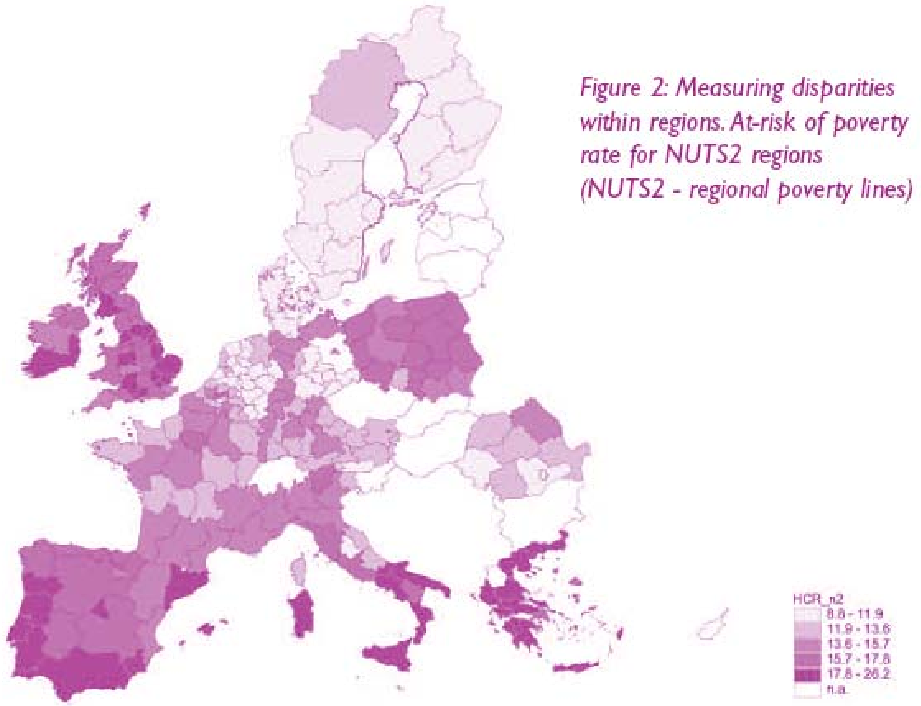
Map 3 At-Risk-of-Poverty-Rate for NUTS II (National Poverty Lines)



Source: Community Action Programme on Social Exclusion

The study carried out by researchers from the University of Siena recommends “using regional poverty rates with national and regional poverty lines as two separate indicators (see map 3 and 4). Interestingly, this illustrates that specific regions, such as capital city areas (Paris, Madrid), appear to count fewer poor people in relation to the national poverty line, but are characterised by greater inequalities within the region itself.

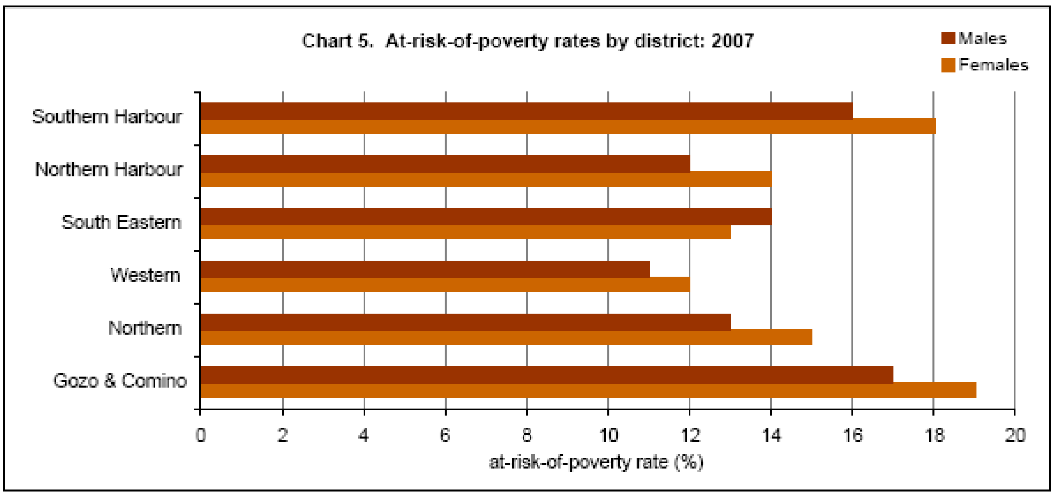
Map 4 At-Risk-of-Poverty-Rate for NUTS II (Regional Poverty Lines)



Source: Community Action Programme on Social Exclusion

It should, however, be noted that in some countries, the risk of poverty is directly measured by the statistical offices for lower than NUTS II units, so that this problem can be further investigated, for example, in Malta:

Figure 5 At-Risk of Poverty Rate 2007 in Districts, Malta



Source: National Statistics Office, Malta

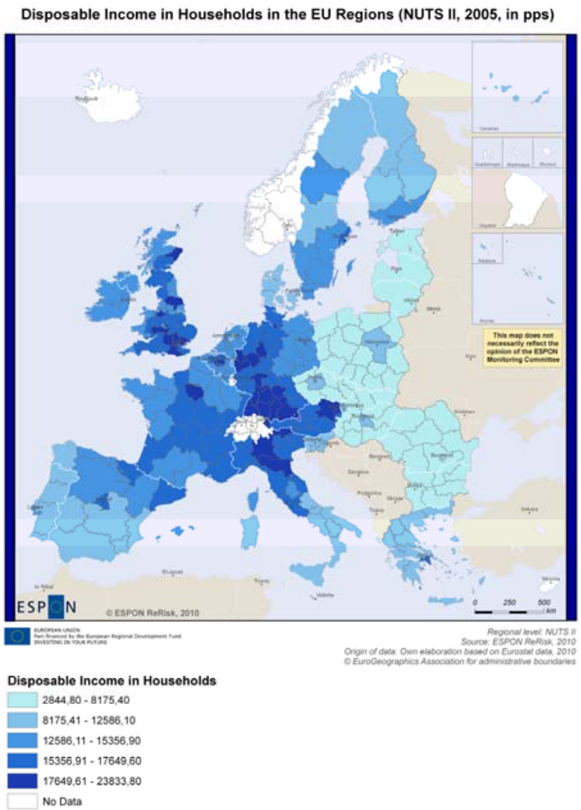
The data behind the at-risk-of-poverty rate has been analyzed in detail on national level, showing that unemployment, although important, can not fully explain the poverty level, because 27% of the poor population in Europe is working. In the Eastern Countries, the number of “working poor” tends to be much higher, for example, 44% in Lithuania. The unemployed only make up 12% of the poor population in the EU 27, although this percentage is much higher (above 30%) in the Czech Republic or Denmark. The different forms of “inactivity” (unemployed, retired and other inactivity), however, have a strong influence on the risk of poverty, as 73% of the poor population in Europe is affected by this situation [EC 2005].

Both, unemployment and activity level can be measured directly by available indicators, and can be completed with the old-age dependency ratio, which highlights the percentage of older people whose well-being depends on the generation that is presently active in the labour market.

Finally, data on available income in the regions can be used to assess the overall “richness” of the population and their capacity to invest in, for example, energy efficiency measures or renewable energy.

All four indicators confirm that the East-West and South-North divide in social terms subsisted in the European Union in 2005. Income disparities are especially important with regard to rising energy prices.

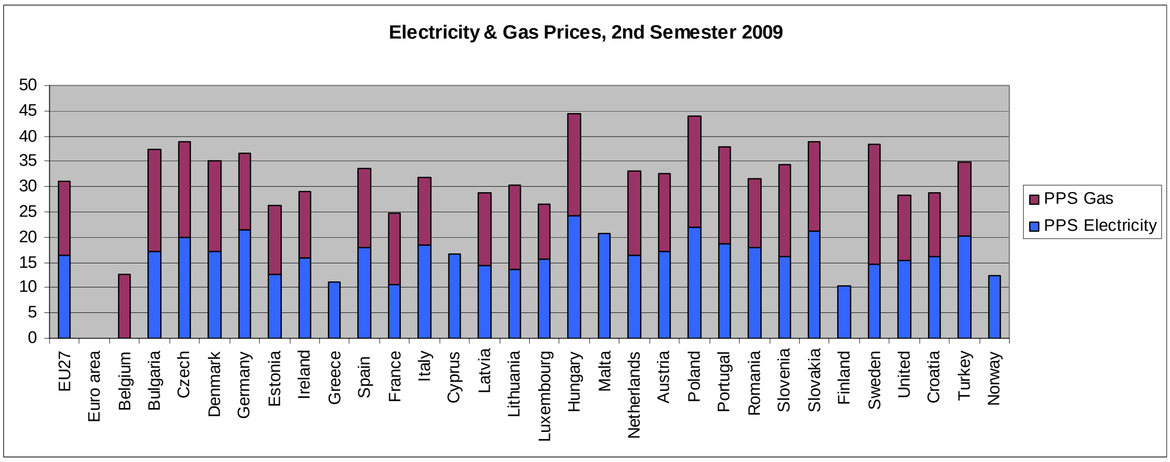
Map 5 Disparities in Household Incomes in the EU Regions (in pps)



The comparison between regions makes disparities in Europe much clearer than national statistics do: people living in the poorest region in Bulgaria – Severozapaden – earn less than 12% of the average income in Inner

London (measured in pps), but Bulgarians pay on average 17.07 pps for 100 kWh, while the British pay 15.37 pps.

Figure 6 Electricity and Gas Prices in Member States, 2009 (pps)



Source: Own elaboration based on Eurostat News Release 75/2010, 28 May 2010

This example makes it quite clear that the actual dimension of the risk of energy poverty – at least on household level – can only be fully understood when taking into account regional realities.

B.2.2. Clustering of Regions by Features of Energy Poverty

The indicators used for describing different features of energy poverty in the European regions have been submitted to a clustering process in order to identify groups of regions with similar characteristics, which could be addressed by policy initiatives. The calculations were carried out using the cluster algorithm called k-means procedure, which attempts to identify relatively homogeneous groups of cases based on selected characteristics. [Kalogirou 2003].

In a first step, the indicators elaborated in the initial phase of the project (data collection) had to be checked with regard to their appropriateness for the clustering exercise. 20 indicators for 287 regions were available, but some had to be excluded, because they a) had small size, b) were correlated with other variables, c) had extreme values, or d) be much-skewed.

After this check of data quality, 11 indicators were considered appropriate for the clustering exercise. However, these indicators were not deemed to be equally important for measuring the regions' vulnerability to rising energy prices. Therefore, they were weighted based on expert judgement in a workshop held in Bilbao in October 2009. After this selection, 9 indicators reflecting the different features of energy poverty (climate conditions, economic structure, transport dependency, social vulnerability and production potential of wind and solar energy) were used in the clustering exercise.

The initial set of indicators is presented in table 6, grouped in five categories. The indicators in bold fonts passed both the statistical and policy relevance tests, whereas those in italic fonts failed these tests. Indicators in standard fronts were found inappropriate for analysis, due to statistical flaws.

Table 6 Final Set of Indicators Used for the Clustering Exercise

Category	Indicators
Climate conditions	**Mean maximum temperature July (Max T July)**
	Mean minimum temperature January (Min T Jan)
	Mean annual temperature (Mean T)
	Mean maximum annual temperature (Max T)
	Mean minimum annual temperature (Min T)
Economic structure	**% of employment in industries with high energy purchases**
	% of GVA in industries with high energy purchases
	Private energy use
Transport dependency	**Spending on transport fuel for freight as % of GDP**
	Population commuting to other regions / population working in the same region
	Employment in the transport sector as % of total employment
	Age of car park (Average age of cars)
	Number of passengers travelling by air / total population
Social vulnerability	**Long-term unemployment rate**
	Disposable income in households
	Age dependency ratio
	Economic activity rate
Production potential of renewables	**Onshore wind power potential 2005**
	PV potential
Other	Region Area Size

Table 7 displays the weights associated to each indicator during the clustering procedure. As there are two variables in each category except for the category of economic structure, the original weight applied to employment in industries with high energy purchases was doubled from 2.50 to 5.00 in order to give a similar importance to each category of indicators and to avoid underestimating the possible impacts on the competitiveness of industrial regions with high energy costs.

Table 7 Indicators' Weights

Indicator	Weight
Climate conditions	
Mean maximum temperature July	1.86
Mean minimum temperature January	2.00
Economic structure	
% employment in industries with high energy purchases	5.00
Transport dependency	
Fuel costs of freight transport	2.43
% workers commuting	2.21
Social dimension	
Long-term unemployment rate	2.64
Disposable income in households	2.36
Production potential of renewables	
Wind power potential	1.86
PV potential	2.14

Despite of the efforts made to achieve the broadest geographical coverage possible, about 50 regions could not be considered in the cluster analysis, because at least one value was missing. The main data gaps refer to Iceland, Denmark, Switzerland, Norway and the French Overseas Territories. However, it was possible to group 237 of the 287 NUTS II regions in EU 27.

In the next pages the results of the clustering exercise are discussed. The analysis was done in two consecutive steps, as explained in detail in the Scientific Report.

Table 8 Characteristics of the Regional Typologies (Cluster Centres)

Mean Values	1a "With problems and potential"	1b "Well-off, with trouble ahead"	2 "Struggling, looking for jobs and a brighter future"	3 "Wealthy and commuting"	4 "Cool and windy, but working"
Maximum temperature July	32.36	30.66	33.70	30.46	26.17
Minimum temperature January	-6.21	-7.55	-11.80	-6.81	-17.59
% employment in industries with high energy purchases	3.41	5.22	5.28	3.60	6.14
Fuel costs of freight transport	1.93	1.89	5.23	1.73	2.37
% workers commuting	4.28	13.71	3.54	48.70	3.67
Long-term unemployment rate	39.15	37.00	48.44	36.51	18.75
Disposable income in households	14,176.55	15,968.78	7,144.57	16,917.15	12,631.45
Onshore wind power potential	108,004.23	69,263.38	153,859.09	65,568.82	843,163.27
PV potential	1065.27	896.13	1041.70	857.19	833.83
Number of regions in cluster	91	73	47	15	11

B.2.2.1. Description of the Characteristics of Each Typology

Typology 1a - "With Problems and Potentials"

This typology is the most geographically dispersed among the five groups, meaning that the regions included have some marked differences with regard to the cluster centre, which should be taken into consideration when applying the characteristics to specific regions.

The diversity is reflected by the fact that it includes most of the capital regions such as Paris, Berlin, Rome, Budapest, Amsterdam, Madrid, Stockholm, Bucharest, Athens, Sofia and others, representing clear-cut urban centres, as well as a large number of communities with a low population density, spread around in what could be characterized as more rural parts of Europe. The appearance of two such different categories in the same typology has to do with the weighing of indicators. The typology is characterized by having the *lowest level of employment in industries with high energy purchas*e, a situation which can typically be found in semi-peripheral and semi-rural areas, but also in capital regions, where both labour-intensive activities and public and private service centres are located.

The economic structure is likely to be rather robust to increasing energy prices, due to the emphasis on activities with low energy intensity. However, it has to be remembered that some of the capital regions are important hubs for air travel and transport and may be affected by increasing fuel prices. Another characteristic of the regional production systems is the low level of workers commuting to other regions. This, again, connects to the capital poles, which are the destination of commuting, but also to the general larger area size of the semi-peripheral and rural regions belonging to the typology.

On the other hand, the larger distances and lower level of commuting to other regions exposes the regions to a higher long-term unemployment rate, just as the more peripheral characteristics of this group of regions explains the medium disposable income in the households. In relation to the option of renewable energy generation, the medium-high wind power potential as well as a generally very high PV-potential provides an excellent basis for a shift towards alternative energy supplies. However, the high summer temperatures in combination with moderate winter temperatures make cooling during summer inevitable, while heating requirements during winter are rather limited.

Typology 1b - “Well-off with Troubles Ahead”

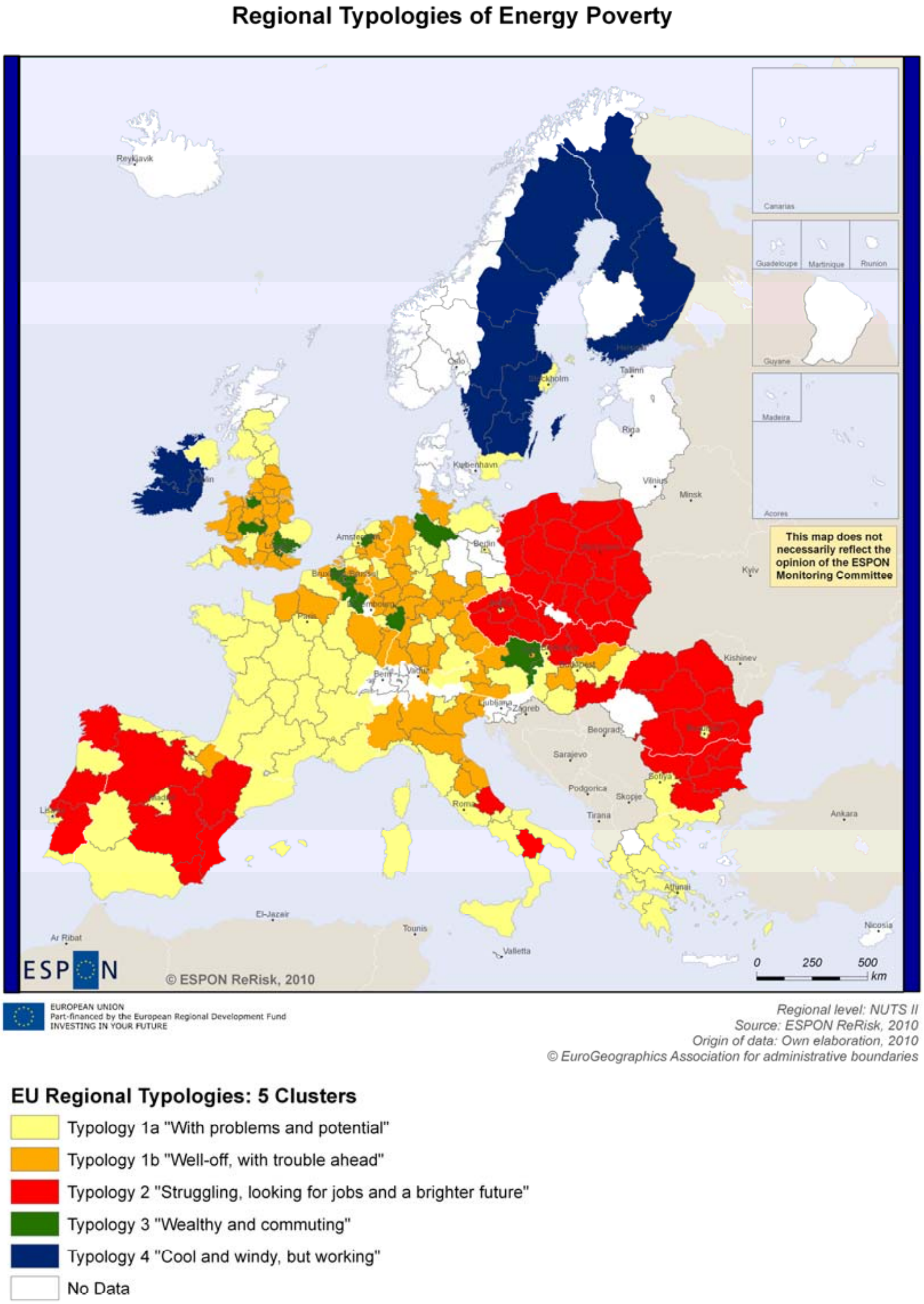
In contrary to the dispersed structure of typology 1a, this group of regions is much more concentrated and located around central Europe. It includes some of the most densely populated regions of Europe, characterized by a high level of industrialization, and a medium level of employment in industries with high energy purchase.

The rather low fuel costs may be a conditioning factor for maintaining the present economic structure in these regions. The combination of regions with relatively small area size and high demand for labour is resulting in a situation with a higher than average number of workers commuting between the regions, as well as high levels of disposable income.

Changes in the economic structures during the last decades have, however, resulted in long-term structural unemployment rates in the higher end. This has especially been the case in relations to large-scale energy intensive activities that used to be a cornerstone of the economies, but are now in the process of being replaced by more knowledge-intensive activities.

In relation to the options of alternative energy resources, this type of region is characterized by both low wind power and low PV potential. The typology includes regions with rural and semi-rural characteristics both in relation to coastal and mountain areas, whose closeness to major urban centres provide them with potential for developing both tourism and second homes. The combination of medium level maximum summer temperature and relatively warm mean temperatures in winter limits the requirement for cooling and heating.

Map 6 K-means Clustering of the Normalized and Weighted Values of the Original Indicators of Energy Poverty in EU Regions (NUTS II) – 5 Typologies



Source: Own elaboration

Typology 2 - “Struggling, but Looking for Jobs and a Brighter Future”

This typology is very coherent in its characteristics in spite of the regions included being geographically dispersed. This group of regions is characterized by a large number of jobs in industries with high energy purchases. The reason for this that it includes those regions, which form the traditional core centres of heavy industry, that have been able to shift towards more knowledge-intensive activities to a lesser degree than the ”Well off – with troubles ahead” typology. And with this shift being a stronghold of typology 1b, regions in typology 2 tend to become a semi-periphery to the central growth regions, experiencing challenges in the transition to the new knowledge economy.

The regions are characterized by spending an important share of GDP on fuel costs and low levels of commuting to other regions. Due to their dependence on heavy and energy-consuming industries, these regions are becoming increasingly exposed to global challenges – the are to some extent caught in a catch-22 situation, because maintaining the present economic base requires the perpetuation of the present economic model and energy supply system, but this is at the same time blocking the introduction of alternatives.

Consequently, the typology is presently exposed to a very high level of long-term unemployment rate, making the transition to new economic activities even harder. Also, the level of disposable income in households is very low, which makes it difficult to rely on private investment during policy implementation.

With regard to access to renewable energy sources, the typology shows a rather diverse structure. The wind power potential of this group of regions is the second highest in Europe, due to the inclusion of several coastal regions and others with open plains and mountain ridges, providing good opportunities for wind power generation. Due to the Southern location of many of the members of this typology, the PV potential is also fairly good – the second highest, only surpassed by typology 1a. This would enable many of the regions to move towards a “brighter” renewable energy future, if the resources can be found to realize this potential. However, regions in the Southern parts of Europe are also exposed to high summer temperatures requiring cooling appliances, while the more centrally placed regions with continental climate experience very hot summers and also very cold winters, with considerable energy demand for both cooling and heating.

Typology 3 – “Wealthy and Commuting”

The “wealthy and commuting” typology comes rather close to group 1a and 1b in relation to most variables. With regard to climate conditions, industrial employment, fuel costs, PV and wind energy potentials, as well as unemployment levels and income characteristics these two types of regions are quite similar. Some minor deviations are apparent, especially to typology 1a where both wind power and PV potential is substantially higher than in the typologies 1b and 3.

One important factor, however, separates 3 from all other regions, namely the level of workers commuting to other regions. With magnitudes of five to 20 times higher than the average values for the other typologies, this difference is a marked characteristic. The very low fuel costs, in combination with smaller area size and shorter distances as well as well rather dense private and public transport networks, allow for a very high level of workers commuting to other nearby regions. This accessibility is therefore crucial for maintaining the presently low level of long-term unemployment and high level of disposable income in households.

In relation to renewable energy sources, the major part of this group of regions is, however, characterized by low potential both for wind power and PV, so these regions should look to other renewable sources to develop, for example energy from waste. The medium level maximum summer temperature in combination with moderate mean minimum temperature limits the need of both cooling in summer and heating in winter.

Typology 4 - ”Cool and Windy – but Working”

Three components are characterizing this “cool and windy – but working” typology. Firstly, the general rural characteristics of the regions, with sparsely populated areas. Secondly, this group of regions shows a general pattern of relatively large-sized regions and consequently marked distances between urban centres. And thirdly, these regions have a very high potential of wind power.

While the regions encompass a medium-high percentage of employment in industries with high energy purchase, in combination with average fuel costs, the accessibility limits interaction between regions, resulting in a lower than average percentage of workers commuting to other regions.

Due to a combination of both traditional and new types of industries, however, the economic diversity within the typology results in very low long-term unemployment rates. This positive aspect can partly be attributed to a tradition of public sector activities, providing jobs in services, infrastructure, and production. This economic background provides a medium disposable income to households.

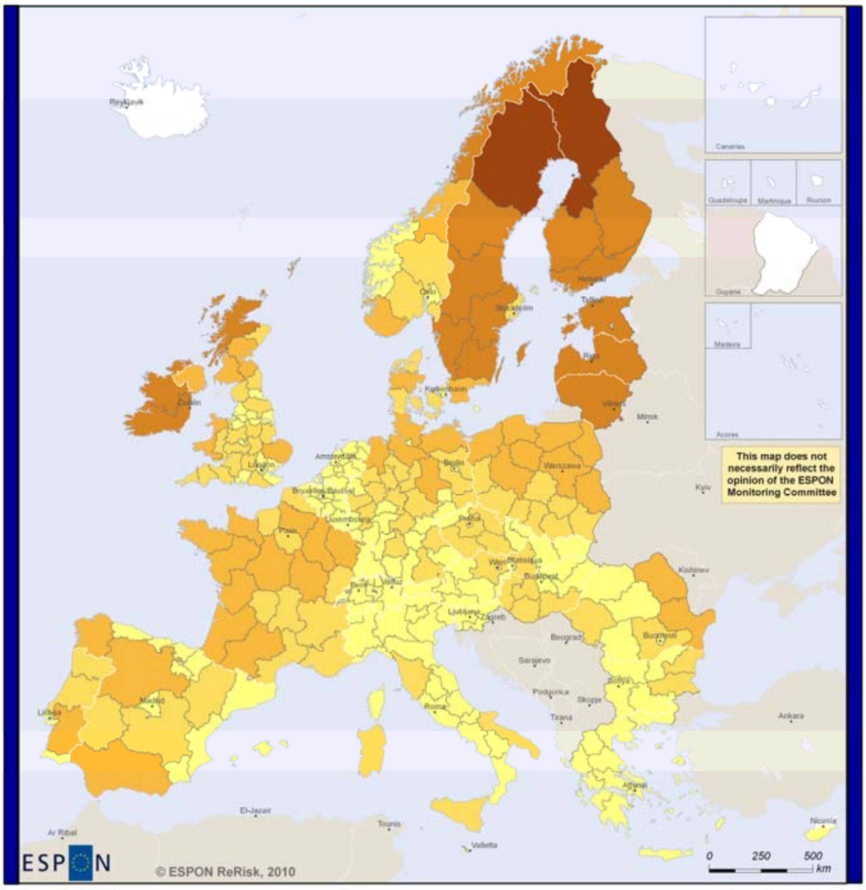
With regard to energy production and demand, the typology 4 regions are characterized by a very high wind power potential, but also a very low PV potential. Biomass is another renewable energy resource exploited in the regions, and, although it has not been included as an indicator in the general analysis, the fact that several renewable resources are available at the same time adds to the likelihood that through “learning by interaction” processes and increasing political awareness of the potential economic role of renewable energy, new sources of energy supplies will be tapped.

On the negative side, the extremely low maximum July temperatures and very low mean minimum January temperatures create the need of heating during winter – and some times also during summer, and the extreme peripheral location of the regions could pose a problem in view of rising transport costs.

Map 7 on the next page hightlights the regions with the greatest wind power potential, with high wind speeds and large area size.

Map 7 Wind Power Potential in the EU Regions (m/s/km²)

Wind Power Potential in the EU Regions (NUTS II)



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Regional level: NUTS II
Source: ESPON ReRisk, 2010
Origin of data: Own elaboration based on European Topic Centre on Air and Climate Change (ETC/ACC) data on wind intensity, 2009
© EuroGeographics Association for administrative boundaries

Wind Power Potential

- 0 - 79180
- 79181 - 204546
- 204547 - 487852
- 487853 - 1031076
- 1031077 - 1795408
- No Data

B.2.2.2. Comparison to Previous ESPON Typologies

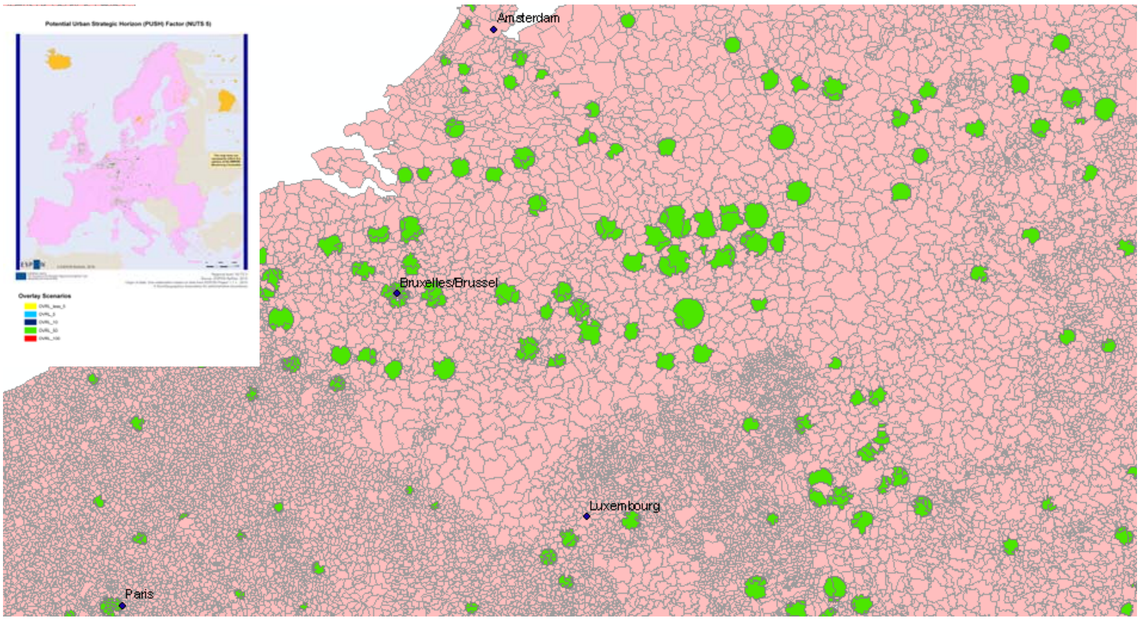
Although the established typology can be considered a broad view of regional characteristics, it provides a valid framework for analysing both the present and the future regional vulnerability, linking the typologies to the scenarios. Additionally, it is useful for the comparison with findings from previous ESPON projects on regional typologies, on the base of which adjustments to regional policies addressing regional competitiveness and cohesion can be proposed.

Among the previous ESPON typologies, the following have been considered most useful for comparison:

1. **Lagging regions**: this typology is based on GDP per inhabitant (EURO) and unemployment rate. The majority of these lagging regions, and especially those from Eastern Europe, are included in the ReRisk typology of "struggling" regions. Some of these regions, however, fare slightly better and belong to those considered "with problems and potential" (typology 1a), which also groups a large number of "potentially lagging" regions. The differences could be due to a considerable improvement of the unemployment rates between 2000 (reference year for the study on lagging regions) and the 2007 data for long-term unemployment used for the present study in some Spanish, Italian, Greek and Hungarian regions with a low presence of heavy industry.
2. **Multimodal Accessibility Potential**: this is a five class typology ranging from very central to very peripheral regions. There is a strong coincidence between this typology and the one developed in the ReRisk project: typology 1a "With problems and potential" groups most of the Southern (French, Greek, Italian, Spanish and some Portuguese) peripheral regions with high solar potential. The "Well-off"-typology 1b is mostly made up by central and intermediate regions, while the "struggling regions" includes most of the peripheral regions in Eastern Europe. The "wealthy and commuting" regions are exclusively intermediate, central or very central, whereas the Nordic and Irish peripheral regions form part of the "cool and windy" typology.
3. **Regions in the Pentagon**: the Pentagon is shaped by London, Paris, Munich, Milan, Hamburg and their surrounding areas. Pentagon regions are considered to be the motor of economic growth in Europe and therefore crucial for Europe's competitiveness. The "wealthy and commuting" group is mostly made up of regions belonging to the Pentagon "hinterland", while most of the capital areas belong to typology 1a and the more industrialized Pentagon regions to typology 1b. This division indicates that rising energy prices will affect these areas in a different form and that strategies to cope with this challenge and to preserve competitiveness will vary.
4. **PUSH Potential Urban Strategic Horizon**: the PUSH factor was calculated as one of the Functional Urban Area in ESPON project 1.1.1. on NUTS 5 level, identifying well-connected local hubs that can be reached in 60 – 90 minutes travel by car from the surrounding areas. In terms of spatial planning, regions with a high number of PUSH areas are considered to offer opportunities for polycentric development. Most of these regions form part of the Pentagon and

belong to the well-off typology 1b or to the “wealthy and commuting” areas. However, some UK regions outside the Pentagon also have a high potential for polycentric development, and so does Vienna. Island and very peripheral areas – both in the South and the North of Europe - show much lower potential for polycentricity, but, in this case, these regions are equally distributed between the two worse-performing typologies and the group of “cool and windy” regions. However, in the context of the ReRisk project, the data elaborated in ESPON project 1.1.1. is mainly useful for analysing in detail where the potential areas of high levels of commuting are located, as exemplified in map 8, which presents a zoom of the PUSH areas on NUTS 5 level for Belgium :

Map 8 PUSH Areas in Belgium



Source: Own elaboration based on data from ESPON project 1.1.1.

5. **Coastal regions:** the spatial typology of coastal regions is relevant for energy consumption and production, although recent analysis on NUTS 3 coastal regions [Eurostat 2009 and 2010] indicates that there are great differences in this type of regions with regard to the employment structure, unemployment level and attractiveness for senior citizens. With regard to energy use, the main feature is that of high level of seasonal demand for energy and water in tourist regions. Harbour regions are often home to industries with necessity to access the international transport lines and therefore have a different employment structure. In terms of energy production, coastal regions tend to have a high potential for onshore and offshore wind and could offer opportunities for developing wave and tidal energy technologies. The distinction between industrial and tourist coastal regions is evident in the ReRisk typologies: the first ones belong primarily to typology 1b “Well-off with troubles ahead”, while the more rural and tourist-oriented, mainly Southern regions form part of typology 1 a “with problems and potential”. Obviously, the group of “cool and windy” regions is also made up mainly of coastal regions.

6. **Island regions:** some of the Island regions could not be considered in the clustering exercise for lack of data, but all those with complete data sets form part of typology 1a, the one with the most service-oriented economies, but also relatively high levels of long-term unemployment. With regard to energy poverty, islands face specific risks, since they rely on smaller and more expensive energy production systems, generally based on imported fuels and depend heavily on air or maritime transport. In terms of economic vulnerability, insular regions, in general, are not dependent on industries with high energy spending, although Cyprus performs worse, due to its specialization in the processing of food products.

B.2.2.3. Conclusions on Regional Typologies

Attending to these previous typologies and their coincidence and differences with the ReRisk results, the following profiles can be drawn:

Typology 1 a "with problems and potential" contains two groups of regions with low exposure to rising energy prices for industry: the service oriented urban centres – the hearts of the Pentagon - and semi-rural, often tourist-oriented coastal and island regions in the South of Europe. The high PV potential of many of the regions in this latter group is an important asset for the future and could help to ease the strain of high demand for cooling in the summer time. However, the capital areas must be prepared for possible changes in transport patterns as a result of rising energy prices, both in terms of commuting (incoming labour) and loss of traffic volumes in the transport hubs. Also, the higher than average unemployment rates in 2007 are an indicator for possible social problems both in the semi-rural and capital areas.

Typology 1 b "Well-off, with trouble ahead" is made up of central, industrialized regions, including the more industrial coastal (harbour) and Pentagon areas, with low potential for developing wind and solar energy. The competitiveness of these regions could be severely affected by rising energy prices if efforts to improve energy efficiency in industry and transport fail, but their starting position is much more favourable than that of regions grouped in typology 2.

Typology 2 "Struggling, looking for jobs and a brighter future" is composed of the most vulnerable regions in terms of social cohesion, located mainly in the East of Europe, with high energy demand both for heating and cooling. These mostly peripheral regions do have potential to develop renewable energy systems, but lack the resources to do so. The number of regions grouped in this typology is smaller than those considered lagging, according to data from 2005 – 2007, but may have increased considerably in the wake of the economic recession.

Typology 3 "Wealthy and commuting" is mostly made up of regions belonging to the Pentagon "hinterland", in which wealth creation is dependent on accessing near-by centres of economic growth. The main challenge related to rising energy prices in these regions is that of guaranteeing affordable mobility. There is a high potential for polycentric development in these regions, but fewer possibilities for using wind and solar power.

Typology 4 "Cool and windy, but working" is very special in terms of features of energy poverty. The greatest concern is the heavy industrial base, combined with extreme peripheral location on the coastline and the high energy demand for heating in these, mostly Nordic, regions. However, opportunities for the further development of wind energy are considerable and the risk of energy poverty in households is low as long as the job situation remains as it was in 2007.

B.2.3. Long-term Scenarios

The four scenarios, which were elaborated in the context of the ReRisk project in two workshops with outside experts from the fields of energy policy and spatial planning, describe how different development paths in the energy sector may affect the European regions and cities in the medium and long term, both in terms of competitiveness and cohesion. This approach is necessary, since energy - like spatial - planning requires the development of infrastructure and therefore operates with a time horizon of 30 to 60 years. The energy sector is presently undergoing a far-reaching transition process, and the political and investment decisions that are now being made will shape the framework for regional competitiveness for time to come.

The scenarios are based on the common hypothesis that energy prices will remain at a high level, but political response to this challenge is different. Scenario 1 “Green High-tech” assumes a quick development of renewable energy sources, both large and small-scale, in which the regions gain greater influence on energy policy. In this scenario, regions can specialize on certain types of renewable energy production and will win from cooperation and shared networks.

The second scenario “Energy-efficient Europe” assumes a greater use of natural gas by 2030, while trying to keep Europe’s energy dependency within limits through important efficiency gains in all sectors and a move towards more regionalized economies. In this situation, regions that depend on gas supplies from one producer region only, will have to deal with a higher risk of supply interruptions, but economic development will probably follow a fairly balanced and more sustainable path.

In the case that the present plans for expanding the use of nuclear energy are actually implemented in a large number of Member States, as assumed in “Nuclear Energy for Big Regions”, it has to be expected that the power sector will remain highly centralized, since few players are able to carry out the needed investment. The logical consequence would be to “go electric” both in industry and transport, but these decisions will be little influenced by local and regional policy makers.

Choosing (clean) coal to fill the gap of dwindling oil reserves, as described in “Business as Usual?”, would obviously benefit the mining and some harbour regions and fits well into certain protectionist ideas in Europe. However, in most parts of Europe, (imported) coal is a preferred option not because of price, but because of availability of reserves. Production from coal power plants will become even more expensive when technologies for carbon capture and storage are widely deployed. This could lead to a situation, in which high energy prices provoke continued backlashes in a world economy that is not able to function “as usual”. In this case, a large number of regions, and especially the urban areas, will face severe social problems over longer periods of time, due to the increase of consumer prices.

Scenario 1: Green High-Tech

The development and utilisation of renewable energy technologies is a top priority in Europe in 2030. Although economic growth has prevailed in Europe, total energy demand has declined considerably, achieving CO2 emission reductions of more than 40% compared to 1990 levels. Energy production from renewable sources has grown most extensively, while the demand for coal and oil has been reduced considerably in the industrial, residential and energy sectors. The demand for natural gas has shown a moderate decrease while a progressive reduction of energy supply from nuclear reactors has taken place. International GHG emissions quotas have been agreed on and a global Emissions Trading Scheme (ETS) is in place. This has strengthened both the scale and scope of the European ETS.

The new renewable energy system is highly decentralized and many production areas are located in places distant from urban areas, a development which has been accompanied by the enlargement and modernization of the power grid and the integration of the European energy markets. Europe shows now a new balance between centralised and decentralised sources, which are adapted to different territorial needs. Energy markets are comprised of many actors at all scales, and particularly individuals with residential energy production systems that sell their surplus of energy to the grid. Across Northern Europe a new network of ocean and land-based power grids is interconnecting wind parks, hydroelectric plants and tidal and wave energy installations located primarily in the Northern regions of the “cool and windy” typology. In the South, wind power is complemented by photovoltaic (PV) and solar-thermal power plants in the semi-rural regions of typology 1a, primarily located along the Mediterranean coast as well as “struggling” regions located in Spain. Additionally, solar installations in Northwest Africa are feeding electrical power into the European transmission grid. The presence of renewable technologies has changed the rural, coastal and urban landscape of Europe as they have become accepted by the population in general. Regions and municipalities have gained increased autonomy with respect to energy policy and this has resulted in the integration of local approaches in energy planning.

Consumer response to high energy prices and the availability of energy-efficient technologies has resulted in reduced energy consumption in all sectors. This process has also been accompanied by programmes, incentives and regulations on the modernisation of industries and old building stocks. Industries have gone through a process of modernisation through the substitution of fuel-based processes by electric driven technologies, better reactors and motor designs, the optimisation of processes, the internal recycling of spill energy, the use of recycled raw materials, and the establishment of industrial symbiosis networks among neighbouring companies, urban settlements and energy producers and distributors. Households and businesses have lowered their energy bills due to the widespread availability of efficient heating and cooling systems, energy efficient appliances, as well as an increased use of PV, solar-thermal and geothermal installations.

The continued economic growth in 2030 is dominated by the service sector and the knowledge economy because of increased competitiveness in technological consulting and high-tech manufacturing. Due to high transportation costs and a well-functioning global ETS system, manufacturing industries have been retained in Europe. Stronger emphasis on self-sufficiency and local production in many regions has also contributed to this development. Recycling industries now act as large producers of energy and materials to industries, farmers and households.

Economic and social growth is still concentrated in large urban areas (typologies 1a, 1b and 3), due to the abundance of job opportunities in these locations, strongly linked to the growing knowledge-based economy. High energy prices also motivate the population to live within proximity to public transport infrastructure and jobs resulting in compact and polycentric urban structures. Nevertheless, a process of decentralisation is also taking place as energy-independent regions have emerged in areas with high potential, even in some of the "struggling" regions, where settlements have benefited from investments in infrastructures and services. Private and governmental interests in developing these regions have in many cases led to the foundation of innovation centres and of companies specialised in the manufacture and deployment of renewable energy technologies. Due to higher prices of raw materials, regions rich in natural resources have become economically more important. Some of the well-off industrial regions belonging to typology 1b, with high energy demanding industries have witnessed a transition towards more service-oriented industries, while many struggling regions lacking innovation capacity are facing economic problems as their industries keep loosing competitiveness as a result of high energy prices. This negative development has been the consequence of the lack of local incentives and support to enhance energy efficiency in industry. Tourist areas, especially in the remote costal regions and islands, have also been negatively affected by high transport prices. Some of the less peripheral tourist areas across the Mediterranean coast have compensated this with an influx of the elderly and distance workers seeking comfortable living conditions away from cities.

The transport sector has become notably less energy-intensive and reduced its oil dependence, mainly due to a considerable increase in the use of public transportation. Preference towards public transport has partly been a consequence of high oil prices and taxation on fossil fuels alongside the increased awareness of climate change. Considerable investments in urban areas and implementation of participatory planning concepts and processes have generated new infrastructures and services that facilitate the use of public routes by pedestrians, bikers and public transport users. Affordable hybrid and electric cars have substituted petrol cars as the norm. The accessibility of ICT, in addition to a general acceptance of distance working, in the semi-rural areas of typology 1a and those belonging to the "wealthy and commuting" group has further reduced the need for the daily movements of workers. Contrary to urban areas, residents in rural areas are still dependant on private cars for short distance travel, and on high-speed trains for travelling long distances.

The total number of airline passengers has dropped, especially on short distance flights, as a consequence of high oil prices and increasing competition from high-speed trains. Freight transport, particularly regarding marine and truck transport, has been seriously affected as it continues to be highly dependant on fossil fuels. In this regard, optimisation in logistics has played a key role in compensating these costs.

Scenario 2: Energy-Efficient Europe

Due to a political emphasis on energy efficiency, the energy intensity of Europe has decreased significantly, but, despite of further deployment of renewables, demand for fossil fuels is still dominant. Renewables have mainly served to compensate the closure of nuclear power plants. This development has resulted in a reduction of the total energy demand while reductions of CO2 in 2030 have been limited to 30% relative to the 1990's.

Large renewable energy projects have been built, but further development was hampered by lack of public support, declining innovation capacity, conflicts of interest, lack of investments and lack of proper information. Scepticism towards nuclear energy has also prevailed due to its high costs and perceived risks. Global GHG agreements have not been reached, and Europe is still facing fluctuating energy prices because of the high dependency on natural gas. New deposits of natural gas have been discovered and major transmission infrastructure investments have taken place as political relations with Russia have improved. The demand for coal has declined because of national and European climate change policies. Where coal is still used, it is consumed more efficiently in modern CHP plants and new industrial processes. The use of oil as primary energy has also been greatly reduced and demand is now mainly limited to the transport sector.

Governments have adopted support mechanisms, standards and directives to stimulate energy savings among consumers in all sectors by adopting energy efficient technologies. Creative and effective information campaigns have raised awareness on the negative consequences of high energy consumption and the potentials for reducing energy expenditure. Electricity conversion and transmission technologies have become highly efficient, thereby reducing energy losses from the generation and distribution of electrical power. Other important factors for change have been the increased incorporation of recycled materials in industrial production and the wide-spread extension of industrial symbioses projects. While the capacity for retrofitting old buildings is still underexploited, energy intensity in the residential sector has improved due to the acquisition of more efficient electrical appliances and lighting, intelligent heat and electric systems, as well as new district heating and cooling networks.

Economic growth has continued during the last 20 years but losses in the service sector and high-tech industries have resulted in a slow-down of the economy. The innovation capacity of countries such as China and India has increased rapidly, thereby surpassing Europe in this regard. This implies that Europe is facing heavy competition in the knowledge-based industries, which are still predominant in the urban regions of typologies 1a, 1b and 3. Higher energy, food and transport prices have resulted in overall decreases in consumption. However, increased wage rates overseas have also made local manufacturing and agriculture more competitive. The recycling industry has particularly shown marked growth due to higher prices of raw materials and the adoption of efficient production processes. These circumstances have led to structural changes in the economy towards a more balanced, efficient and regionalised economy that has started to replace the predominant growth of the service and knowledge-intensive sectors.

Urban socio-economic growth in Europe is still unavoidable, but is now more polycentric and aiming at mixed-use and properly planned dense urban environments with reduced energy demand. In lieu of this it is increasingly important that urban spatial and land-use planning is integrated with energy planning to produce spatial arrangements and built environments that meet high efficiency standards. Accordingly, city planning now includes binding energy and environmental protection policies that govern energy use across multiple sectors.

Growth in the industrial and agricultural sector has been an important component in the revitalization of some rural economies. Peri-urban areas, especially those especially those in typologies 1a and 1b with good accessibility to natural resources, have particularly benefited, while new rural functionalities have increased the demand of skilled working force. Similarly, ICT developments allow more people to live predominantly in attractive rural areas while being able to work from distance. Remote and insular tourism regions in typology 1a and remote settlements in the “cool and windy” regions, on the contrary, experienced important economic and population losses due to the high cost of flights and road transportation. Therefore, tourism is now concentrated in attractive costal and mountain regions in the proximity of urban areas in typologies 1a and 1b. Some of the regions in the once “well-off” group and most of the “struggling” one, where industries could not cope with high energy prices, have also suffered economic decline.

While the overall transport intensity has decreased, the dependence on the private car has increased, which is particularly related to the growth of rural environments in all regions that do not have the populations of scale to rationalise public transit infrastructure. Due to high oil prices and important technological advances, hybrid and electric cars are now economical and efficient, and thus constitute the largest share of car purchases in Europe. The higher costs associated with car ownership have led to a situation, in which numerous individuals and families that cannot afford a private car. However, this has led to the growth of innovative solutions such as co-operative vehicle ownership and car-pooling networks.

Scenario 3: Nuclear Energy for Big Regions

Nuclear energy is the main priority for energy development in many European countries. Programmes driving the construction of nuclear reactors have been carried out as planned in the 2010’s, and they have been accompanied by intensive information campaigns aimed at improving public acceptance of nuclear energy.

Despite the fact that some of the most energy intensive economies in the world have not signed the proposed global agreements on GHG quotas, Europe has maintained its energy and climate change goals. While the new generation of nuclear plants was under construction, renewable energy deployment witnessed a significant expansion; primarily large-scale renewable energy systems such as offshore wind, solar farms, and CHP networks. However, renewables have encountered a phase of stagnation due to increasing allocation of funds toward the construction of nuclear reactors, a lack of public acceptance and decreasing innovation capacities. The demand for fossil fuels has been reduced significantly in 2030, as nuclear energy and renewables have replaced coal use in industries and thermoelectric plants. Also, the use of oil for heating has almost been entirely replaced by electricity and district heating. Consequently, the transport sector is the primary consumer of fossil fuels. Thus, in this scenario, CO_2 emissions have been reduced by 30% in comparison to the 1990's but overall energy demand has increased.

The energy sector is dominated by a small number of big producers. The continued centralisation of the energy system has provoked both technical and economic vulnerabilities. On one hand, Europe is vulnerable to large blackouts caused by failures in the transmission network and, on the other hand, national governments have acquired important debts resulting from the large capital investments necessary for the construction, operation and maintenance of nuclear energy infrastructure.

Increases in energy demand are regarded as the consequence of the relative growth of manufacturing and primary industries and the abundant availability of electricity. Persistent energy efficiency improvements have also been difficult to achieve due to the lack of incentives, lack of dissemination of information and the limited availability of energy efficient technologies. However, reductions in the energy intensity in some sectors have been achieved due to consumers' responses to higher oil prices; especially in the transport sector.

The prolific growth of nuclear power generation after 2020 has made renewable energy and efficient technologies less competitive. The deployment of medium and small scale renewable energy technologies has also failed in urban areas due to inadequate information about their benefits and reliability.

The innovation capacity of Europe in creating high-value products and services has been moderate in comparison to Asia, which now is the leader of high-tech R&D. At the same time, political emphasis in Europe has been placed on improving the conditions for manufacturing and primary industries, and on providing incentives to large companies to deploy heavy industries.

While the service sector is still dominant in the European economy, primary and heavy manufacturing industries have grown faster than other sectors, a situation that has strengthened the economies of industrial regions, especially those in the "well-off" and the "cool and windy" typologies. Increasing transport costs have opened the opportunities for local industries to recover European markets. Industrial production has also benefited from the increase of electricity production from nuclear power plants added during 2020's while production costs have been notably reduced through automation and efficient industrial processes. Spatially, industries are now organized in compact industrial complexes in order allow the exchange of waste materials and reducing transport costs. The agricultural sector has also witnessed growth due to higher demand of locally produced food crops as well as improvement of agricultural practices performed by large farming companies.

Immigration and economic growth has continued to be concentrated in urban areas, where most working opportunities are found. These regions have benefited from continued investments in infrastructure and services, including the electrical power supply. Most of the new industries are concentrated in compact complexes located in peri-urban areas or neighbouring regions of typology 1b and 3. Increasing population densities coupled with industrial concentration in the central regions has put pressure on land and water resources. Housing prices have risen in attractive areas, while other areas have witnessed a reduction in quality of life and increasing public expenditure on social aid. Also, signs of poverty are tangible in these areas due to the recession of the local economy and the increased costs of basic products.

Rural regions rich in natural resources with good access to large cities have witnessed economic growth. Here the population is concentrated in compact settlements where investments have been made to deploy and improve public and private services. Conversely, remote and isolated settlements mainly in the Northern peripheries (typology 4), as well as insular and remote regions in groups 1a and 2, have experienced severe depopulation, caused not only by the disappearance of economic activities but also by the lack of investments in local distribution grids. Due to the fact that nuclear waste has accumulated quickly during the last ten years, inter-regional disputes on which regions should carry the burden of processing and storing nuclear waste have become tenuous.

As a result of the high price of oil, progressive efforts are made to electrify transport systems. However, the balance between public and private car transport from the 2010’s has been maintained as developments in public transportation are still insufficient. High speed trains connect main urban nodes in Europe while trams and subways are predominant in the urban core of major cities. Also, a rapid transition towards hybrid and electric cars has taken place which is dominant in peri-urban and rural areas where the availability of public transport is limited. The freight and air transport sectors continue to be heavily dependant of fossil fuels and therefore face difficult economic conditions. This has had profound repercussions on the tourism industry in insular and remote regions, as tourism has now shifted to areas closer to large cities.

Scenario 4: Business as Usual?

In this scenario, only a moderate transition to renewable energy sources has taken place. Energy systems are dominated by centralised solutions and coal use for electricity generation has increased. Central Asian, Russian and Arctic gas deposits have become increasingly important for Europe’s energy supply. This has meant major capital investments in natural gas pipelines and storage. The construction and operating costs associated with nuclear power, the public concerns about waste storage, insecure uranium supply, and security concerns have all contributed to the phase-out of nuclear energy programmes.

Multi-national energy corporations now dominate the energy sector more than ever, despite protectionist schemes of several European countries. The market power gained by large energy producers has limited the number of actors able to invest in energy production and the effective lobbying of energy corporations has strangled the market for small-scale energy alternatives.

Efforts to reduce GHG emissions have been hindered by the lack of political commitment from the USA and China, which has negatively affected Europe’s willingness to cooperate internationally. This has made other countries hesitant to make large concessions during periods of economic stagnation or recession. Accordingly, precedence to protect local jobs over climate control is the common trend. The absence of international agreements on GHG emission, high energy prices and the prolonged economic crisis, has also resulted in the removal of the EU-ETS.

Improved energy efficiency was achieved mainly during the early 2010's, but further improvements have not been persistent. The loss of political will to combat climate change, along with a lack of investment capital for eco-upgrading of industries, houses and the transport system has resulted in marginal efficiency gains. Overall, energy consumption has decreased as a consequence of a reduction of GDP since the national economies cannot sustain the burden of high energy costs and their negative impact on private consumption.

Stagnant economic conditions have also hampered the development of affordable clean energy technologies. Consequently, technologies on the market are expensive, implying that economies of scale have not been achieved. The shortage of free capital has also resulted in minimal retrofitting of existing building stock and poor deployment of efficient energy generation systems. As such, no new district heating systems have been built since early 2010's. Large scale renewable projects have also been hampered by the "not in my backyard" attitude of the public.

The stagnation of GDP growth has been mirrored by a lack of investment in R&D. European scientists are now moving to China, India and Brazil, where income possibilities are better. Smaller companies that closed during the economic crisis in the first decade of the century never reopened and their workforces went into unemployment rather than contributing their tacit knowledge to new opportunities for growth. Now, very few companies can afford to invest in R&D, and public stimulation schemes are few and poorly funded. The outcome has been a pervasive structural economic problem rooted in dependency on costly energy. Industrial growth has been hampered by outdated infrastructure and high prices for scarce raw materials, a situation that has hit the regions in the "struggling" and "cool and windy, but working" groups particularly hard. Start-up enterprises have failed at a high rate due to lack of affordable venture capital and poor framework conditions. The "buy local" movement from the early years of the century has taken hold, but now the motivation is based on protectionism rather than environmentalism. The only blossoming business ventures can be found in the second-hand market, as many people cannot afford to buy new goods.

The protectionist stance is also apparent in the attitudes of cities and regions. Cooperation is weak and competition is strong. In spite of the decline in the quality of urban life due to unrest, poverty, crime and homelessness, the urban areas represent the only economic opportunities now available and are therefore still growing. Moreover, high transport prices have severely affected the rural economies, strongly affecting the "wealthy and commuting", as well as "cool and windy, but working" typologies. The demand for housing in urban areas is rising as rural settlements have been abandoned. The hardest hit regions are, however, those that were already "struggling" at the outset of the crisis.

Urban planning has stagnated, and the response to growing population has been inadequate. New construction in urban areas has not kept up to demand, so crowding and sprawl to the surrounding suburbs is apparent. There are some "islands" of wealth and innovation, but these are not integrated into the urban fabric, but instead are "outposts" of international companies. Income and price levels have been de-coupled; some consumer goods are cheaper due to lack of demand, but food and basic goods are expensive due to high transport and production costs.

High oil prices and decreasing disposable income have also had a negative impact on the transport sector. The lack of investment in efficient and competitive public transportation options makes the use of private cars often unavoidable, but the car-stock is growing older. Even though high fuel costs make hybrid cars attractive, a considerable part of the population cannot afford the initial investment, thus making hybrids a viable option only for the rich. The shift to electric cars that seemed to be in the offing some years ago has not materialised due a lack of public investment in infrastructure that may have stimulated their adoption. This situation has resulted in the substantial use of bicycles as a mode of transportation in urban areas.

The four pictures of possible “energy futures” are likely to have different impacts and implications for the five regional typologies, depending on the prominent features of energy poverty in each group of regions and their capacity to deal with the challenges ahead. The main conclusions drawn from these two strings of analysis are summarized in table 9 on the next pages.

Table 9 General Overview of Scenarios and Clustering Results

General overview of scenarios and clustering process	Scenario 1 "Green High Tech"	Scenario 2 "Energy-efficient Europe"	Scenario 3 "Nuclear Energy for Big Regions"	Scenario 4 "Business as Usual?"
Energy-related policies	Large-scale renewables connected by the European grid and small-scale renewables for local consumption Energy from waste and material recovery from recycling	Energy efficiency all along the chain Nuclear phase-out Large-scale renewables Increased gas imports	Grid extension High level of investment in nuclear energy and security Renewables take off, but stagnate	Increased use of coal and gas for electricity generation Phase-out of nuclear Lack of investment in the retrofitting of buildings and local networks
Other policy domains	High investment in R&D and education ICT and infrastructure policies International climate change agreements on GHG Participatory planning processes	Technological development in efficient technologies (R&D) Regionalisation of economies, polycentric development Hybrid / electric cars and car-sharing Binding environmental policies in planning	Moderate investment in R&D and education No international agreements on GHG but European climate change policies Electrification of the transport system	Low R&D Low investment in education No agreements on GHG, removal of European ETS Inadequate urban planning
Governance	Increased autonomy for regions with regard to energy policy priorities	National energy efficiency strategies implemented on local level	Centralized (national and EU level)	Protectionist (national and EU)
Region with opportunities	Regions with high PV and wind potential Rural regions with natural resources and access to large cities	Regions with energy-intensive industries but with clean technologies and access to secure gas supplies; agricultural regions	Regions with industries with high electricity consumption and central urban regions	Medium-sized cities surrounded by resource rich areas Coal and harbour regions
Regions experiencing threats	Regions with high fuel costs Regions with industries with high energy purchases (need for adaption)	Regions dependent on long-distance freight transport (islands, remote..) and commuting	Regions with high l/t unemployment rates and/ or low disposable income Peripheral regions	Urban regions with l/t unemployment rate and lowest income Regions with energy-intensive industries Tourism-dependent regions
Expected performance of regional typologies				
Typology 1a "With problems and potential"	Highly favourable for rural and coastal regions with high solar and wind potential	Negative for the most peripheral coastal areas	Favourable for Metropolitan and Pentagon regions with high levels of employment in the knowledge economy	Increasing poverty and overcrowding in metropolitan areas
Typology 1 b "Well-off, with trouble ahead	Need for developing renewable resources others than solar and wind	Strong positive impact on the competitiveness of the more industrialized Pentagon areas	Need for accelerating transition to more service-oriented activities	Weaker impact on harbour regions, danger for industrial areas to slide into the category of struggling regions
Typology 2 "Struggling, looking for jobs and a brighter future"	Possible positive impact if resources for the development of renewables can be found	Highly positive if affordable clean energy technologies can be accessed by industries in these regions	Increased burden on households, due to rising costs for heating and fuel purchases	Job oportunities for Eastern coal regions, but "no way out" for the rest
Typology 3 "Wealthy and commuting"	Strong opportunities for polycentric development	Living standards could be negatively affected in these areas due to increased costs on car ownership	Favourable, due to increased electrification of transport systems	Deteriorating infrastructures in cities and urban sprawl
Typology 4 "Cool and windy, but working"	Strong positive impact on Nordic and Irish regions with high wind potential	Strong positive impact on the competitiveness of industrial strongholds in the North, but possible negative impacts of increased transport costs	Favourable only for industries with high electricity consumption	Strong risk of loosing industrial base and employment

B.2.4. Regions as Actors in Energy Policy - Survey Results and Case Studies

So, what can regions do to reduce the impact of rising energy prices on industry and population and grasp arising opportunities? Which is the scope of actions of regional policy makers with regard to energy policy making and which are their priorities? What can be learnt from good and bad practice examples?

This type of empirical knowledge necessary for formulating the policy recommendations was collected from a series of case studies and a survey of regional energy agencies. The questionnaire was completed in mid-2009 and identifies evolving governance structures in response to present and future energy concerns in Europe. The analysis focuses on four key aspects:

1. the distinctions in policy approach between centralised and decentralised public authorities;
2. key differences between mechanisms used to implement policies derived from different political scales;
3. sectoral implications of these varying policy perspectives and implementation mechanisms – in terms of what tends to get governed locally; and
4. how these conditions effect the mode of decentralised governance for implementing green energy initiatives in practice.

Through the analysis, the relationship between environmental policy rationales and decentralised governance is highlighted. It also illustrates the importance of facilitative policy mechanisms and the ability of sub-national authorities to effectively govern the energy consumption patterns of individuals in their everyday lives.

Accordingly, the aim has been to critically analyse green energy governance at decentralised scale to put forward a comprehensive understanding of how it can operate, as well as its constraints and limitations. Put together, the unique characteristics of decentralised energy governance can be identified as an opportunity for reducing the socio-economic risks of energy poverty; thereby improving regional competitiveness.

Further valuable information about the EU regions' present activities in the field of energy efficiency and renewables might become available in the context of the First Action Programme for the Implementation of the Territorial Agenda and the "Thematic Group on Energy Efficiency and Renewable Energy", which has been carrying out a survey on these issues in the Member States. "The purpose of the questionnaire is to examine how and to what extent MS have incorporated EERE [energy efficiency and renewable energy] considerations in their planning. It focuses on the tools that MS use in order to embed their considerations for EERE to their spatial development planning, on the one hand and on the processes of decision making on the other."[3] However, it has not been possible for the ReRisk team to access the survey results and integrate them in the policy recommendations presented here.

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[3] DG Meeting on Territorial Cohesion, Greek Intervention http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/predsedovanje/territorial_cohesion_directors_meeting/tc_greece.pdf

B.2.4.1. The ‘Sustainability Impact’ of Sub-national Energy Governance

According to the responses received from 42 regional administrations, competences with regard to the three pillars of energy policy (security of supply, energy efficiency and environmental protection) in the EU are distributed unevenly. The state is perceived as being the government level that places the most emphasis on security of supply, while the regions play a greater role in relation to energy efficiency and environmental protection.

Regional autonomy in terms of energy policy seems to be relatively limited in two thirds of the regions. However, and despite of not being the main responsible level for energy policy, 41% of the regions are able to implement binding policies beyond the standards set at the national level.

Responses to the questionnaire also indicate a marked division of labour between the national and the regional energy policy level with regard to the use of energy sources. Whereas national energy policies are clearly identified as treating each energy source with similar importance, the regional involvement is comparatively higher in the field of renewable energy (66%) and natural gas (41%) and less important with regard to coal use (24%) and nuclear (10%).

Reinforcing the supply perspective, the role of renewable energy solutions has been also analysed. While none of the regions consider decentralized energy solutions as insignificant, only 14% declare it to be a top priority. The key perspective in this connection, however, is the question of centralized versus decentralized solutions. Even though one can think of renewable energy solutions in relation to small scale and decentralized conditions, most regions view the development of these renewable in connection to centralized decisions. Therefore, the answer appears to be more or less the recognition of the status quo.

In six Member States, plus Norway, regions are carrying out their own R&D programmes in the energy field. Additionally, some regions from countries with centralized energy research, participate in R&D activities in the framework of European programmes[4]. Experts in the field argue that “Sustainable energy supply structures based completely on the import of knowledge and technology do not seem to be favourable for countries and regions. Local or regional R&D constitutes a good basis to optimise energy systems and to reduce vulnerability. Besides, the yield of renewable energy sources and the types of optimal technologies depend, in part, on local (climatic) conditions. Thus, specific technologies have to be developed – mostly by means of local or regional R&D” [Luther 2004]. It would therefore be interesting to analyse on the basis of benchmarks if regions with competences in energy R&D perform better with regard to the development of renewable energy sources and energy efficiency than regions that are not involved in energy R&D.

As indicated above, the questionnaire results reveal a tendency among regional energy experts to give higher priority to environmental protection and energy efficiency than to security of supply, when compared with the priorities of national governments. Also, regions that prioritize the

[4] See, for example, the PITER (Platform for Integration of Transregional R&D Activities) project, financed by Regions of Knowledge http://www.fp7-piter.eu/index.php?id=146

development of renewables - meaning that they draw at least 30% of supply from these sources - tend to put a stronger emphasis on the environmental and efficiency pillars of energy policy than those regions that do not prioritize renewables.

To further validate this hypothesis, Table 10 shows the survey results as related to drivers for the development of renewable energy systems. When these responses are analysed - based on a delineation of renewable energy priority - some notable perspectives are revealed:

- While security of supply is ranked as the predominant driver by most regions, followed by energy prices, regions with a clear focus on renewables value environmental protection almost as high, which is not the case in regions that give priority to coal, gas or nuclear.
- Interestingly, there is a negative shift for international commitments when renewables are prioritized by regions. This indicates that regional energy governance is not only responding to top-down initiatives when implementing sustainable energy policies.

Table 10 Drivers of Renewable Energy Development in the Regions

Question 5: Regional Energy Source Priority:		**Question 6: Regional Drivers of Renewables and Efficiency:**			
Energy Source Priority	**Noted as an Energy Priority**	**Internatio nal Commitme nts**	**Energy Price**	**Security of Supply/Self - sufficiency**	**Environmen - tal Protection**
Coal	**No**	0.93	1.61	2.06	1.42
	Yes	1.20	1.80	1.90	1.10
Natural Gas	**No**	1.08	1.79	1.92	1.29
	Yes	0.94	1.47	2.18	1.41
Nuclear	**No**	1.05	1.59	1.97	1.43
	Yes	1.75	2.25	2.50	0.50
Renewable Energy	**No**	1.50	2.00	1.93	0.71
	Yes	0.78	1.48	2.07	1.67

The policy analysis of the questionnaire indicates that regions appear to confer a general priority to follow national interests related to security of supply. While doing so, however, they also portray a heightened awareness of environmental concerns that are a guiding rationale for developing clean energy solutions. Accordingly, green energy development can be viewed as a strategy to mitigate future risks associated with foreign and non-renewable energy dependence.

Table 11 illustrates a binary comparison between the level of regional priority for renewable energy sources and the relative autonomy for regional authorities to govern energy issues in their own territory. Based on the output, each of the four solution spaces reveals a concomitant relationship between renewable energy production and decentralised energy governance, indicating that:

- Regions with renewables as a priority are much more likely to have a higher degree of governance autonomy.

- Regions without renewables as a priority are more likely to be governed nationally.

Table 11 Renewable Energy and Decentralised Governance

	Regions with decentralised energy governance	
Question 5: Regions with a renewables priority:	**Yes: 24 (71%)**	**No: 17 (29%)**
Yes: 26 (63%)	18	8
No: 15 (37%)	6	9

The distinctions between operative policy mechanisms of centralised versus decentralised authorities appear to affect the energy activities that tend to be governed sub-nationally. This is indicated in the analysis of EU energy policies, questionnaire results, case examples and literature reviews. For example, the Emissions Trading System (ETS) is the EU's principle mechanism for meeting energy policy goals in the most energy-intensive sectors [EC 2010a]. It operates based on a clear economic rationale in which green energy investments either imply cost savings or are a source of revenue. In contrast, the EU's other main policy tool is the distribution of Structural Funds for sub-national institution building. EU policy documents indicate that this is often directed towards initiatives that promote information and awareness of energy issues associated with residential and commercial buildings, local transport and behavioural change [EC 2010b].

This is reaffirmed by the questionnaire (table 12), which indicates that the residential sector – i.e. green energy investments and consumption behaviours in the home – is the only sector where sub-national authorities have a dominant governing role.

Table 12 Distribution of Competences for Awareness-Raising

Governance responsibility for energy information and awareness			
Sectors	**Local government**	**Regional government**	**National government**
In the Industrial Sector	4.88%	31.71%	63.41%
In the Energy Sector	4.88%	21.95%	73.17%
In the Transportation Sector	7.32%	21.95%	70.73%
In the Residential Sector including the consumption patterns among the general population	29.27%	24.39%	46.34%
n = 42			

B.2.4.2. Structural Characteristics of the Regional Groupings

The responses received from the regional energy agencies can be grouped, combining the questions related to regional energy policy distinctions, regional energy source priorities, degree of decentralised governance, and the importance of decentralised renewable energy sources. The results show the distinction of three primary groups. From here, the individual regions were analysed based on the internal consistency of their survey responses; and specifically on the degree of governance decentralization and renewable energy priority they indicated (table 13):

Table 13 Regional Grouping of Responses to Questionnaire

Group 1		Group 2		Group 3	
Regions	Typology	Regions	Typology	Regions	Typology
1: Austria, Burgenland	3	3: Belgium, Flanders	1b, 3	6: Cyprus, Cyprus	
2: Austria, Voralberg	1b	5: Bulgaria, North East	2	10: Finland, Central	
7: Czech Rep., Zlin Region	2	16: Greece, Central Macedonia	1a	15: Greece, Crete	
8: Denmark, Midtjylland Samsoe		27: Poland, Podlaskie	2	17: Hungary, National	1a, 1b, 2
14: Germany, Freiburg	1b	29: Portugal, North Alentejo	2	18: Ireland, Cork	4
25: Netherlands, South	1b	34: Spain, Basque	1a	19: Ireland, Midlands	4
38: Sweden, Kalmar	4	39: Sweden, Örebro	4	33: Slovenia, Podravje	
40 UK, South West	1a, 1b				

Group 1:

- Strong overall policy focus, emphasizing efficiency and environmental protection rather than security of supply
- Unanimous priority for renewables
- Very strong emphasis on sub-national scales of energy governance
- The importance of pursuing all opportunities for producing renewable energy, including smaller scale and decentralised solutions
- High diversity of economic activities

Group 2:

- Strong overall policy focus on efficiency and environmental protection and lower emphasis on security of supply
- High priority for renewables
- Relatively high priority on coal within the energy mix
- Moderate emphasis on sub-national scales of energy governance
- Low diversity of economic activities and a higher energy intensity of the economy

Group 3:

- Relatively low policy focus, emphasizing security of supply and efficiency rather than environmental protection
- Relatively low prioritization for renewables
- A strong emphasis on nationally-governed energy policy
- Low diversity of economic activities and higher energy intensity of the economy

The details of these findings, just as the previous analysis, confirm that there is a correlation between increased governance decentralization, an emphasis on the environment and energy efficiency as guiding policy rationales, and the preferential support for green energy technologies.

B.2.4.3. Case Examples of Regional Energy Governance

The use of regional case studies and a theoretical approach that acknowledges the relational and network perspectives of governance can help to understand the unique characteristics of decentralised governance. They also reinforce findings of the questionnaire and identify limitations and constraints to actions that sub-national institutions can carry out to guide European regions towards more sustainable energy profiles. Accordingly, three case studies previously completed in the ReRisk project and three case examples for each of the typologies are summarized.

Navarra, Spain: The Regional Government in Navarra has the main competence on all energy matters for the region and success of wind energy is based on three key factors: medium wind energy potential, but in suitable areas for wind farms, a well-established energy policy that aims to reduce external energy dependency and a clear linkage between renewable energy and regional economic development [IEA 2005]; [De Miguel Ichaso 2000]; [Fairless, 2007]. In regards to the latter, it is specifically noted that rapid development of renewables in Navarra is closely related to regional efforts to diversify the economy from energy-intensive manufacturing to a knowledge economy centred on renewable technologies.

Freiburg, Germany: Within a federalist system in Germany, regional authorities of Baden-Württemberg have the main control over energy matters in Freiburg. At the same time, the District of Freiburg has developed a strong local competence for emphasizing clean energy technologies. This process was initiated by a local environmental movement surrounding plans to expand nuclear energy production in the region. It has subsequently evolved into a comprehensive environmental movement that shapes the local political situation, economic growth and the development of the built environment [Hoppe 2009].

Samsø, Denmark: The national government has the main responsibility for energy planning in Denmark, but through the principle of subsidiarity extensive decision-making power is left to local actors [Pettersson 2006]. As such, local initiatives in response to a strong feed-in tariff and other national subsidies led to a focus on wind energy development to a point where the island of Samsø is a net-producer of energy. Citizen acceptance was a direct result of local ownership where the eleven land-based turbines belong to the local farmers and citizen cooperatives. The growth of wind power has built a strong local competence for wind energy technologies, which has helped to diversify the economy toward knowledge-based activities and a well-developed eco-tourism sector [Hermansen 2009].

Group 1: Kalmar County, Sweden: Kalmar's regional energy policy is predominantly characterized by an enhanced regard for environmental protection and adherence to international climate change commitments at both the national and regional levels. In addition to realizing their strong wind energy potential, the region currently focuses on three branches related to energy efficiency management: transport and mobility, the building sector, and learning and lifestyles. Each of these has a direct focus on influencing energy consumption behaviour of the general citizenry and local businesses. The aim is to promote awareness of the externalities of energy production and consumption, as well as the potential for efficient investments in clean energy technologies [Eckerberg, 2010].

Group 2: Central Macedonia, Greece: As a unitary state, Greek energy policy is formulated nationally and disseminated to the individual regions. One result of this is that administrative challenges tend to engrain national interests of security of supply and economic growth, and these have hindered the development of locally bound green energy initiatives [IEA, 2007]. Consequently, the energy intensity of Central Macedonia is notably high. The perception is that many local energy savings programmes are run by municipal authorities, which decide to "go on alone" with their own green energy schemes [Konstantinou 2010]. However, these actors wishing to pursue environmental initiatives appear to be limited in their actions due to a lack of available resources from senior political scales.

Group 3: Cyprus: The ability of sub-national actors to facilitate local initiatives is limited by the centralised nature of overall governance in Cyprus, which is tied to the spatial characteristics of the small island state. Energy policy has the primary focus of safeguarding competition and ensuring security of supply. In 2009, renewable energy production covered 4% to total energy supply and less than 1% of total electricity supply. However, according to the ESTIF (European Solar Thermal Industry Federation), Cyprus has the largest number of solar collectors per capita in the EU. The potential for marked growth of renewable energy production is constrained by low potential for wind power and concern over landscape and "environmental" impacts of renewables. This is very likely connected to the important weight of tourism in the Cypriot economy [Vlachos 2010].

B.2.4.4. Relations between Regional Typologies and Governance Characteristics

While the EU regions have been clustered according to resemblances in relation to a number of independent selected indicators (details in main report), the grouping of the regions above has been based on the institutional framework for energy development and planning with emphasis on their perspectives on energy development. Despite of the difference in approach, some common conclusions from the two strings of analysis can be drawn:

While Group 1 primarily consists of members of the typology 1b identified as being "Well-off, with troubles ahead", where the transition to the new economy has happened or is under way. This process could eventually lead to a higher diversity of economic activities and lower energy intensity of the economy, moving towards a de-coupling of economic development and energy consumption. And this process is also linked to a strong emphasis on energy governance on sub-national scales, opening up opportunities for producing renewable energy, including smaller scale and decentralised solutions. With the right policies in place, these regions will move towards the more service-oriented economies of the regions belonging to typology 1a.

In group 2 where the "struggling" regions are dominating, the lower diversity of economic activities leads to a higher energy intensity of the economy. For a large number of the regions included in the typology – and for the group in general – a relatively high priority on coal exists within the energy mix. Consequently, security of supply is of lower importance than economic efficiency, and increasingly also environmental protection. With a moderate emphasis on sub-national scales of energy governance, the question of small-scale local activities is second to more top-down approaches. Even in the situations where the regional authorities give high priority to developing renewable energy, the national or large scale regional approaches are dominating in shaping the development path.

The major part of the regions excluded from the clustering exercise due to data gaps is gathered in group 3, among them the “island representatives” such as Crete and Cyprus, but also Central Finland and the Podravje region in Slovenia. Among the identified members in the group are two representatives from typology 4 – “Cool and windy, but working” where Central Finland would be fitting in case sufficient data had been available. The group also includes Hungary, actually representing three different typologies – 1a, 1b and 2 – due to the fact that the questionnaire respondent was representing not only a single region, but Hungary as a national entity. The group – from an overall perspective – tends to emphasise security of supply and efficiency, rather than environmental protection. This includes a relatively low prioritization of renewable energy options, and at the same time a strong emphasis on nationally-governed energy policy. In relation to economic performance the group is characterized by a low diversity of economic activities and higher energy intensity of the economy.

B.2.4.5. Policy Implications

The case findings describe the varying relations between national and sub-national governing authorities, the actors involved in governance processes and the specific energy activities that tend to be approached by decentralised governance. This provides an opportunity to position decentralised approaches within a conceptualization of governance that operates between the EU and community levels. Accordingly, notable points of interest include:

Political context: Centralised political structures do not tend to transfer governing responsibility of energy matters to sub-national authorities, a fact that limits their ability to act autonomously from national interests. On the other hand, sub-national governance is dependent on policies and legislation derived from senior institutional scales. In particular, renewable energy promotion is usually dependant on national feed-in tariffs and EU policy analysis shows that decentralised institution-building is reliant on the deployment of Structural Funds.

Policy integration: Case examples of Navarra, Freiburg, and Samsø clearly show the potential of locally-bound energy movements to integrate sustainable energy development, regional competitiveness and long-term planning, thus mitigating the risk of energy dependence and energy poverty. The Freiburg case also provides an example of how an initial focus on non-economic rationales for green energy development sectors can pave the way for long-term growth as economies diversify and transform due to changing development goals and local demands.

Historical context: It is necessary to recognize that the early stages of movements towards promoting green energy can have important implications on who tends to be involved in the governing process. A clear distinction can be made between Navarra - where the process was initiated by agents operating under a clear economic rationale - and Freiburg, where the movement emanated from social resistance to nuclear energy development.

The following conclusions can be drawn from the quantitative and qualitative strings of research carried out in the project: first of all, that the economic and social backgrounds behind the national settings, and especially the question of authority delegation, seems to be more important for the specific policy measures than the natural, environmental, economic and social conditions characterized by means of the indicators. Secondly, that delegation of initiatives and development strategies towards the inclusion of regional and local actors may provide access to potentials otherwise overlooked. And these observations may be an important issue in connection with decisions on policy measures to meet the challenges of rising energy prices!

B.2.5. Policy Recommendations for Reducing Regional Exposure and Increasing Adaptive Capacity

The policy recommendations elaborated in the context of the ReRisk project take into account the main findings from the initial analysis of regional vulnerability, and the clustering and scenario exercises. The recommendations do not focus on energy policy only, since energy is a cross-cutting issue and therefore has to be approached from many different angles. The recommendations are addressing decision-makers on regional level with the objective of

1. reducing the regions' vulnerability on the short term
2. improving the regions' adaptive capacity on the medium and long term

Some of the policy recommendations are highlighted in this section – a more extensive list of recommendations can be found in chapter C.4. of the scientific report.

B.2.5.1. General Policy Recommendations (Good Governance)

The first set of policy recommendations addresses measures, which could increase their influence on decision-making in the energy field, by strengthening the ties between regions and reducing their vulnerability through "energy solidarity", in line with § 3 and § 8 of the Territorial Agenda [EC 2005]. "Energy solidarity" in practical terms is linked to the strengthening of regional and local networks, the modernization of which is one of the actions to be reinforced by the "EU 2020 Strategy". According to the Association of European Border Regions [AEBR 2010], the strategy should take into account the territorial dimension. The findings from the ReRisk project confirm that this is a central issue for reducing the vulnerability of regions with a high level of commuting and for the development of broader and complementary portfolios of renewable energy sources in neighbouring regions. Local energy networks, both for district heating and cooling, would also help to make a much more efficient use of energy. Financing and organisational models for promoting these networks should be made available.

Regional "research-driven clusters" are an interesting tool to strengthen the cooperation of public bodies, sector collectives, research institutions and other stakeholders. Particularly in regions with obsolete industrial sectors, this form of cooperation can help attract necessary investments. These research-driven clusters should be lead by the less vulnerable regions and those having the strongest adaptive capacity to face the impact of increasing energy prices. There is also room for regional specialization within the European Strategic Energy Technology Plan (SET Plan), but most of the technologies promoted presently by the SET plan are large-scale.[5]

One of the basic actions to be taken urgently is that of raising awareness among regional policy makers on the challenges ahead and the need for longer-term planning. According to the survey, 51% of the respondents consider economic growth in their region as dependant on energy intensive sectors. However, it is interesting to note that 22% of the respondents are either undecided or unaware of the nature or extent of the linkage between these two variables. Defining long-term visions for a regional energy model for 2050, for example, would facilitate the transition towards regional economies that are less vulnerable to rising energy prices. Visions and scenarios can be helpful tools for regional policy makers both to make better-informed decisions and to help communicate and attract citizens, involving society into a shared plan. However, such exercises, which could be financed in the context of the National Energy Efficiency Plans, should be carried out on a sound methodological basis and as a participatory process.

Regional administration will have to cooperate closely with the municipalities in the transformation of energy-intensive economies. Public-private partnerships on municipal level help encourage investment in alternative energy production and promote the involvement of private companies and society. This is particularly interesting in regions with high potential for the development of renewable energy sources. Some experiences already exist at neighbourhood level, where citizens have joined and made private investments thanks to public support. For example, roofs of public buildings can be made available by the administration so that residents from large apartment buildings or tenants in rented flats also have an opportunity to support the deployment of PV installations. However, financing schemes must be revised to account for the diminishing investment capacity of households after the prolonged economic recession. The British government's strategy for warmer homes proposes such an innovative financing scheme, ""Pay as you save or PAYS" [HM Government 2010] to avoid expensive upfront investment by poorer households.

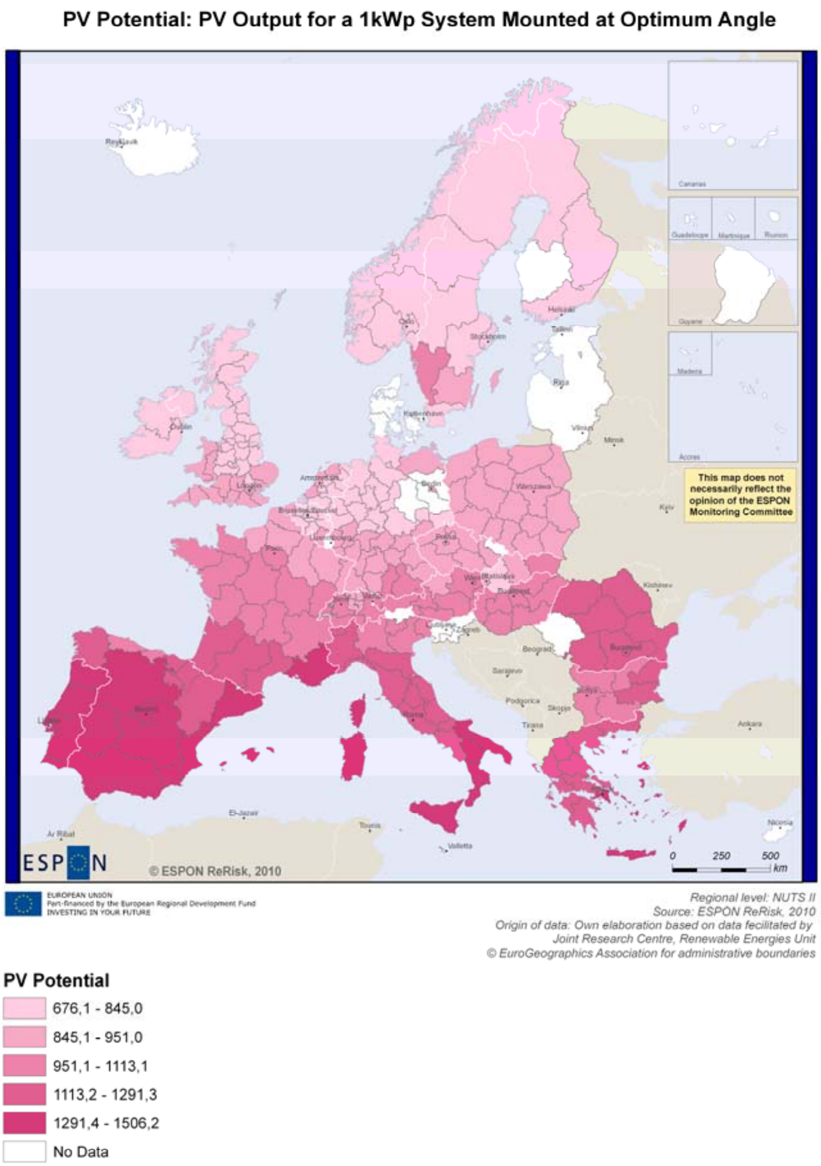
B.2.5.2. Spatial Planning Policies and Strategies to Promote Renewable Energy Sources

Spatial planning instruments, based on an understanding of territorial dynamics, will help regions to advance towards a more sustainable territorial management, in line with § 10, § 11, § 23 and § 27 of the Territorial Agenda. They can be highly useful for coordinating the deployment of renewable energy systems. Initiatives with this perspective have already been established, for instance the Integrated Coastal Zone Management or ICZM [DG Environment 2010]. This is a necessary tool for planning the development of coastal areas, where conflicts may arise when planning off-shore wind parks or advanced ocean technologies, which may interfere with security issues, fishing interests, cargo traffic, tourism or protection of marine biodiversity.

[5] http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/07/493&format=HTML&aged=1&language=EN&guiLanguage=en

Experimental instruments are also available to plan the deployment of solar energy applications more effectively on municipal level. Planning tools need to predict the baseline energy consumption of domestic properties and to determine the potential for using the three key solar technologies of passive solar design, solar water heating and photovoltaic (PV) systems. A new dwelling classification system needs to be developed to address the major problem of data collection for city-wide domestic energy modelling [Gadsden et al 2003].

Map 9 Regions with the Highest PV Potential



In this context, planners can apply "urban metabolism" concepts to describe the functioning of modern cities and to improve local energy planning [Decker et al. 2000]. In practice the study of an urban metabolism requires quantification of the inputs, outputs and storage of energy, water, nutrients, materials and wastes. This is particularly interesting in highly urbanized regions with severe ecological footprints.

In regions dependent on industries with high energy costs (typologies 1b, 2 and 4) industrial symbiosis could represent a solution for reducing overall energy demand. Industrial symbiosis refers to loop cycles, in which energy consumption, production and waste management are integrated in industrial developments aiming at using the residues from one industrial process for the production of other products. By-product synergy is then exchanged in a circular flow, which, in the best cases, provides settlements with energy surpluses through district heating. This is particularly interesting when renovating older industrial sites, usually linked to other obsolete urban areas, but it is also a valuable tool when planning new industry parks. As the two case studies on industrial symbiosis have shown, such projects are easier to implement and have greater success if the companies involved have or develop a relationship of trust and recognize the mutual benefits, so project design is an important element in this policy.

B.2.5.3. Environmental Protection and Risk Prevention

The importance of a regional perspective in relation to environmental protection is very clear, as environmental problems usually have regionally dispersed effects. The current lack of sustainability of the European and World energy models, and specially their climate change consequences, require an urgent action in this field in order to prevent the exhaustion of local and regional energy sources. This problem has already been recognized with regard to biofuels [EEA 2005]. Biocrops compete with other uses for scarce resources, such as land and water, in agriculture, forestry or natural sites. Specializing on certain types of plants with high energy yield could jeopardize other objectives of agricultural policy, such as that of promoting a higher level of regional sufficiency with regard to food production (by growing subsistence crops). Large-scale biomass plants could accelerate deforestation or endanger the local biodiversity. Apart from choosing technologies and crops that are appropriate in a given regional context, attention must also be paid to the parallel development of local social and educational skills, which will be needed to manage and maintain the installed facilities.

But the main challenge for regional environmental policy making is presently related to climate change. Impacts will vary from region to region - with coastal and mountain areas and flood plains particularly vulnerable – and therefore many of the adaptation measures will need to be carried out regionally[6]. Impacts are likely to be severe in the Southern regions belonging to Spain, Greece, Portugal and France, both in terms of energy production and demand. In these regions, summers are going to be complicated for energy companies, due to diminishing water reserves, higher average temperatures and heat waves, and consequently, forest fires. The supply problems will coincide in time with higher peaks of electricity demand, derived from a more extended use of air-conditioning.

The need for new, expensive and under-used peak load capacities for electricity production will be greatest in regions that have not yet reached full market saturation of air-conditioning appliances. However, much of this may be avoided by promoting passive cooling techniques or solar-based appliances in buildings and cities or by defining a minimum threshold for

[6] For further information, please see the discussion paper on climate change impacts in the energy sector, submitted along with the Updated Interim Report

their installation in offices and public buildings. Solar cooling technologies will play a decisive role for energy demand development in these regions [Holmes et al 2007]. Actions in this field could also be considered when the national emergency plans for the prevention of heat waves are extended to the regional and municipal level.

B.2.5.4. Policies to Accelerate Deployment of Renewable Energy Sources

Regions should thoroughly evaluate the "feasible" potential of the different technologies available, including concentrated solar, geothermal, wave / tidal technologies, biomass, and hybrid solutions. Neighbour regions with different types of potential for renewable energy can cooperate to improve the reliability of energy supply from these sources. The generation of "maps of untapped energy reserves" can be of great use for developing longer-term plans in the regions. In densely populated urban areas, wind and solar applications should increasingly be incorporated in the built environment. Small-scale technologies are already available to be installed on roofs and at various wall orientation and façades. Bioclimatic urbanism has a solid set of measures to assist designing urban areas in line with their natural resources.

One of the main challenges in the energy field is the future of the aviation industry, which is expected to face serious supply problems in the coming decades, even if the present level of air traffic is maintained and efficiency improvements of 5% per year to 2026 are achieved [Nygren 2008]. Peripheral and island regions with a high dependence on air traffic, as well as regions specialized in air transport will be hardest hit by these developments. They should cooperate with the aeronautic industry to prepare the transition from fossil fuel use in air transport to alternative sources not competing with food production, both in terms production of these fuels and the needed infrastructure adjustments.

B.2.5.5. Policies to Promote Energy Efficiency

Energy efficiency is becoming an important policy issue at regional level. Several European policies are already in place, like the "Action Plan for Energy Efficiency: Realising the Potential", the Green Paper on energy efficiency, the "Intelligent Energy for Europe" programme, etc. However, there are serious concerns that the Member States are not implementing their National Energy Efficiency Action Plans (NEEAP) on time and that the 20/20/20 objective might not be reached [EESC 2009a].

A comprehensive account of regional and local energy consumption is a prerequisite for justifying any investments in improving energy efficiency [Rutland and Aylett 2008]. The lack of data makes it difficult to measure and monitor progress and, ultimately, to enforce policies in this area. However, the majority of regions produce statistics on energy use, so the main problem is not data collection, but harmonization and the selection of the right indicators for European comparison.

The European Economic and Social Committee (EESC) points to white certificates as a means for enhancing energy efficiency [EC 2005]. "White certificates" and similar regulations, which oblige energy companies to either invest in energy efficiency or buy "certificates", have already been introduced in some Member States. The analysis carried out on the implementation of this policy in Italy[7] shows that as a consequence of this regulatory change, the number of energy service companies (ESCOs) offering services aimed at reducing energy consumption increased considerably and the market for energy efficiency services became much more dynamic. However, implementation and monitoring of these programmes is complex and requires a high level of institutional cooperation. Pilot projects could be launched on regional level to evaluate the energy savings, which can be achieved and to identify the most efficient interventions for different types of industrial and residential markets.

Changes that are occurring in work arrangements may also present an opportunity for making a more efficient use of energy in offices and reduce the need for transport by extending the opportunity to work at home. The average office worker spends 30 percent of the workday at a workstation. Changes to how, where, and when we work have led current office design to the “networked office.” The majority of workspaces still emulate older versions of the building type, dedicating a lot of space, lighting, and climate control to increasingly mobile and immaterial work that does not really need it [Hanley 2008].

One of the most urgent actions to be tackled on European level is the definition of BAT (Best Available Technologies) for industrial energy efficiency. Solid knowledge and sound technologies are available for improving energy efficiency in certain industries, but their implementation might be quite complex when looking at the entire production process. Table 14 shows the efficiency potential in some of the industrial sectors with highest energy consumption, assuming only technical improvements. The “current best practice” values indicated below should be completed for all NACE subsectors and constantly updated, as they can serve as a reference benchmark for companies in the same sector / subsector.

[7] Lorenzoni, A. (2008), “ The Italian Experience. White certificates in electricity and gas. A regulatory review”. http://www.catedrabp.upcomillas.es/Documentos/Actividades/Foro/2008/Lorenzoni.pdf

Table 14 Technologies with the Highest Efficiency Potential in Selected Industrial Sectors

		Specific energy consumption (GJ/tonne)	Current best practice	Thermo-dynamic minimum	Technical potential in [r]evolution scenario			Refer-ence scenario
Sector	**Unit (specific final energy**	**2005**	**2005**		**2020**	**2030**	**2050**	**2050**
Iron and steel	Primary steel BF/BOF route (GJ/tonne crude steel)	10	6.4	1.3				
Iron and steel	Primary steel OHF route (GJ/tonne	23						
Iron and steel	Secondary steel EAF route (GJ/tonne crude steel)	2.2	1.6	1.3				
Iron and steel	Hot/cold rolling (GJ/tonne crude steel)	2.9	2.2	0.05				
Iron and steel	Share secondary steel	35%	35%		41%	48%	60%	
Iron and steel	**GJ/tonne crude steel**	**12.5**	**5.5**	**1.3**	**10.3**	**8.0**	**3.5**	**8.0**
Iron and steel	*Index (GJ/tonne crude steel)*	*100*	*44*	*10*	*82*	*64*	*28*	*64*
Non-metallic minerals	GJ/tonne clinker	4.2	3.1	1.8	3.9	3.5	2.8	
Non-metallic minerals	Clinker to cement ratio	80%	25%	<25%	75%	70%	60%	
Non-metallic minerals	Electricity use grinding/blending (kWh/tonne cement)	110	105	<100				
Non-metallic minerals	**GJ/tonne cement**	**3.7**	**1.2**	**<0.5**	**3.2**	**2.7**	**1.7**	**2.4**
Non-metallic minerals	*Index (GJ/tonne)*	*100*	*31*	*<14*	*86*	*73*	*45*	*64*
Aluminium	Primary aluminium (MWh/tonne aluminium)	15.3	12.5	6.4	13.85	12.4	9.5	
Aluminium	Secondary aluminium (GJ/tonne aluminium)	0.8	0.8	<0.8	0.7	0.7	0.7	
Aluminium	Share secondary aluminium	33%	33%	100%	40%	47%	60%	
Aluminium	**GJ/tonne aluminium**	**10.5**	**8.6**	**<0.6**	**8.9**	**7.4**	**4.2**	**6.7**
Aluminium	*Index (GJ/tonne aluminium)*	*100*	*82*	*<6*	*85*	*70*	*40*	*64*
Ammonia production	GJ/tonne ammonia	15	8					
Ammonia production	Ammonia (index)	100	53					
Chlorine production	MWh/tonne chlorine	3.6	2.6					
Chlorine production	Chlorine (index)	100	72					
Ethylene production	Ethylene production by naphtha (GJ/tonne)	25-40	18					
Ethylene production	Ethylene production (index)	100	60					
Chemical and petrochemical	Index best practice implementation (GJ/tonne)	100	62		89	77	55	
Chemical and petrochemical	Index improved material efficiency and recycling (GJ/tonne)	100			95	90	80	
Chemical and petrochemical	*Index (GJ/tonne)*	*100*			*86*	*72*	*45*	*64*
Other industries	*Index (GJ/tonne)*	*100*			*84*	*68*	*35*	*64*
Total industry	Index (GJ/tonne)	100			84	69	38	64

Source: Umweltbundesamt, Germany, 2009 [UBA 2009]

B.2.5.6. Policies to Fight Energy Poverty

As indicated in the introduction to this report, concerns about energy poverty are growing in Europe. The Parliament warns “that special attention must be paid to consumer protection and that safeguards must be put in place in order to prevent grid disconnection” [EP 2008] of customers who cannot pay their energy bills.

Customers need transparent and comparable information on energy use and prices in order to reduce their energy bills. This should be taken into account when implementing the European strategy on “education and training needs for the carbon-free energy society” [EESC 2009b]. The EESC also gives a series of recommendations on how to “enhance energy efficiency policies and programmes by end users”, which should be taken into account.

Energy poverty in households must be addressed in the context of social policies, which are generally implemented on the local level. However, there is a need for setting a common definition of public service obligations, which are specific to the energy sector, as foreseen by the European Charter on the Rights of Energy Consumers. Work in the area is just beginning, since, according to the Parliament, the notion of energy poverty still needs to be defined and an “appraisal should be made of the extent to which the individual national social security or tax systems take account of the risks associated with energy poverty." However, it is clear that policy measures must prioritize investment in energy efficiency in low-income households, rather than on subsidizing energy consumption.

B.2.5.7. Relevance of Policy Measures for Regional Typologies and Scenarios - Conclusions

Although all policy measures proposed in this report are considered important to fight the different forms of energy poverty in the regions, some have a higher priority for certain typologies and under different scenario assumptions. Typology 2, for example, groups the regions with the most unfavourable economic structure, so that industrial diversification strategies are vital to conserve competitiveness. Since this group of regions is also characterized by high demand for heating and cooling, the construction of efficient networks is also a priority. Likewise, regions with high level of commuting (typology 3) or at the periphery (mainly typology 1a and 4), with an important dependence on air travel, have a greater need for action in the field of mobility and freight transport.

Social policies – so far rather underdeveloped with regard to energy poverty – play a crucial role for regions belonging to typologies 1b and 2 and under the assumptions of the "Business as Usual?" scenario and could be combined with innovative financing measures on municipal level. For regions with low disposable income, but considerable PV potential, urban solar planning tools may provide the information necessary to achieve the greatest deployment of these technologies at the lowest cost possible. In Member States that opt primarily for building new nuclear plants and will therefore have a large baseload capacity (electricity that is being produced 24 hours a day), overall energy efficiency may not be the determining aspect in the corresponding policies, but rather the shift from fossil fuel use to the constant consumption of electricity. A critical question in this context is acceptance and consumer preferences, for example for "green tariffs".

European initiatives are especially important when benchmarks are needed, for example in industries with high energy spending, and for promoting regional cooperation through network extension, energy research and the development of a joint and more reliable renewable portfolio. The European framework will furthermore be decisive where major transition processes need to be implemented, mainly with regard to air and freight transport.

C. Scientific Report

This scientific report contains the full contributions from all partners in the project in charge of research activities, namely:

1. Additional analysis of the risk of “carbon leakage” in the EU regions (Inasmet-Tecnalia)
2. Clustering methodology (NTUA)
3. Scenario descriptions and methodology, case studies and survey of regional energy agencies (Nordregio)
4. Policy recommendations and summary table (Labein-Tecnalia)

Each of these documents gives further explanations of the conclusions presented in the main report and has been written as a stand-alone document, with the objective of facilitating the further dissemination of the project results to different audiences (scientific community, policy makers and interested lay persons) by the project leader and the partners.

C.1. Additional Analysis- Risk of “Carbon Leakage” in the EU Regions

Authors: Edurne Magro, Daniela Velte (Inasmet-Tecnalia)

As requested by the response to the Updated Interim Report, the analysis on regional competitiveness has been amplified to take into account the expected impact of carbon pricing on certain sectors and subsectors in Europe, based on the list of industries with risk of “carbon leakage”, which was published recently by the European Commission. “Carbon leakage” refers to the possibility that companies decide to transfer their facilities to countries outside the EU if production costs rise as a result of carbon taxes. The analysis done by the Commission services complements the ReRisk results as it combines production costs with the intensity of trade with third countries. Based on employment data, it has been possible to identify the EU countries with the highest “risk of carbon leakage” and to indicate some regions that may face specific problems in this context.

The Commission Decision of 24 December 2009 [EC 2009b] defined a list of sectors and subsectors which are deemed to be exposed to a significant risk of “carbon leakage”. These are sectors and subsectors, which could consider relocation as a consequence of the direct cost of the CO2 allowances that the companies must purchase and the indirect costs from higher electricity prices. Since this analysis is also relevant for the competitiveness of the EU regions, the ReRisk team has compared the Commission’s list with the project’s own findings on industrial energy spending and has tried to identify the regions, which face the greatest risk of “carbon leakage”.

The Commission defines these sectors as follows:

“15. A sector or subsector shall be deemed to be exposed to a significant risk of carbon leakage if:

(a) the sum of direct and indirect additional costs induced by the implementation of this Directive would lead to a substantial increase of production costs, calculated as a proportion of the gross value added, of at least 5 %; and

(b) the intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries), is above 10 %.

16. Notwithstanding paragraph 15, a sector or subsectors also deemed to be exposed to a significant risk of carbon leakage if:

(a) the sum of direct and indirect additional costs induced by the implementation of this Directive would lead to a particularly high increase of production costs, calculated as a proportion of the gross value added, of at least 30 %;or

(b) the intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries), is above 30%". [EC 2009a]

The analysis has been made by the Commission for the years 2013/14, assuming a carbon price of 30 € / t of CO_2. The resulting list comprises 16 subsectors on NACE 4 level, which would be exposed considering the criteria laid out in the paragraphs 15 and 16 of Article 10, as well as 11 subsectors corresponding to paragraph 15 and two subsectors corresponding to paragraph 16(a). The subsectors, which show a risk of "carbon leakage" only because of their intensity of trade (paragraph 16 b), but not as a result of increased production costs, have not been considered in our analysis.

The comparison of sectors with risk of carbon leakage and sectors with high energy spending (those which spend 10% or more of their total purchases on energy) shows that some of the sectors with the highest energy spending are not considered to be exposed to a significant risk of carbon leakage, namely

CB1412 Quarrying of limestone, gypsum and chalk

CB141 Quarrying of stone

CB1421 Operation of gravel and sand pits

DI2614 Manufacture of glass fibres

DI264 Manufacture of bricks, tiles and construction products.

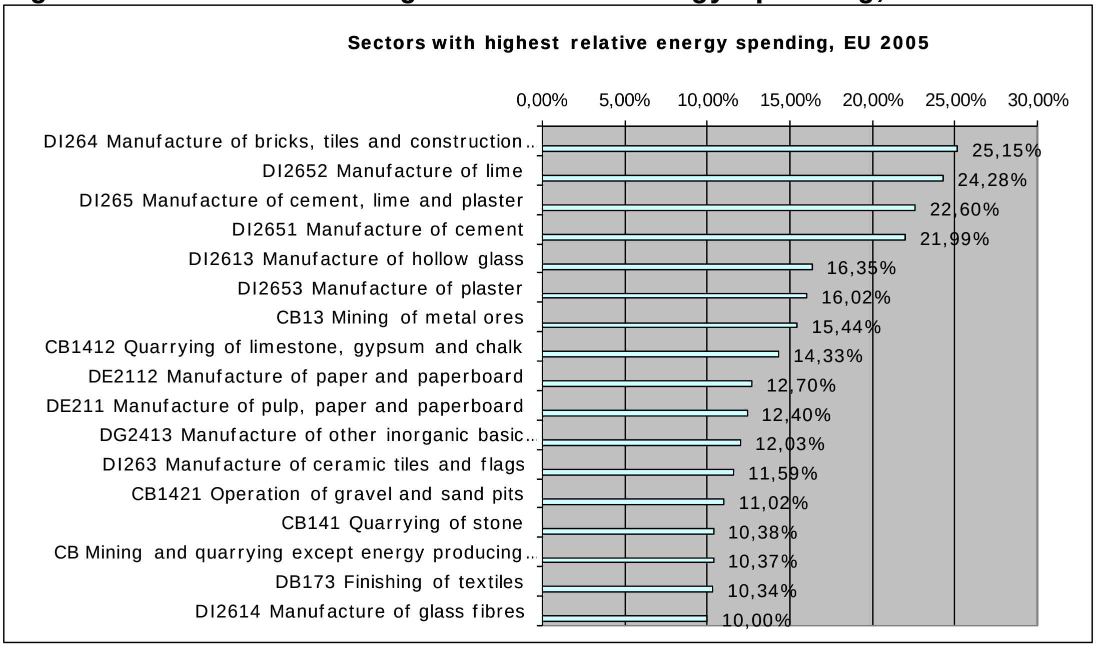
In the first three cases, this can be explained by the fact that mining is an economic activity imminently related to local resources. A similar explanation may apply to the subsectors supplying materials to the construction industry, but no explanation is given on this question in the Commission document.

In addition, there are some sectors and subsectors exposed to a significant risk of carbon leakage, which have low levels of energy purchases, such as *CB143 Mining of chemicals and fertilizer minerals, DA 1583 Manufacture of sugar, DA1595 Manufacture of other non-distilled fermented beverages, DA1597 Manufacture of malt, DB181 Manufacture of leather clothes, DF231*

Manufacture of coke oven products, DF232 Manufacture of refined petroleum products, DG2417 Manufacture of synthetic rubber in primary forms, DJ2721 Manufacture of cast iron tubes, DJ2731 Cold drawing, DJ2742 Aluminium production, DJ2743 Lead, zinc and tin production, DJ2744 Copper production, DJ2745 Other ferrous metal production and *DK2931 Manufacture of agricultural tractors*.

The sectors, which have a high level of energy spending (more than 10% of total purchases) and are considered to be at risk of carbon leakage, are displayed in figure 7.

Figure 7 Sectors with Highest Relative Energy Spending, EU Level



Source: Own elaboration based on Eurostat data

Based on the ReRisk findings, we can highlight those countries where these industries spend more on energy purchases than the European average8. Consequently, these might be considered most vulnerable after the implementation of this Directive:

DI2652 Manufacture of lime: this sector has the highest relative energy spending in Hungary, Germany, Spain, Greece and Portugal.

DI2651 Manufacture of cement: energy purchases are a considerable production cost in this sector all over Europe, but the highest levels of purchases can be found in companies in Greece, Slovakia, Italy, Hungary, Germany and Austria.

DI2613 Manufacture of hollow glass: energy costs are highest for companies in Romania, Slovakia, United Kingdom, Portugal, Greece, Hungary and Belgium.

DI2653 Manufacture of plaster: the companies with the highest energy spending are located in Hungary, Germany, Spain, Greece and Portugal.

[8] Please note that the following countries have not been included in this analysis for lack of data: Albania, Bulgaria, Switzerland, Lithuania, Malta, Poland, Slovenia

DE2112 Manufacture of paper and paperboard: again, energy purchases are generally high in this industry, but for companies in Belgium, Lithuania and Slovakia this cost is higher than average.

DG2413 Manufacture of other inorganic basic chemicals: highest relative energy spending in United Kingdom, Austria, Spain and France.

DI263 Manufacture of ceramic tiles and flags: energy purchases (as % of total purchases) are highest in Portugal, Greece, Hungary, Germany and Ireland.

The analysis realized above and based on the European average must be completed with country-specific data in order to take into account also those national industries, which spend more than 10% of their purchases on energy, even if the sector in the EU on average remains below this threshold. The list of most vulnerable sectors can be completed as follows:

CA101 Mining and agglomeration of hard coal: highest relative energy spending in Hungary, United Kingdom and Spain.

DA1592 Production of ethyl alcohol from fermented materials: highest relative energy spending in Hungary and Romania.

DB1711 Preparation and spinning of cotton-type fibres: highest relative energy spending in Austria, Hungary and Romania.

DG2414 Manufacture of other organic basic chemicals: highest relative energy spending in Belgium, Latvia, Norway, Romania and Slovakia.

DG2415 Manufacture of fertilizers and nitrogen compounds: highest relative energy spending in Hungary, Romania, Belgium and Netherlands.

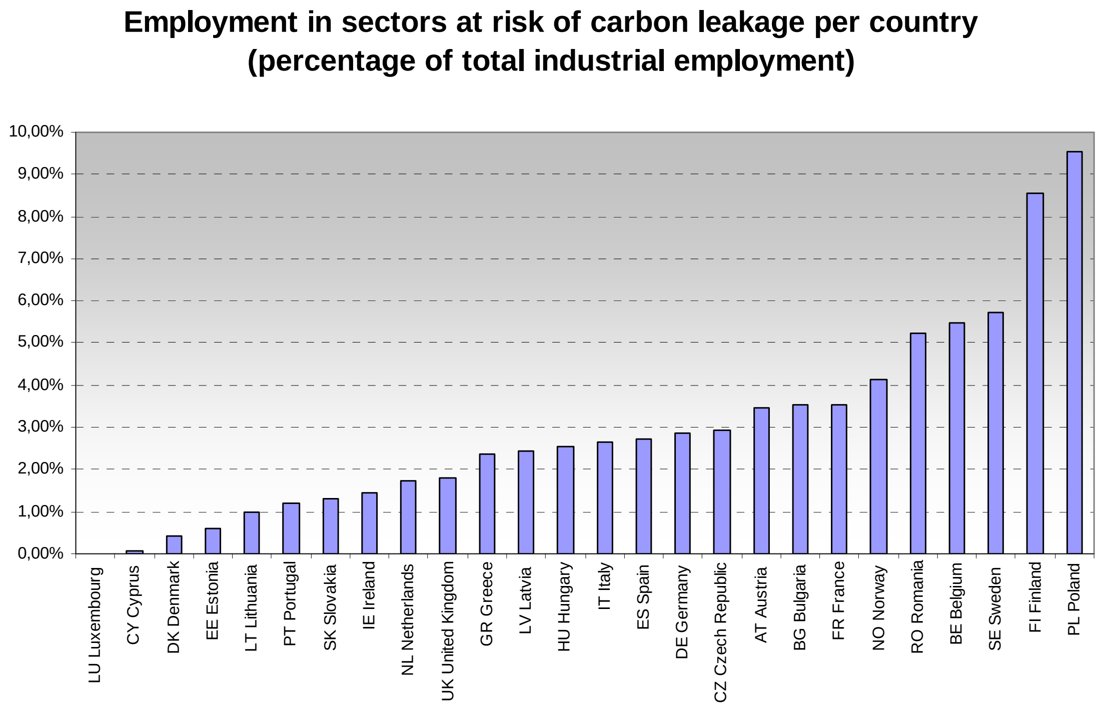
DI2611 Manufacture of flat glass: highest relative energy spending in Romania and Finland.

DJ271 Manufacture of basic iron and steel and of ferro-alloys: highest relative energy spending in Romania, Austria, Hungary, Norway and Germany.

The data indicates that the Eastern European Countries (Romania, Hungary and Slovakia) and two Mediterranean Countries (Greece and Spain) are those with a highest energy relative spending in sectors at risk of carbon leakage.

Taking into consideration all sectors at risk of carbon leakage, it is possible to determine the possible impact of “carbon leakage” on industrial employment. As shown in figure 8, in Poland, Finland, Sweden, Belgium and Romania between five and ten percent of industrial employment could be affected, if companies decide to relocate their activities.

Figure 8 Employment in Sectors at Risk of Carbon Leakage per Country



Source: Own elaboration based on Eurostat data

These findings cannot be entirely transferred to the regional level, because data on employment is not available for the different subsectors (NACE 4 level), but only for the larger sectors (NACE 2 level). However, since most of the affected sectors belong to four NACE groups (DE 21 Manufacture of pulp, paper and paper products, DI 26 Manufacture of other non-metallic mineral products, DJ27 Manufacture of basic metals and DG24 Manufacture of chemicals and chemical products) an estimate can be presented here:

Table 15 Regions with more than 25% of Industrial Employment in Sectors at Risk of Carbon Leakage

NUTS2_ 2006	**NAME**	%employ ment DE21	%employ ment DI26	%employ ment DJ27	%employ ment DG24	%employ ment total
BE31	Prov. Brabant Wallon	4,82%	0,00%	9,87%	41,25%	55,94%
DEB3	Rheinhessen-Pfalz	2,10%	4,09%	1,18%	34,78%	42,15%
NL34	Zeeland	0,00%	2,58%	18,47%	20,21%	41,26%
BE21	Prov. Antwerpen	2,00%	3,32%	14,69%	21,06%	41,06%
BE22	Prov. Limburg (B)	2,83%	7,35%	23,97%	6,83%	40,98%
SE31	Norra Mellansverige	11,62%	0,76%	22,12%	1,67%	36,17%
NL11	Groningen	9,81%	4,66%	13,72%	7,79%	35,98%

NUTS2_ 2006	NAME	%employ ment DE21	%employ ment DI26	%employ ment DJ27	%employ ment DG24	%employ ment total
UKE1	East Yorkshire and Northern Lincolnshire	3,56%	4,69%	16,63%	10,83%	35,72%
BE32	Prov. Hainaut	2,17%	11,36%	10,36%	11,42%	35,31%
FI1A	Pohjois-Suomi	5,39%	2,38%	26,65%	0,00%	34,41%
NL13	Drenthe	2,06%	4,67%	13,71%	12,75%	33,19%
SK04	Východné Slovensko	1,68%	3,86%	24,56%	2,39%	32,50%
DEA1	Düsseldorf	2,26%	2,58%	14,31%	13,01%	32,16%
UKD2	Cheshire	3,87%	2,92%	1,12%	23,04%	30,95%
ES12	Principado de Asturias	1,17%	7,61%	17,19%	4,25%	30,23%
BE23	Prov. Oost-Vlaanderen	3,74%	3,37%	15,94%	5,79%	28,85%
NL32	Noord-Holland	2,07%	1,36%	17,28%	8,08%	28,79%
GR24	Sterea Ellada	0,00%	9,33%	15,97%	3,38%	28,68%
AT33	Tirol	0,00%	16,34%	5,10%	6,85%	28,29%
DEA2	Köln	4,89%	4,04%	3,75%	15,26%	27,96%
LU00	Luxembourg (Grand-Duché)		7,93%	16,43%	3,42%	27,79%
NL33	Zuid-Holland	1,47%	3,24%	12,56%	10,46%	27,73%
NO03	Sør-Østlandet	8,72%	4,93%	2,76%	10,76%	27,18%
DE41	Brandenburg - Nordost	5,21%	6,02%	12,33%	3,48%	27,04%
BE33	Prov. Liège	2,14%	4,83%	14,28%	5,06%	26,31%
SE32	Mellersta Norrland	15,51%	2,01%	4,03%	4,39%	25,94%
NL42	Limburg (NL)	4,10%	8,55%	3,10%	9,85%	25,60%
FR23	Haute-Normandie	3,22%	5,17%	2,66%	14,32%	25,37%
DE71	Darmstadt	1,40%	1,54%	1,90%	20,50%	25,33%
DEB1	Koblenz	4,82%	9,42%	5,62%	5,42%	25,28%

Source: Own elaboration based on Eurostat data

Combining the available data, “carbon leakage” seems to be a major threat to the Belgian provinces of Brabant Wallon and Antwerpen, which should analyse the situation in the subsectors *DG2414 Manufacture of other organic basic chemicals* and *DG2415 Manufacture of fertilizers and nitrogen compound*, since these spend more than the EU average on energy purchases. There could also be a problem, although minor, in the German region of Koblenz with regard to *DI 263 Manufacture of ceramic tiles and flags* and in Düsseldorf with regard to *DJ271 Manufacture of basic iron steel and of ferro-alloys*. The British regions of East Yorkshire and Northern Lincolnshire might be exposed to the risk of carbon leakage by companies dedicated to *DG 2413 Manufacture of other inorganic basic chemicals*, which do not perform well with regard to the subsector's average spending on energy.

Within the two countries most affected by the risk of carbon leakage, Poland and Finland, two specific problem regions can be identified: Swietokrzyskie (21.24% of industrial employment in sectors with risk of carbon leakage) and Pohjois-Suomi, where more than 34% of industrial employment is in the critical sectors.

For the rest of the countries with high levels of industrial employment in sectors at risk of carbon leakage, it has not been possible to establish the relationship between higher than average energy spending and certain sectors and regions. Further analysis based on more detailed regional employment data will be needed to determine the actual risk of carbon leakage and it possible impact on regional competitiveness.

C.2. Area Typologies – Clustering

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C.2.1. Introduction and Approach

The classification of the EU regions into groups of regions with similar characteristics is a helpful tool in the study of the risk of energy poverty in Europe. This classification may result in regional typologies that will assist policy makers to understand the picture of Europe in various aspects and adjust their policy agenda accordingly.

In the previous phases of this project the typologies suggested were meant to allow the assessment of risk for of energy poverty as well as the spatial differentials of this risk. This would help policy makers to make informed decisions. In order to assess potential energy poverty it was apparent that it is necessary to account for economic development and prosperity of the region, infrastructure and access to the supply of energy, demographic structure of the population and of course weather conditions.

Based on the recent literature, we rejected the use of principal component analysis and fuzzy classification although they are two well established classification methodologies for this kind of analysis. Instead, we proposed to employ techniques that allow for a straight forward classification of regions. This, in combination with an effective visualization of the results, would allow a good communication of these to policy makers. We also proposed that it would be interesting to adopt an area classification method that is based on the theory and applications of geodemographics.

The production of an area classification / typology is a long process that consists of several steps. We present these steps here but a more technical discussion on the methodology is presented in the next section.

Step 1. Data Input: Assessing Raw Data for the Regional Typology

When data from different countries is combined in a single geographical layer it is very common that it needs to be harmonised in order to account for the different approaches the data sources use for data collection. At this stage, data source(s) for each variable / indicator are checked to ensure that the data fits into a single distribution. This is important to ensure as high as possible quality data for the regions.

We identified potential gaps in the dataset and the need for new variables/ indicators that could be derived from existing data, such as accessibility measures and urban sprawl measures, but it has not be possible to produce this data during the time of the project.

Step 2. Preparing Data for the Classification

It is always necessary to check the nature of the data and prepare it in a form that can be inserted to the classification algorithm. One example has been the wind power potential that was originally provided in the form of wind power density. We also needed to check if some variables would make a real contribution to the analysis.

Step 3. Evaluation of Input Variables in Terms of Statistical Inference

In this step of the process the appropriateness of each variable / indicator in terms of statistical inference is assessed. Some variables may be replaced or excluded from the classification because they will a) have small size, b) be correlated with other variables, c) have extreme values, or d) be much-skewed.

The classification methodologies assume that variables/indicators follow a Normal/Gaussian distribution. In many cases in the real world this is not the case. Therefore, it is necessary to perform descriptive statistical analysis for each variable in order to identify those with extreme values or those exhibiting high skewness. Extreme values are usually excluded or smoothed. However, skewed variables require more attention. If the problem of skewness exists the criterion of normal distribution is violated. It is thus necessary to perform a normalisation / standardisation process to the variable in order to ensure the classification method will not suffer from misspecification bias. Another way to address this problem without replacing the variable with its normalised version is by applying a low weight.

The last part of this step consists of performing pair-wise correlations in order to identify highly correlated pairs or groups of variables. It is likely that two or more variables will have similar values or distribution and therefore a high degree of correlation. This is also inappropriate for the classification algorithm because one variable may be replacing the effect of another during the classification process and thus, wrong conclusions for the type of regions may be derived. An obvious way to address this issue is by performing factor analysis and replacing the group of correlated variables with a product variable. We rejected this approach because it will then be hard to describe a region and even harder to perform scenario based analysis. Another way of reducing the potential bias is by applying lower weights to the correlated variables. Choosing the best representative variable is also common practice for experienced researchers. For the latter, opinions of energy experts were taken into account.

Step 4. Weight Selection

It is apparent from the theory and empirical work that not each variable should be assumed to have an equal influence in the classification of a region. Furthermore, variables with high values could dominate the clustering results. Based on theory and depending on the research questions the region typology is trying to answer, some indicators should receive higher weights than others.

Applying a weight to each variable is a way of addressing data issues as well as ensuring the proper influence of each variable in the regional typology. However, we addressed this data quality issue by removing problematic indicators. The influence of each variable was not only assessed on the basis of the research question, taking into account previous empirical findings for the appropriateness of each variable for the required typology, but also based on the evaluation of the results that could force the choice of different weights other than those applied in the first run of the classification.

The final set of indicators was assessed by the ReRisk research team and the energy experts participating in the ReRisk Workshop III held in Bilbao. Based on the experts' opinion about the appropriateness of each indicator and their ranking of the indicator's importance in terms of the policy implications of this project's results, a single set of weights has been produced and use here.

Step 5. Clustering

It is apparent from the geography literature that among others, there are two main categories of clustering algorithms: stepwise, top-down methods and iterative location–reallocation methods. In the former, the algorithm examines all possible combinations of areas into classes and converges to a fixed number of classes which are then interpreted. In the latter category of algorithms, the number of classes are predefined and the algorithm allocates all areas to classes ensuring that the variation within a class is minimised. An example algorithm of the latter is the k-means clustering.

A geodemographic-like approach for area typology could be a superior methodology for ReRisk. Geodemographics use an alternative approach for defining regional typologies. One important aspect of this approach is that a high number of classes is produced or selected. An optimisation process follows in which the classes are assessed and may be merged manually or by repeating the clustering steps with different configuration. Hierarchical clustering is more appropriate here as it provides a clustering tree that shows the groupings in terms of statistical output. The resulted classes are then numbered, interpreted and labelled accordingly. If there are too many classes and communicating the results is inefficient, these are grouped to categories resulting in a cluster hierarchy. It is possible that the classes are grouped to match the four types of regions specified above; however, this is not known a priori. Although an attempt has been made to employ this technique, this is far from being a proper geodemographics approach mainly due to data availability. This should be a research question for future analysis, especially if the analysis is applied at a finer geographical scale.

Finally, visualisation tools have been applied and a short description of the profile of each cluster is provided in order to ensure good communication of the results to the policy makers and the reader in general.

C.2.2. Methodology

C.2.2.1. Introduction

In Annex 1 of this report, a thorough presentation of the available data and their sources has been presented. From this data some 20 variables have been identified and are available for the area typology exercise. However, in order to ensure quality input and to comply with the criteria of the clustering algorithms in terms of statistical inference, it is necessary to statistically assess the characteristics of each of these variables. This is a standard procedure in exploratory analysis in quantitative geography to ensure data quality (input) and robustness of the results (output).

The area typologies of the 287 EU regions clustered these regions based on the available variables. The clustering procedure has about seven main steps referring to data quality checking, clustering and presenting results. The main steps of this procedure are shown in figure 9.

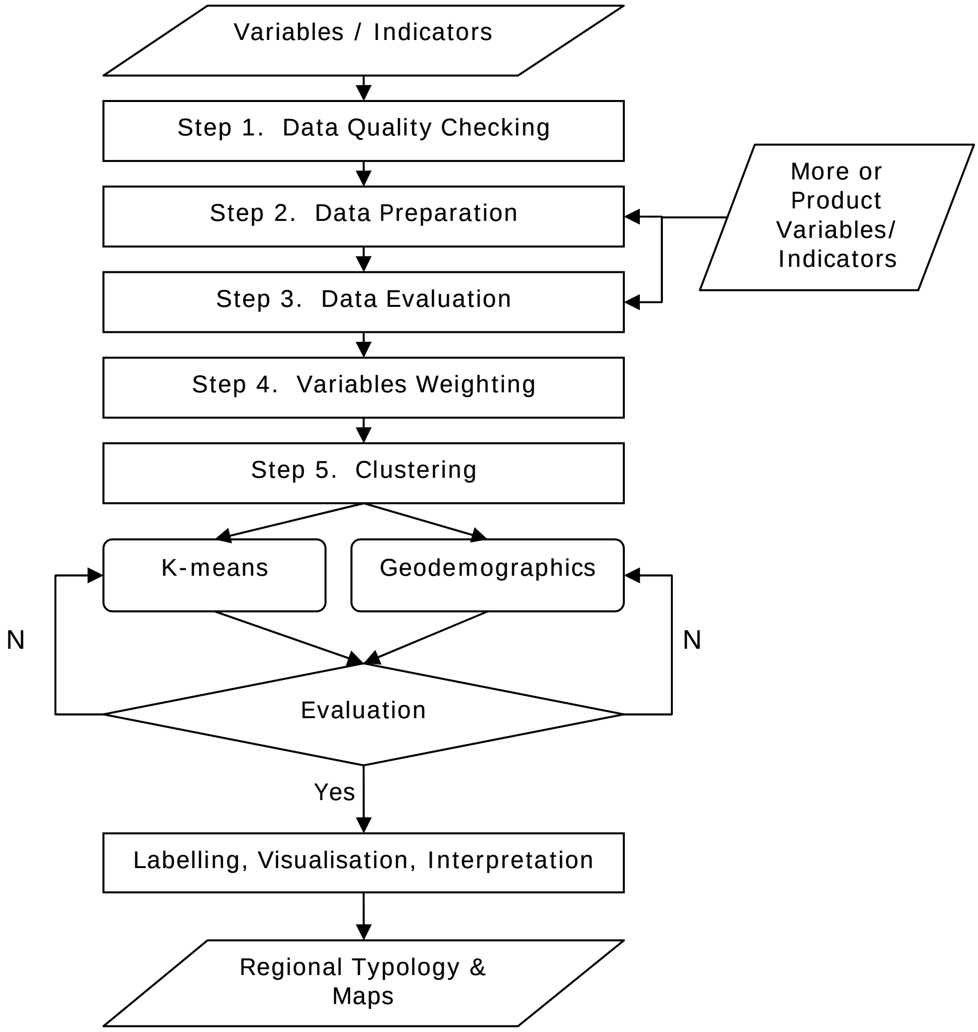
The main data issue in concern here is that some of the variables have missing values in some EU regions. Other issues include the distributing of the values that ideally should be normal and the correlation between the indicators that should be independent to ensure high quality analysis.

Since the data analysed here is spatial, one should also look at their spatial structure and potential spatially dependencies. In order to do this it is necessary to produce maps and apply spatial autocorrelation diagnostics to each variable. In order to assess spatial autocorrelation, the global and local Moran's I statistics are calculated [Anselin, 2003, 2004; Cliff and Ord, 1973, 1981; Moran, 1948]. However, the clustering algorithms employed here do not account for the spatial dependence of the data. Furthermore, the issue of spatial dependence has not been properly discussed in the clustering literature of aggregate data, thus we ignore the spatial characteristics of the data.

The decision of which indicators to include in the clustering exercise was based both on the preliminary descriptive analysis as well as on the expertise of the research team and the experts who participated in workshop III in the context of the scenario building process. Of course, one could not completely address Steps 1-4 of the flowchart below, as we do not have an a priori knowledge of what each variables distribution and spatial structure should be.

In the Updated Interim Report we have looked at the data quality in terms of statistical inference. This was necessary because the k-means clustering algorithm works on the basis of minimising the sum of squares of the distance from cluster centres. The application of the algorithm requires that the input variables have a normal distribution and are independent from each other. It is also necessary that outliers due to error or miscalculation are removed in order to avoid biased results.

Figure 9 Steps for Clustering Procedure



It is necessary to pay special attention to the issue of missing values. Clustering algorithms allow two options: one is to classify all regions with as many variables as possible and the other is to leave a region with at least one missing value out of the clustering exercise. The former option ensures as many classified regions as possible, but the variable set for classification changes in each region introducing bias in the results. The latter option apparently will leave several regions out of the classification exercise, but is the standard in clustering software. The latter option has been applied here whereas the former option was applied in the clustering presented in the Updated Interim Report of the ReRisk project.

C.2.2.2. Background

Several algorithms and software has been used for the clustering. K-means and hierarchical clustering are the main function available both in commercial (such as SPSS) and open source statistical software (such as R).

The k-means procedure attempts to identify relatively homogeneous groups of cases based on selected characteristics, using an algorithm that can handle large numbers of cases. The procedure tries to form groups that do differ. The reason for choosing to apply a k-means cluster analysis is that it allows for the grouping of regions into categories of similar rates for a set of variables. It is a quick algorithm the results of which can be easily mapped [Kalogirou, 2003].

The k-means clustering algorithm is described in detail by Hartigan [1975]. The k-means used here is an efficient version of the algorithm presented in Hartigan and Wong [1979]. The aim of the K-means algorithm is to divide M points in N dimensions into K clusters so that the within-cluster sum of squares is minimized. It is not practical to require that the solution has minimal sum of squares against all partitions, except when M, N are small and K=2. We seek instead “local” optima, solutions such that no movement of a point from one cluster to another will reduce the within-cluster sum of squares [Hartigan and Wong, 1979, p. 100].

Geodemographics have originally been designed to classify areas based on the socio-economic profile and demographic structure of the people living in these areas. They allow for a straightforward understanding of the average person living in an area. The inclusion of energy and climate related variables in the analysis can produce an extended geodemographics-like system. Such systems use a two level hierarchical classification that can be top-down or bottom up. The top classes are groupings of the bottom classes that are more detailed. Thus, one can have an initial reading of the regions and their classification. However, the system allows for a more detailed classification of the regions that may be useful for specific policy making actions. Unfortunately, the lack of appropriate data and the fact that NUTS II regions are very large in size and cover diverse population groups limit the advantages of this method and its proper application to the dataset.

The Geodemographics approach can be also implemented using k-means clustering. Based on the literature [Harris et al., 2005] this method is appropriate for high geographic details, such as the UK output areas [Singleton and Longley, 2008; Vickers and Rees, 2007]. Thus, although originally proposed as an alternative to the standard clustering it has been decided that would not contribute to the conclusions of this research and should form a future agenda where the same research questions are asked for more detailed geographies, such as Local Authorities [Webber and Craig, 1978].

C.2.2.3. Data Normalization and Weighting

It is common place in the geography literature about clustering that data in their original form may not result in efficient typologies if the variables that are included in the analysis have data with very different means and variances and their distributions are skewed [e.g. Batagelj et al., 2006; Harris et al., 2005; Milligan and Cooper, 1988; Su et al., 2009].

Harris et al. [2005, p. 152] suggest that “In an ideal world we would include as clustering variables only those which have a bell curved, normal (or

Gaussian) distribution. In practice many important dimensions that need to be included in a classification are not normally distributed."

Indeed in our analysis many variables have skewness and kurtosis statistics that indicate a problematic normal distribution. In a normal distribution the skewness and kurtosis should be 0 [Kalogirou, 2003]. A near zero values, such as for climate and socioeconomic indicators is acceptable. However there are indicators such as wind energy potential and % commuters that exhibit high values of skewness and kurtosis.

In order to address this issue it is necessary to standardise or normalise the data. Milligan and Cooper [1988] suggest seven methods of standardisation. Here we employ two methods of standardisation, the z-score (Formula 1) and the normalisation to the sum of the values (Formula 2).

The z-score is very common in the literature. "The z-score method addresses the differential scale of the original variables by transforming the variables to have unit variance; however, the z-score method places no specific restrictions on the ranges of the transformed variables." (Su et al., 2009, p. 281). The formula for calculating the z_i score for the value x_i of an indicator X is

$$z_i = \frac{x_i - \bar{x}}{\sigma} \tag{1}$$

where $\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$ is the mean and $\sigma^2 = \frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N}$ is the variance of X. Milligan and Cooper (1988, p. 185) recognise that "standardization based on normalizing to the sum of the observations has been suggested: $Z_6 = X/\Sigma X$. Formula Z_6 will normalize the sum of the transformed values to 1.00 and the transformed mean will equal 1 / n. As such, the mean will be constant across variables, but the variances will differ." The formula for calculating the q_i score (the Z_6 proposed by Milligan and Cooper) for the value x_i of an indicator *X is*

$$q_i = \frac{x_i}{\sum_{i=1}^{N} x_i} \tag{2}$$

The q-score defined here ensures that the indicators will have an equal influence in the clustering. This allows the easy use of the weights for the indicators. By just multiplying each value of the indicator with the indicator's weight, we ensure that the indicator with the highest weight will have more influence in the convergence of the k-means algorithm. The results of the application of this method in the ReRisk dataset are presented below.

According to Harris et al. [2005, p 162] "The next stage in the clustering process used by Experian involves the calculation of the means and standard deviations of the input variables, and the standardization of the data. An important feature of this process is that these, and all subsequent, computations are population weighted. That is to say that when calculating the means and standard deviations the algorithm gives correspondingly more attention to the values of zones with high populations than to those with low." Thus, the new z-scored note pz_i below for the value x_i of an indicator X is

$$pz_i = \frac{w_i x_i - \overline{x}}{\sigma} \qquad (3)$$

where $\overline{x} = \frac{\sum_{i=1}^{N} w_i x_i}{\sum_{i=1}^{N} w_i}$ is the mean and $\sigma^2 = \frac{\sum_{i=1}^{N} (w_i x_i - \overline{x})^2}{\sum_{i=1}^{N} w_i}$ is the variance of X and w_i is the weight assigned to the ith EU Region and is proportional to that region's population count.

C.2.3. Clustering Results

C.2.3.1. Introduction

The clustering results presented in this chapter are the final. The assumptions made were based both on preliminary research findings and the comments from the ESPON team. In the first attempt for clustering it was assumed that variables should be independent, should have less than 20% missing values and should have a good shape normal distribution. However, no outliers where removed from the variables. It was decided that the clustering will be based on nine variables and that most EU regions should be clustered based on as much available data as possible. It was also decided that the best clustering results were provided after the data had been normalized and weighted. The availability of the PUSH factor and the new clustering results were not approved by the partners of the project.

It was then decided that regions with missing values for at a least one variable should be left out as the results would be misleading. This means that 237 out of the 287 Regions for which data was available could be clustered. It was also decided that one typology with a large number of regions should be split.

In this section the results of the final clustering applications are presented. These include:

1. A k-means clustering with 4 typologies based on the weighted normalized values of the original indicators
2. A k-means clustering with 5 typologies after splitting the largest cluster 1 of the previous analysis into two subclusters following the

same clustering procedure (a k-means with two clusters and 9 variables on a subset of regions)

The variables included in the clustering are:

- **Climate conditions**
    - o Mean maximum temperature July
    - o Mean minimum temperature January
- **Economic structure**
    - o % employment in industries with high energy purchases
- **Transport dependency**
    - o Fuel costs of freight transport
    - o % workers commuting
- **Social dimension**
    - o Long-term unemployment rate
    - o Disposable income in households
- **Production potential of renewables**
    - o Onshore wind power potential
    - o PV potential

C.2.3.2 4 Typologies K-means of the Normalized and Weighted Values of the Original Indicators

For the k-means clustering procedure applied here the following choices have been made: a. the number of typologies is 4; b. the q-scores (the sum based normalised values documented in Section C.2.3) of the original indicators were analysed after they were weighted by being multiplied by the values presented in Table 16. The weighting was based on the experts' opinions about the appropriateness of each indicator and the experts' ranking of the indicator's importance in terms of the policy implications of the results of this project (Workshop III). Since there are two variables in each category but Economic structure, the original weight for the variable "% employment in industries with high energy purchases" was doubled from 2.50 to 5.00.

Table 16 Indicator's Weights

Indicator	Weight
Climate conditions	
Mean maximum temperature July	1.86
Mean minimum temperature January	2.00
Economic structure	
% employment in industries with high energy purchases	5.00
Transport dependency	
Fuel costs of freight transport	2.43
% workers commuting	2.21
Social dimension	
Long-term unemployment rate	2.64
Disposable income in households	2.36
Production potential of renewables	
Wind power potential	1.86
PV potential	2.14

The cluster centres of the original variables based on the resulted membership are presented in Table 17 along with the number of regions that were assigned to each typology. Map 10 shows the membership of each EU region in one of the four typologies in different colours whereas regions with missing data for at least one variable are coloured grey.

Description of the Characteristics of Each Typology

The following description is based on the mean values for each variable in each typology and presented in Table 17 and the spatial patterns shown in Map 10.

Table 17 Cluster Centres – 4 Typologies

Variables / Mean Values	Typology 1	Typology 2	Typology 3	Typology 4	Data Mean
Maximum temperature July	31.61	33.70	30.46	26.17	31.70
Minimum temperature January	-6.81	-11.80	-6.81	-17.59	-8.30
% employment in industries with high energy purchases	4.22	5.28	3.60	6.14	4.48
Fuel costs of freight transport	1.91	5.23	1.73	2.37	2.58
% workers commuting	8.48	3.54	48.70	3.67	9.82
Long-term unemployment rate	38.19	48.44	36.51	18.75	39.22
Disposable income in households	14974.32	7144.57	16917.15	12631.45	13435.81
Wind power potential	90759.83	153859.09	65568.82	843163.27	136600.50
PV potential	989.98	1041.70	857.19	833.83	984.58
Number of Valid Cases	164	47	15	11	237

Typology 1

This is the largest typology in terms of members. More than two thirds of the regions with valid data in all variables are classified in this group. Thus, it is not surprising that the mean value for each variable for the regions in typology 1 is similar to those of all 237 regions in Europe that were classified. The only differences include a higher mean household disposable income and lower mean fuel costs of freight transport. It could be argued that typology 1 is the average EU region in terms of these 9 indicators and has an average risk of poverty in a case of rising energy prices. The fact that this is a large group of regions motivated the need to be further divided. This division is presented in the next section. In terms of geography, typology 1 includes regions in most of Central and South Europe as well as the UK.

Typology 2

Typology 2 is characterised by a very low average household disposable income (half of the overall average), lower mean January temperatures and a very low proportion of workers commuting; high proportion of long-term unemployment and very high fuel costs of freight transport. Thus, typology 2 regions could be the most vulnerable to poverty in a case of rising energy prices and require special attention in terms of policy making. The fact that these regions have a higher than average potential for energy production from renewable sources could perhaps indicate an opportunity for development. In terms of geography, typology 2 includes rural regions in Spain and Italy and most of the regions in Eastern Europe.

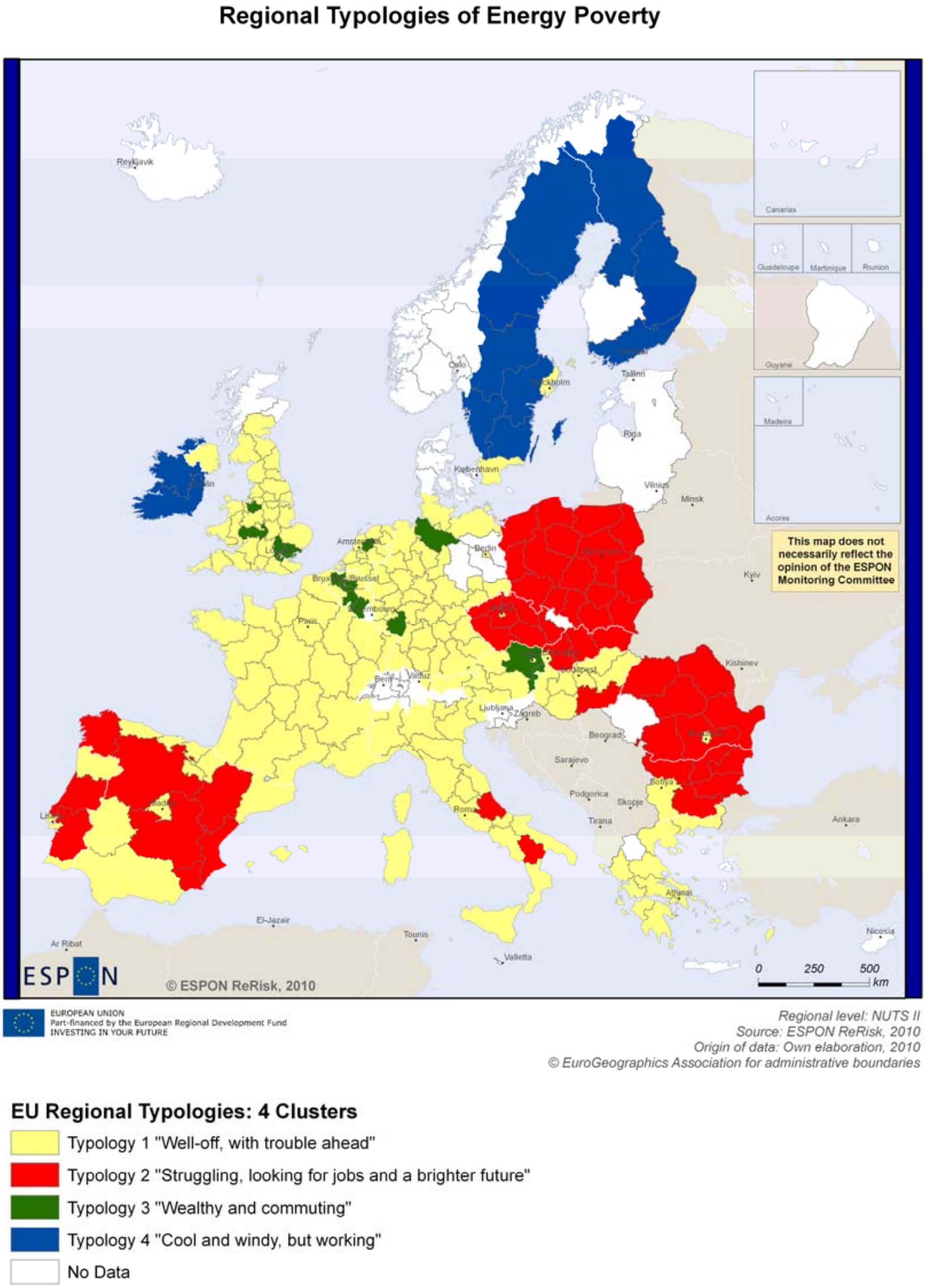
Typology 3

The regions classified in Typology 3 are characterised by extreme proportion of workers commuting (50%) and a high mean household disposable income. Although the dependence on transport fuel is high in these regions and the production of energy for renewable sources rather low, the fact that they seem to be developed and allow their residents to generate high incomes make them less vulnerable in view of rising energy prices. However, it is necessary to develop policies for the reduction of dependence on fossil fuel use for transport. In terms of geography, Typology 3 includes urban regions in Central Europe including Brussels, Vienna and London.

Typology 4

This typology has the fewest members and is characterised by extreme weather conditions and potential for energy production from wind power. Although lower proportion of people commute and the long-term unemployment rate is low, the regions have high proportions of employment in industries with high energy purchases and high demand for energy for heating due to extremely low mean temperatures in winter. In terms of geography, typology 4 includes most of the regions in Ireland, Sweden and Finland.

Map 10 K-means Clustering Membership of EU Regions (NUTS II): 4 Typologies, Normalised and Weighted Values



Source: Own elaboration based on Eurostat data

C.2.3.3. 4+ Typologies K-means of the Normalized and Weighted Values of the Original Indicators (Typology 1 Was Split in Two)

The difference in this clustering is that the previous typology 1 was now split in two groups (1a and 1b) with distinct profiles the profiles. This was possible after reclassifying the 164 regions of typology 1 using a 2 cluster k-means procedure and the same indicators. The results are presented in Table 18 and Map 11.

Typology 1a

This sub-group is now characterised by a much lower dependency on energy-intensive industries and has high potential for energy production from solar energy. In terms of geography, the regions belonging to typology 1a are located across all central and south Europe including both urban centres such as Paris, Rome, Madrid, Athens and Stockholm, as well as mixed and rural regions.

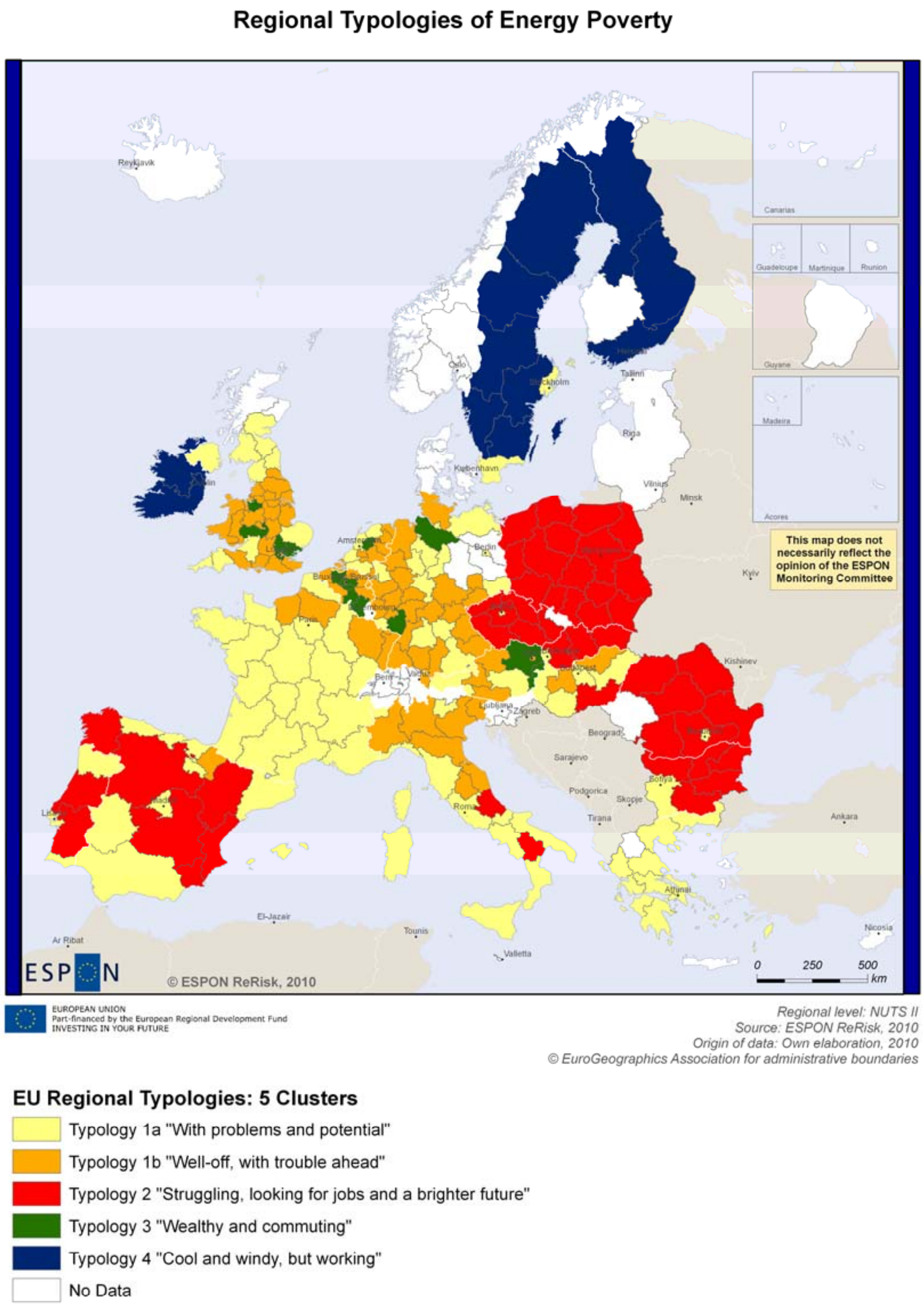
Typology 1b

This sub-group is characterised by a higher dependency on energy-intensive industries and fuel, has low potential for energy production from wind power and higher mean disposable income. Thus, typology 1b is more similar to typology 3. In terms of geography, the regions belonging to typology 1a are located in Central Europe and the UK.

Table 18 Final Cluster Centres – 4+1 Typologies

Variables / Mean Values	Typology 1a	Typology 1b	Typology 2	Typology 3	Typology 4	Mean
Maximum temperature July	32.36	30.66	33.70	30.46	26.17	31.70
Minimum temperature January	-6.21	-7.55	-11.80	-6.81	-17.59	-8.30
% employment in industries with high energy purchases	3.41	5.22	5.28	3.60	6.14	4.48
Fuel costs of freight transport	1.93	1.89	5.23	1.73	2.37	2.58
% workers commuting	4.28	13.71	3.54	48.70	3.67	9.82
Long-term unemployment rate	39.15	37.00	48.44	36.51	18.75	39.22
Disposable income in households	14176.55	15968.78	7144.57	16917.15	12631.45	13435.81
Wind power potential	108004.23	69263.38	153859.09	65568.82	843163.27	136600.50
PV potential	1065.27	896.13	1041.70	857.19	833.83	984.58
Number of Valid Cases	91	73	47	15	11	237

Map 11 K-means Clustering Membership of EU Regions (NUTS II): 5 Typologies after Splitting Typology 1, Normalised and Weighted Values



Source: Own elaboration based on Eurostat data

C.2.3.4. Discussion

In the beginning of this project the NTUA research team suggested the following indicative set of types of regions:

Type 1: Metropolitan regions (high accessibility, well developed, above national average household incomes, completion holds energy prices low, economically active households)

Type 2: Evolving regions (smaller towns with high growth, improvement in income and quality of life)

Type 3: Hidden risk regions (areas that seem to do well, but due to the population structure, e.g. high proportion of older people, access to energy, or energy demanding climate conditions, may face problems)

Type 4: Lagging regions (regions with current or eminent energy poverty)

In an attempt to link the ReRisk results to this typology, ReRisk typology 3 and partly ReRisk typology 1b matches Type 1; ReRisk typology 1a matches Type 2; ReRisk typology 1 and ReRisk typology 4 matches Type 3; and ReRisk typology 2 matches Type 4. Of course it is not possible to have a perfect match since significant indicators (such as those related to population age structure and centrality/accessibility) have not been accounted for in the analysis.

C.2.4. Conclusions

In this report the classification procedure of the EU regions into groups of regions with similar characteristics has been presented. Area classification (typologies) is a helpful tool in the study of the risk of energy poverty in Europe. This classification has resulted in regional typologies that should assist policy makers in to understand the picture of Europe in various aspects and form their policy agenda accordingly.

It is necessary to note that although the classification is sensitive to the input data, there are distinct groups of regions that are very dissimilar to each other. Sometimes this dissimilarity is based on only a few indicators such as wind power potential and climate conditions (ReRisk typology 4 - Nordic regions), commuting (ReRisk typology 3 - Central European regions) and social dimension (ReRisk typology 2 - South and East European regions).

Typologies suggested in the beginning of this project were meant to be such that allowed the assessment of the risk for of energy poverty as well as the spatial differentials of this risk. This would help policy makers to make informed decisions. However, we believe that the policy makers and other readers of this report should not be bound to the suggested typologies but understand the performance of each group / typology of regions based on different criteria.

Obviously this type of research is an on-going process. Future attempts should need more indicators and a finer geographical scale, e.g. NUTS III. For a geodemographic-like area classification that seems to be gaining a lot of credit in the literature in answering deprivation related research questions, detailed data on the demographic and socio-economic structure of the population and business is required.

C.3. Case Studies, Scenario Report and Survey of Regional Energy Agencies

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C.3.1. Introduction

This report presents the results of the scenario exercise in the ReRisk project and consists of four key activities: a structural analysis, a questionnaire survey, four case studies and the creation of four scenarios through morphological analysis. The goal of the scenario-building activity is to create four plausible scenarios that illustrate the likely impact of rising energy prices on regional competitiveness and cohesion for 2030. The task also seeks to identify regional development opportunities and policy options available to regions to better cope with this challenge.

The structural analysis resulting from Workshop I not only reveals the drivers of regional competitiveness and energy development, but also shows the strong dependencies between these two fields. The drivers of competitiveness are identified as the innovation capacity, the economic robustness given by the diversity of the regional economies, the internal and external markets, the spatial characteristics, and the governance of the regions. Moreover, the hierarchy of these elements is dependent on the time-perspective in which regional competitiveness is viewed; namely short term and long term competitiveness.

In the context of regional competitiveness, energy is seen as the provision of a resource that keeps the economy running, provides quality of life for the inhabitants of a region, and accordingly, is a critical asset that is transformed, distributed and commercialized locally as well as internationally. In energy development the innovation capacity appears as the main driver alongside the availability and price of energy resources and the economic specialization of regions. Closely related to innovation and another central factor is the availability of technologies both for energy production and for achieving energy efficiency. Two other important elements in energy development are governance, which sets local, regional, national and international regulations on the use of different energy sources; and consumer behaviour, which relates to cultural perceptions on how the energy is consumed.

The case studies provide concrete examples of different approaches to energy vulnerability by specifically investigating wind and biomass power generation, energy efficiency in the residential sector, and energy savings and recycling through industrial symbiosis. The studies of the Municipality of Samsø in Denmark and the Region of Navarra in Spain exemplify two different approaches to renewable energy deployment. While in both cases the respective national governments acted as a provider of policy frameworks and support mechanisms for wind energy, completely different forms of participation by various actors took place at the regional and local level. In the case of Samsø the citizens were engaged as investors, together with the municipality and private companies, in the planning process of both the land and off-shore wind energy projects. This has resulted in the creation of renewable energy as an integral part of the local energy supply and the process has turned out to be a source of best practices in renewable energy deployment. This is in contrast to the region of Navarra, where the Regional Government and some private companies were the main actors of wind energy development. Furthermore, the strong involvement of the private sector wind energy development in Navarra has resulted in the creation of their own renewable energy industry that positions the region as one of the world's leaders in renewable energy technology. Accordingly, the case studies also showed that different natures of wind energy development and their impact on the local economy are rooted not only in the availability of natural resources but equally important in the regions' socio-economic characteristics.

Similar to the two previous cases, federal authorities in Germany have provided a solid energy and building policy framework whereby proactive standards and support mechanisms actively promote renewable energy and efficiency development in Freiburg. At the same time, it was discovered that local authorities, in concert with NGO's and local firms, have had a significant impact by integrating ambitious environmental goals with their overall development policies. The origins of this local approach on renewables and energy efficiency were partly motivated by the rejection of nuclear energy development by the local communities in the 1970's. Additional factors include the relatively high innovation capacity of the local economy and their specific focus on developing the environmental economy. Also, it is shown that Freiburg's comprehensive environmental movement – which their green housing development is largely based on – has had a pioneering role in the creation of transnational municipal networks that diffuse environmental technologies and best practices for local governments around the world.

The case study of Industrial Symbiosis (IS) in Kalundborg also exemplifies a bottom-up initiative. However, in contrast to the other case studies, IS in Kalundborg was a response from private companies to strengthen regulations on water protection, resulting in important energy efficiency solutions. The case illustrates how companies can adapt towards resource depletion and find new business opportunities by sharing information, services, by-products and waste materials. The case study also demonstrates the fundamental role of networking and commitment between the actors in IS development. This observation is confirmed in the case of Landskrona where the outcomes of IS are still very limited due to the slow process in consolidating networks between local companies.

In terms of governing energy development, to identify different roles, responsibilities and interactions between levels a web-based survey was conducted among 41 European regional energy agencies. The results show that while energy policy is generally concentrated at the national level, differences exist between the national and regional level regarding the character of emphasis on energy policy. Specifically, security of supply is usually emphasised relative to environmental protection and energy efficiency at the national level, while the opposite is the case at the regional level. The questionnaire also reveals interesting differences regarding the emphasis of different energy sources between the two governance levels; in particular where increased regional governing responsibility is correlated to a higher emphasis on renewable energy sources being prioritised. Consequently, the linkage between "decentralised governance" and green energy development is one of the central issues taken up by the analysis.

In terms of fomenting cross-sector awareness on energy consumption it is also revealed that national governments have an overarching role in relation to various sectors, while local and regional governments have a particular role in governing domestic energy activities surrounding households and the built environment. The questionnaire responses indicate that these activities possess the highest relative energy savings opportunities and potentials, but also face significant implementation challenges. Accordingly, the agency analysis highlights the general response characteristics of the questionnaire by discussing the distinctions between real and perceived roles and responsibilities of energy authorities at varying political levels. At the same time, it goes into more detail regarding the interactions between policy distinctions, policy mechanisms, sectoral impacts and the potential for sub-national agents to facilitate their own energy development initiatives to overcome energy "*challenges*".

Scenario 1

In scenario 1, international agreements on more ambitious GHG quotas have been reached and emissions trading schemes are operational worldwide. The demand of renewable energy has increased significant while the demand of nuclear energy and especially fossil fuels has been reduced. The energy intensity in Europe has decreased in all sectors not only thanks to the availability of energy efficient technologies for industries and households but also important changes in consumption behaviour on energy. Europe has also witnessed a new balance between centralised and decentralised solutions, in which large and small-scale renewable energy installations are interconnected by a new network of ocean and land-based power grids.

While the overall innovation capacity in Europe has increased during the last 20 years, the European economy is characterized by continued growth dominated by the knowledge and service industry. New economic activities have also appeared in some rural areas, especially considering new opportunities for renewable energy production, while urban areas continued to witness social and economic growth. Moreover, a more polycentric organization in urban areas has characterized the development of many European cities during the last two decades. The share of public transport, especially railways, trams and metros has increased and there have been decreases in private car transportation.

Scenario 2

This scenario presupposes a decrease of the total energy demand. The demand of coal and oil has been almost excluded from the industrial and residential sector while increases on the demand of natural gas have dominated accompanied by a moderate increase of renewable energy. This development has been accompanied by phasing out programmes on nuclear reactors.

Energy efficiency has become the main mitigation measure against climate change in Europe. Consumption patterns on energy have changed towards a rational use of energy and natural resources which has been the result of good availability of clean energy technologies for producers and consumers as well as new policies and information campaigns. Not forgotten is the fact that prices on fossil fuels are high thereby making clean energy technologies more competitive.

While the innovation capacity has been reduced Europe is moving towards a more regionalized and balanced economy. Higher prices on raw material and transportation have created new market conditions that have favoured some primary industries. Economic and social growth is evident in both urban and rural areas. Hybrid and electric private cars are affordable and therefore favoured as mode of transport especially in rural areas where investments on public transportation have not been enough to compensate transport needs.

Scenario 3

In this scenario nuclear energy is the main priority for energy development in Europe. Renewable energy deployment has also witnessed significant growth, but not to the same degree as nuclear. The energy demand on fossil fuels had decreased as electricity replaced coal and oil in the industrial and residential sectors. Additionally, priorities on climate change policies prevail in Europe despite the fact that the most energy intensive countries have not signed global agreements on GHG emissions.

The domination of nuclear energy has resulted in a centralised energy sector where only few actors have been able to invest. The development of small-scale energy solutions has on the contrary been largely restricted to remote and isolated areas which are not connected to central power grids. The initial substantial increase of energy generation from nuclear reactors in the 2020's have resulted in one hand increases in the energy demand and in the other renewable and energy efficiency technologies become less competitive.

The innovation capacity of Europe has been moderated as the R&D spending has been reduced. The economy is characterized by major economic growth in the manufacturing and primary industries, though these sectors have gone through a process of modernization. Due to the growth of manufacturing, primary industries and overall population, energy consumption in Europe has increased.

Urban areas continue to witness major social and economic growth dominated by the service sector, while industries will proliferate especially in the urban outskirts and nearby regions. Investments in both public and private transport have been significant as progressive efforts to electrify the transport system have been made, but the balance between public transit and private car use from early 2000's has been maintained.

Scenario 4

Scenario 4 is characterized by a significant demand of coal and natural gas and a limited increase of renewable energy. At the same time, energy demand from nuclear reactors has been reduced. The lack of available technologies on renewable energy and energy efficiency, in combination with a lack of appropriate energy policies has led to high energy demand.

Globally, energy intensive countries are not part of the agreements on GHG-reductions. Clean energy technologies are expensive, thereby only available for large energy producers. Economic growth has been negative due to decrease innovation, higher energy prices, lack of capital and lack of appropriate policy instrument to foster necessary adaptation capacity towards new market conditions. All sectors of the economy are present, though the most energy intensive industries have either been modernized, while others have disappeared.

Urban areas are still the only centres of economic and social growth, while depopulation has continued to aggravate in rural regions. Poverty and social problems have increased due to rising unemployment and higher prices on basic products. Furthermore, the private car transportation dependency has increased due to the lack the public transport infrastructure. Moreover, old cars are dominant in the roads as new efficient ones are too expensive for average consumers.

C.3.2. Outline of Methodology

The scenario building activity in ReRisk is based on explorative prospective that aims to shed light on multiple images of possible futures, which are constructed on the notion of past and present conditions of the studied system. Therefore, the four scenarios created in this exercise are not prognoses or forecasts, but instead they are plausible visions of the future that shed light on the implications of different development trends on a system. This implies the identification of the drivers determining the evolution of both energy and regional development, and, in this connection, the identification of different development paths to be taken by possible actions and their consequences.

This exercise complies with the four key principles of prospective scenario building: relevancy, consistency, likelihood and transparency [Ritchey, 2007-2009]. The approaches applied for the scenario building process are:

1. Exploratory; by using past and present trends leading to the description of likely futures. This includes using data analysis and the case studies carried out within the ReRisk project as point of departure for building the scenarios.
2. Anticipatory; by analysing predetermined visions of the future. In this case, four distinct hypothetical visions of the future under high energy prices for year 2030.

The method behind the scenario building exercise has its bases mainly on the General Morphological Analysis (MA) originally developed by Fritz Zwicky, which is a qualitative method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable problem complexes by using the technique of Cross Consistency Assessment (CCA) [Ritchey, 2007-2009]. Accordingly, the scenario building exercise is comprised of two phases: the construction of the scenario bases, which consists of the identification of the drives, the actors and trends in the studied system; and setting out the four scenarios, which consists of the definition of the hypotheses, CCA and the selection and validation of the scenarios.

C.3.2.1. Construction of the Scenario Bases

When analyzing the options for structuring scenarios in relation to future energy dependency, it was also necessary to identify the role of energy planning and development at different administrative levels, their actors and the interactions between them. Also it was necessary to identify the trends in energy supply and demand as well as the current policy regarding energy development, regional competitiveness and cohesion. This was achieved by utilising multiple research contributions - qualitative as well as quantitative - that enable triangulation between each approach to provide well-supported rationales for the scenarios. Accordingly, these contributions were obtained from:

3. The inputs obtained from Workshop I (structural analysis)
4. The inputs from two questionnaires
5. Four case studies that provide a synthetic analysis of energy systems, their actors in the deployment of alternative energy solutions.
6. A study on the policy target from the EU Energy and Climate Change Package and the Lisbon Treaty (presented along with the Updated Interim Report). These policy targets served to define the policies target in which the scenarios were based.

The trends on energy supply and demand in Europe were identified by using three available reference studies:

7. European Commission 2007. *Energy, Transport and Environment Indicators.* EUROSTAT pocketbooks.
8. European Commission 2008. *European Energy and Transport: Trends to 2030- Update 2007.* Directorate-General for Energy and Transport.
9. International Energy Agency (IEA) 2008. *World Energy Outlook 2008*.

Structural Analysis

The objective of the structural analysis was to set the bases for the scenarios by providing a better understanding of the interdependencies of regional spatial/structural characteristics, energy production and consumption. This included:

10. Identifying the internal and external elements/factors in energy and spatial systems (System delimitation)
11. Identifying the mechanisms of change and adaptation in terms of the energy sector and regional competitiveness (retrospective).
12. Selecting the drivers to be used in the morphological analysis by analyzing the relationships between elements of energy and spatial systems.

The structural analysis was carried in Workshop I. The basis for this workshop was built through a preparatory workshop with specialists from Nordregio and series of interviews with the independent experts who participated in the workshop. While the preparatory workshop served to identify the issues to be discussed during Workshop I, the interviews helped to collect individual perceptions of these issues. The result was a set of questions that were used in Workshop I to initiate and structure the input from the experts.

In order to identify the elements for energy supply, energy demand and regional competitiveness during Workshop I, a version of Creative Problem Solving [Parnes, 1992] was used. This led to a phase which aimed at a degree of consensus on the most relevant, salient and viable drivers (the convergent mode). Ultimately, Workshop I not only resulted in the identification and analysis of the drivers, but also four test scenarios that shed light on how these drivers related to each other.

The Case Studies

The case studies present four concrete examples of different approaches to managing energy vulnerability. The aim was to identify the drivers and mechanisms of change in energy systems, the relationship between the public and private actors, and the relations between different governance levels in terms of the development of energy production, consumption and distribution. The case studies also shed light on different strategic decisions in energy development and their consequences on regional competitiveness.

The Agency Analysis (The Web-based Survey)

While the case studies show concrete examples of regional and local energy approaches, they do not show the distribution of perceived and actual responsibility between different levels of governments. Therefore, the *Agency Analysis* provides insight regarding this distribution and uses it to develop an understanding of the abilities for sub-national governments to respond to regional energy issues. In this connection the first step was a web-based survey among representatives from at least one regional energy agency from all EU member states. The responses provided insight into the distribution of authority and responsibility between three governmental levels (State; Regional; Local); the energy policy distinctions between these levels of government; and the sectoral implications of governing energy from different political levels. This gave an initial overview over the relationship between sub-national and national energy governing responsibility, which has served as an important input into the initial scenarios, the case studies and the structural analysis.

In a second phase, after Workshop III, a cluster analysis was completed based on a selection of the survey questions. The clustering allowed for a representation of regional energy governance typologies, to formulate a cross-section of regional energy authorities for the pursuit of more in-depth interviews. This was abridged with the preliminary survey analysis, case studies and scenario building processes to generate insight into the particular abilities of sub-national authorities for responding to regional energy concerns with long-term socio-economic and environmental considerations in mind.

A two-step model was used in connection with the questionnaires. The first step involved the creation of a detailed draft questionnaire. The 45-question survey was tested by obtaining 21 responses from regional agencies. These results were combined with the results from Workshop I to produce a more focussed questionnaire with 23 questions. The revised version was submitted to representatives from over 120 European regional energy agencies and a total of 41 responses were received. These questions were then used as a basis for the agency analysis.

C.3.2.2. Setting Out the Scenarios

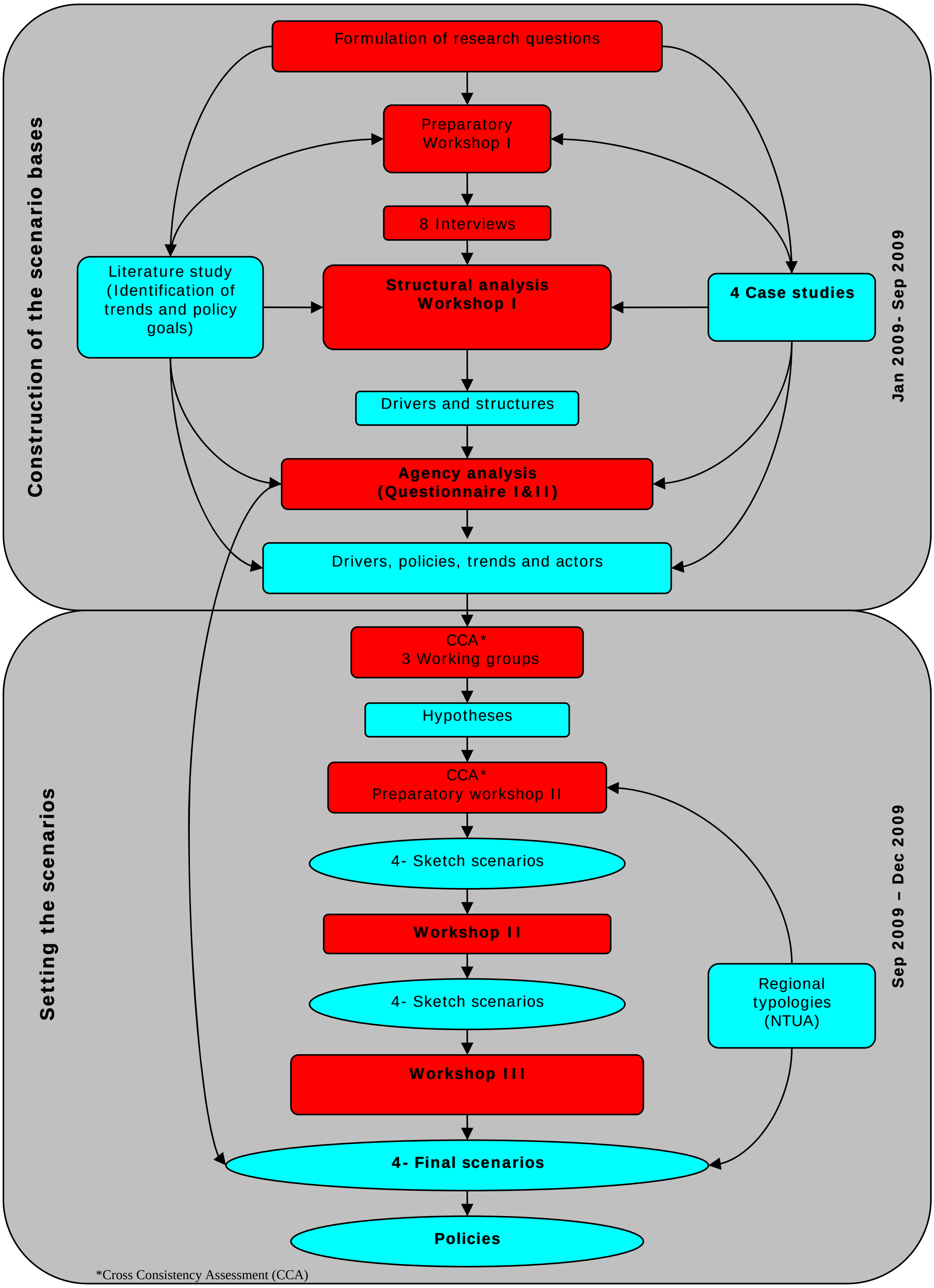
This phase consisted of three steps. The first step consisted of three working group sessions and one preparatory workshop where experts from Nordregio defined several hypotheses (values) for each of the drivers (variables) identified during the structural analysis, questionnaire and case studies. While the hypotheses were being defined the same groups carried out the cross-consistency analysis, which compared, pair-wise, each of the hypotheses in the morphological field. This helped reduce the morphological space through further elimination of less-dominant drivers and the identification of inconsistent pairs of hypotheses. This exercise resulted in a cross-consistency matrix that was used as the framework for the morphological analysis.

During the second step, the hypotheses, exclusions and preferences indicated in the cross-consistency matrix were entered in the Lipsor-Morphol software to visualize and select different plausible scenarios. This resulted in subset number of scenarios that were further reduced to four based on conditions of internal consistency, plausibility, uniqueness (clearly distinguished from the outset), likelihood and relevance for European regional policy. During this process the different scenarios were further evaluated against the results of Workshop I, the case studies, the questionnaire survey, as well as the objectives of the project.

The scenarios were further evaluated and reconfigured during a second project workshop (Workshop II) that included the participation of all project partners. This exercise was complemented with further recommendations from the project partners. For example, one of the scenarios was modified by having its point of departure based on decreased economic growth and increased fossil fuel dependency in order to illustrate the vulnerability of regions with high energy expenditures under extreme conditions.

In step 3, the invited external experts to Workshop III further analysed and rationalised each scenario. This provided further details and examples of early events that can cause each scenario to happen in Europe by 2030. This also included outlining the causalities between the hypotheses within each scenario. After the scenarios were validated during the first day, the groups discussed the impact of the scenarios and identified different sets of policy options that may enhance regional competitiveness and regional cohesion under the given circumstances for each scenario. The remaining step here will be to send the scenarios to the experts for a last round of consultations and validation.

Figure 10 Scenario Process in Task 2.3.



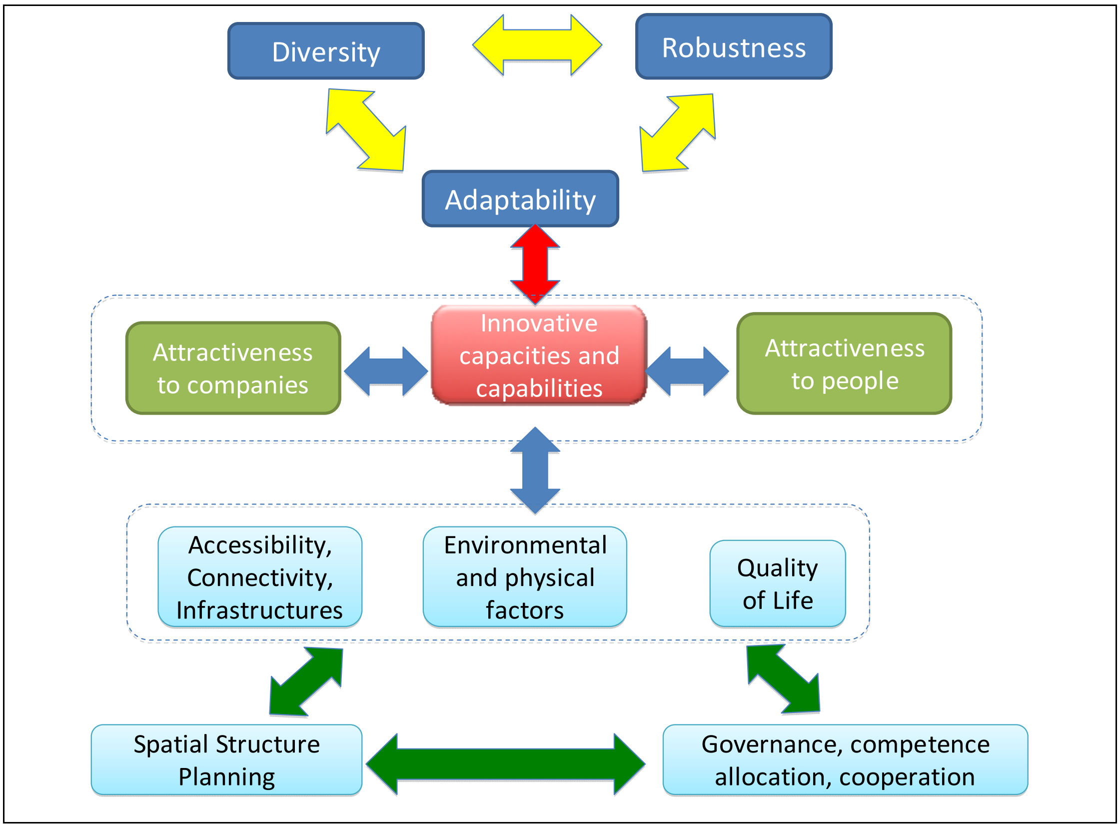
Main activities are marked in red and their deliverables are marked in blue.

C.3.3. Structural Analysis

This section presents the results obtained from Workshop I, thereby providing an overview of the most important internal and external elements and drivers of regional competitiveness and energy development, and the interdependencies between them. In the presentation below only the main characteristics are outlined while details regarding the in-depth definitions are available in Annex I of this part of the Scientific Report.

C.3.3.1. Drivers of Regional Competitiveness

Figure 11 Elements of Regional Competitiveness and their Interaction



Regional competitiveness includes "a range of factors from measures of income and prosperity to economic creativity and innovative ability that describe the performance of one economy relative to others". Furthermore two different perspectives should be emphasised: Short term competitiveness as the capacity of a region to maintain a high level of economic performance in a short term (5 to 15 years) perspective, and long term competitiveness as the capacity of a region to maintain a high level of economic performance in a long term (15 to 25 years) perspective. Long term competitiveness chiefly relies on the adaptive capacity of a region, which in turn is dependant on economic robustness, but also the diversity of the regional economy.

Innovative Capacity

Innovative capacity as *"the capacity of generating new ideas"* reduces economic vulnerability because it diversifies economic structures by fostering the creation of new industries and products. The capacity to create new ideas is determined by three factors; the openness of the society towards new thinking, the knowledge capital, and the accessibility to this knowledge. Knowledge accessibility includes the availability and quality of the education bringing in new sources of knowledge and fostering new ideas through R&D. Social, physical and financial infrastructures are needed, just as regional densities of scale are important because it helps to promote a collective commitment among individuals on attaining competitiveness. The networking capacity is another important factor allowing the exchange of information and experiences necessary for both the creation of new services and technologies and the formation of trans-boundary cooperation between regions, firms and research institutes. Similarly the accessibility to qualified labour force plays a central role, and in this regard education not only serves to build the social capital of a region by forming young professionals, but also attracts both students and professionals from other regions. Finally access to financial resources is important because it provides the bases for public and private investments in R&D, education and entrepreneurship.

Attractiveness

Aspects of attractiveness are closely linked to the innovative capacity of regions as living conditions and highly-developed business environments attract and retain skilled workers and high-tech firms to the region. Skilled labourers seek good living conditions, and more specifically, good quality of life determined by cultural perceptions of achieving lifestyle ideals and opportunities to develop. This includes efficient and affordable internal and external transport, accessibility to the social, natural and built environment, accessibility to health services and affordable and available housing.

Robustness of Regional Economy

Economic robustness as *"the ability of a region to withstand fluctuations in the markets"* is generally determined by the presence of territorial capital: economic, social and resource capital, as well as diversity in the region's economic structure. In order to attract companies and labour force a region is also dependent on the region's economic robustness. In the long term the innovative capacity becomes central as it generates flexibility in the regional economies by stimulating new industries and services. Here, energy is seen as a resource that serves the region's economy.

Governance

In order to promote and sustain the innovative capacity of a region political stability and good governance is required by means of well-functioning authorities and the creation of proper policy frameworks for innovation and entrepreneurship. Governance puts forward the framework conditions and the directions in which the internal and external factors of competitiveness may interact proactively.

Spatial Characteristics

Spatial factors include on one hand environmental factors related to the quality of the environment for living and performing economic activities, such as clean air and water, food and land, and on the other hand to physical factors including the nature of the residential, transport and communication infrastructure, as well as infrastructure for energy and water distribution. Spatial factors are also internal factors of competitiveness as explained above.

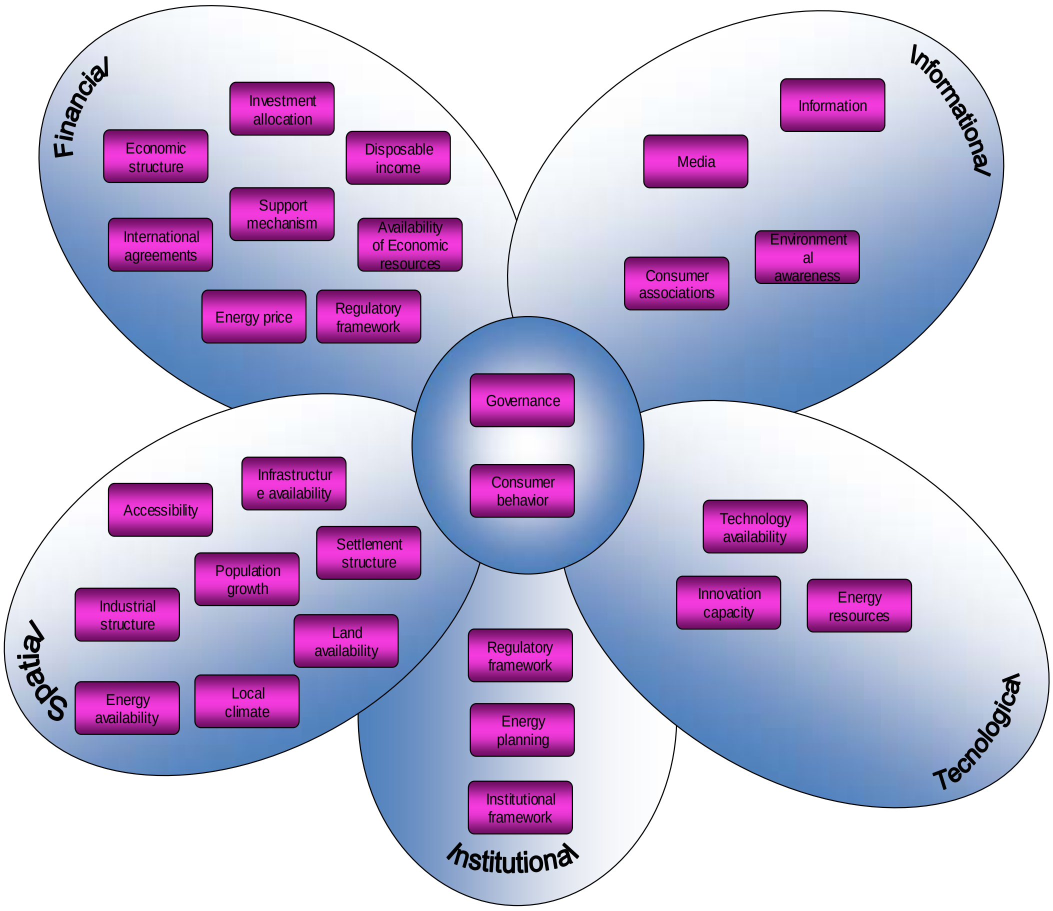
Internal and External Markets

Competitiveness is a balance between import and export of tangible and intangible resources between regions. Tangible resource flows are goods while intangible resources flows are represented by knowledge and services. The competitiveness is influenced by three elements; *where* the served markets are located, *what* products and services are offered by a region, and *how* these offers are presented and delivered to the markets. The acceptance of new products and services will be determined by consumer openness towards new products and the availability of those produces. The availability hinges not only on the physical presence of the products, but equally decisive are price factors - the economic capacity of consumers to pay for a particular product or service - and qualitative factors such as ideologies, life styles and behaviour.

C.3.3.2. Drivers of Energy Development

Energy development as *"the endeavour to provide sufficient primary energy sources and secondary energy forms to fulfil societies' needs involves both deployment of already available energy technologies as well as research, development and deployment of new technologies".* Traditionally it include security of supply, energy efficiency, natural resource management and environmental impact. The results from workshop I show that energy development comprises a large number of elements that can be grouped into clustered loops that are mutually dependant: institutional, financial, spatial, informational and technological loops. In addition two elements are intimately related to each of the loops: governance and consumer behaviour.

Figure 12 Clustering Model for Energy Development



The Institutional Loop

Institutions can be governmental, non-governmental and commercial, they can be centralised or decentralised, which is both important factors in terms of policy orientations and energy development decisions. Regulatory frameworks encompass legislations regulating production, transmission and consumption of energy, and assigns governing powers to authorities in the energy sector. The regulatory framework also steers the exploitation of energy sources and sets limits such as building restrictions, caps on GHG emissions, etc. Depending on the institutional framework energy planning sets the directions for the development of the energy sector and serves the interests of national, regional and local actors.

The Financial Loop

While energy production and transmission are essential elements, they implicitly raise the question of availability of economic resources for investment. The significant elements in this regard are listed below:

• **Market price for energy**: influencing the investment choices of energy consumers, and plays an important role in determining which energy sources are exploited. Prices of traditional energy sources act as drivers for the exploitation of new alternative sources.
• **Profitability**: determines the choice of energy source exploitation for producers and whether or not new sources of energy will need financial support.
• **Availability of economic resources**: has a direct impact on investments in new technologies as well as the allocation of investments such as development of alternative sources and infrastructure deployment.
• **Disposable income**: determines the price that consumers are willing to pay for energy.
• **Financial system**: determined by the legal and policy frameworks for the finance sector.
• **Support mechanisms**: are widely used by governments as market based instruments to subsidise renewable electricity, usually through two categories of support schemes: *investment support* playing a role during development stage and market introduction of renewables, and *operating support* such as support per unit of electricity produced.
• **International Agreements on GHG emissions**: create commitment towards common goals on caps for emissions and help to internalize the externalities of energy production from fossil fuels. Often tied to emissions trading schemes providing economic incentives for achieving reductions in the emissions of pollutants. It is a quantity instrument because it fixes the overall emission level (quantity) and allows the price to vary.

The Spatial Loop

Settlement structures affect energy consumption patterns with two elements being particularly important: *The distribution of living and working places*, related to *distances* between living and working areas (the distance, ICT and transport mode), as well as *time* for transportation and commercial activities associated with everyday life (the spatial arrangement of cities and regions), a*nd accessibility to commercial and living areas* relating to energy demand through the availability of infrastructure and technologies enabling energy efficient modes of transportation both for passenger and goods.

The availability of, and accessibility to, infrastructure define peoples' transport patterns to-and-from work despite the availability of different working arrangements today. Similarly the size of population affects total energy as reduced per capita energy consumption can be achieved through greater population densities because due to denser living arrangements and increased transportation opportunities.

Economic Structure shapes the energy mix and intensity of a region mainly in the short term. Regions with heavy industries will consume more energy relative to regions with high proportions of the economic mix dominated by the service sector. The accessibility to energy is also important because energy independent regions have little pressure emphasize structural changes in the economy.

In centralised energy systems settlements and industries will rely on long distance transmission infrastructure for electricity and gas, while decentralised energy systems provide locally produced energy that is transmitted over short distances. Centralised solutions may fit well in areas lacking energy resources while areas rich in energy resources are able to generate energy in situ. Land availability plays a fundamental role for the use of renewables. For wind energy for example, vast areas exposed to suitable wind conditions are needed and the conflict between landscape conservation and wind energy development is well established. Also local climates also play a significant role in the ways energy is consumed and generated. Seasonal cold and heat periods, and extreme weather events increase energy demand in order to maintain comfortable temperatures of homes and workplaces.

The Technological Loop

The nature of technology availability is delineated between domestic development and imported technology. Access to technological solutions helps facilitate the shift towards utilization of alternative energy sources and makes these sources competitive in markets. Technologies are tied to the availability of endogenous energy resources. Innovation Capacity is a central driver in energy development by providing technologies on energy efficiency and renewables. Specifically, regions exposed to fluctuations in energy markets due the lack of domestic energy sources can find ways to reduce their dependency though the creation of innovative solutions on energy production and efficiency. And innovation enable energy-rich regions to further this by exporting excess energy created by a reduced internal demand and increased energy production from alternative energy sources.

The Informational Loop

Environmental awareness is part of the culture, but can also be inculcated through information and education programmes. Information influences consumer's habits by creating awareness of benefits or negative consequences of irrational use of energy and use of unsustainable energy sources. The media works as the link between information sources and energy consumers, determining how consumers perceive the information. Consumer associations have proven to promote environmental awareness among both the general public and government institutions.

Governance and Consumer Behaviour

Governance relates directly to all the loops by setting the institutional, policy, legal and planning framework for production, transmission and consumption, as well as for regional development. The governance style has impact on the Institutional Loop in terms of the regulatory framework and structure of energy prices. Therefore, the Governance Loop reflects the particular actions and their respective actors that are embedded within the overall governance style of energy development. Not least, governance styles have a fundamental role in setting up taxation and trade schemes, reaching international agreements, allocating investments and promoting the future development of the economy.

Consumer behaviour is crucial for supporting a transition in energy development. Consumers have impact on energy consumption through behavioural changes on energy use as well as through their purchase by selecting energy efficient technologies for households and transport. As explained in the Informational Loop section, consumer behaviour tied to cultures and dependant on the level of awareness not only on the negative effects of excessive energy consumption or the use of fossil fuels, but also on how to apply these technologies and consume less energy through behavioural changes.

C.3.4. Case Studies

The following case studies illustrate multiple aspects, priority issues and implications of energy generation from wind energy as well as energy efficiency through green housing and industrial. Furthermore, the following case studies also provide a picture of top-down and bottom-up development processes and the relation between the public and the private sector in relation to energy supply and demand.

C.3.4.1. The Development of Wind Energy on the Island of Samsø, Denmark

Spatial Characteristics of the Island of Samsø

Samsø is an island and a municipality located in proximity to the east coast of Jutland. At the time when the sustainable energy project was initiated, Samsø was part of the county of Aarhus, which since the local government reform in 2007 has changed to the Region of Central Denmark. The island covers an area of 114 km², the length of the island is approx. 26 km, and its maximum breadth is 7 km. As it is also the case for other small island communities, there are limited education opportunities on the island for young people after they finish secondary school. Therefore, Samsø struggles with a falling population, as most young people move away, and only a few returns to the island. Thus, in 1997 there was a population of 4366 persons which in 2005 had fallen to 4124. The occupational structure on Samsø is dominated by the agriculture and tourism industries. [PlanEnergi 2007]

Planning System

The Danish Planning, which originates from the 1970s, has three main characteristics. First, it involves a decentralised planning system meaning that extensive decision making power is left to municipalities. Second, it involves the principle of framework management which entails that different levels of physical planning, i.e. regional, municipal and local planning, are subject to a hierarchic implementation structure that aims to ensure that due attention is paid to national interests, political objectives, etc. Third, the importance of transparency in the planning process is emphasised through legal requirements stating that the public shall be engaged in the planning process. The Danish planning system comprises a system of plans at both national, regional, municipal and local levels, and a zone system which divides the country into three categories: summer cottage areas, urban zones and rural zones. Another significant part of the Danish planning system is the Environmental Impact Assessment (EIA) which is carried out before certain activities are initiated and serve as a basis for decision making.

Danish Wind Energy Policy

The overall focus of national energy strategies has changed since the 1970s, when the first national energy strategy was launched in Denmark. Thus, from 1990 the overall goal of energy policy shifted to focus on promoting sustainable energy development and complying with commitments to reduce greenhouse gas emissions. Both the energy plans from 1990 and 1996 strongly pursue the development of RES and the expansion of electricity generation based on RES, especially focusing on wind power. There is a high acceptance of wind turbines in Denmark, partly due to the fact that a majority of windmills are owned by private households based on neighbourhood cooperatives. In 1992, the government introduced a feed-in tariff for private wind power producers. It was fixed at 85 % of the utility production and distribution costs. In addition to the feed-in tariff from the utilities, the private wind power producers received a “tax refund” of 0.27 DKK (3.7 eurocents) per kWh. This policy has changed gradually, as the focus of national strategies has also changed. Today wind power is produced cheaper as the technological development of wind turbines has entailed that they have become larger and more efficient. Thereby, the feed-in tariff was mainly an incentive which was provided to private investors during the 1990s [Meyer, 2004].

Deployment of Wind Power on Samsø

The development of wind energy on Samsø has taken place on the basis of a competition launched by the Danish Ministry of the Environment in 1996 which this municipality won. The purpose of the competition was that a local community during a period of ten years from 1998-2008 should demonstrate that it was possible to convert an entire local community to renewable energy supply. At the project’s initiation only 5 % of the island’s electricity consumption was generated by local windmills, whereas in 2005 locally generated wind power covered more than 100 % of the island’s electricity consumption.

Through the renewable energy project, eleven land based wind turbines were established on Samsø. Before the project was initiated a few land based windmills were already in operation on the island. They were owned by local farmers and as neighbourhood cooperatives. The planning phase of the land based windmills, which were to be established as part of the energy project, was difficult, as the island’s citizens and the planning authorities of respectively the county and the municipality were in disagreement on the placement of the windmills. Especially issues of preserving nature and heritage sites were prevalent in the discussions. Eventually agreement was reached on three sites that took into consideration nature and heritage issues. The acceptance of the public was referred to by the interviewees as being very much in line with the local ownership of the turbines. Thus, according to both national and local tradition, the eleven windmills are owned by farmers and two of them are owned as neighbourhood cooperatives. The generation of power from the land based windmills covers the local electricity consumption which is possible due to the relatively small population size of the island.

The renewable energy project also included the establishment of ten offshore turbines. The establishment of offshore windmills was made possible by the energy project and the investment from the Ministry of the Environment. It implied the construction of a connection from the offshore turbines to the national grid. The introduction of offshore turbines further strengthened the supply of wind power on the island and, through its export of power, it compensates for the transport area which has not been transformed to RES. In terms of ownership, one turbine is cooperatively owned, three are owned by investors from Samsø, one is owned by a financing company and the remaining five are owned by the municipality. The municipality decided to take a loan of 25 million DKK in order to invest in the off-shore wind turbines. The municipality’s investment was approved by the county, and in order to limit the responsibility of the municipality, the Ministry of the Interior demanded that the investment should be based in an independent public limited company. Thus, the company Samsø

Offshore Wind Co. was established. The planning of the offshore wind turbines took place after the feed-in tariff was eliminated with the Energy Act in 1999. However, in February 2002 a political agreement was reached to guarantee a minimum price of 43 øre/kWh in a period of ten years. During December 2002 and January 2003 the ten off-shore windmills were established and connected to the national grid. [Hansen *et al.* 2007]

Policy Implications

The main influencing factor which made the development of wind power possible on Samsø was the national policy framework in the 1990s which was focused on the development of RES. The fact that the Ministry of the Environment organised the competition which Samsø won was a precondition in terms of including wind power in regional and municipal plans. The feed-in tariff provided to owners of windmills further supported the development of wind power as it served as a solid economic incentive to invest in wind power. At the regional level the county's planning department was involved in the planning process and ensured that environmental considerations were taken in connection to the establishment of wind turbines. At the municipal level, the planning department was involved in deciding the location of the wind turbines. Moreover, the municipality was a main investor in the offshore wind turbines. At the local level the citizens of Samsø were engaged in the planning process and as investors in the wind turbines. In order to take into consideration the local level involvement, two organisations were established on the island: Samsø Energy Company which ensured the technical part of the RES implementation, and Samsø Environment and Energy Office which dealt with the public participation and involvement. These organisations and their combination of technical and citizen concerns have been significant at the local level throughout the project. Finally, in accordance with Danish planning traditions, NGOs were also influential in the planning processes of the land based and offshore turbine.

Impacts on Regional Competitiveness

The renewable energy project was initiated in 1998. One year later the local slaughterhouse, employing 100 local residents, was shut down. This closure was expected to have a tremendous impact on the economy of the island, as already, Samsø was a municipality with a low per capita income and an increasing number of people moving away from the island. The municipality in cooperation with the regional development department of the county of Aarhus saw the energy project as an opportunity for regional development. Thus, the county produced a development plan which placed the energy project in the centre. The idea of the plan was that the energy project was seen as an opportunity to restore balance on the island and it would serve as an addition to the two dominant industries, agriculture and tourism.

The main impact of the renewable energy project on regional competitiveness is the increase in tourism which has come as a consequence of establishing Samsø Energy Academy, which was opened in November 2006 as an independent organisation. The background for establishing the Energy Academy was to combine Samsø's experience with implementation of renewable energy in a local community and the future challenges which the island faced in further developing the project. The opening of the Energy Academy has led to an increase in tourism with a new group of 5-6000 professional tourists visit the island every year. The international professionals come to the island to learn from Samsø's experiences and to exchange experiences with the academy's employees. The Energy Academy also participates in European projects. The regional development department perceives the energy project to be a good example of regional development, using the case of Samsø in its marketing of the region, communicating that the case of Samsø is a good example that the region cares about the peripheral areas of Central Denmark.

Another way in which the energy project has strengthened regional competitiveness is through competence development. Different elements of the implementation of initiatives of the energy project generated employment for craftsmen, especially in establishing district heating systems. Moreover, the decision to establish Samsø Energy Academy proved to be of significance for job creation and competence development, especially for the local smiths. The building of the Energy Academy was designed on the notion that local craftsmen should be employed in the project. The head of Samsø Energy and Environment Office, as a strong communicator, was a significant actor in terms of engaging the local workforce, convincing the local smiths to become certified solar heat installation contractors. Subsequently, the smiths and other craftsmen were engaged in constructing the ecological smarthouse that became the Energy Academy. Thereby the local craftsmen have gained new competences, and thus companies involved in the construction of the Energy Academy are now consulted by companies in the rest of the country in terms of smarthouse construction. Moreover, the services of the craftsmen have expanded to also include installation of solar panels and water pumps.

C.3.4.2. Wind Energy in Navarra, Spain

Spatial Characteristics

The Autonomous Region of Navarra is located in northern Spain and covers a total area of 10,391km^2, approximately 2.1% of the entire country [Faulin *et al.*, 2006]. Similar to its small absolute size, Navarre has a total population of 578,210, only 1.3% of the national population; and accordingly, has a population density of just 55.65 inhabitants/km^2, well below the national average of 80 [Faulin *et al.*, 2006]. Pamplona is the largest municipality in Navarre (total population: 195,769) and is the only city with a population over 35,000 inhabitants [Government of Navarre, 2009]. Navarre is characterized as a small, predominantly rural region with only a few urban agglomerations and good access to natural assets. The size, however, has not stopped it from contributing more than its share towards the Spanish economy. In 2006, with a GDP per capita of €30,900, Navarra continued its trend of being well ahead of both the Spanish national average (€24,600) and EU27 average (€23,600) [Government of Navarra 2009]. This currently positions Navarra in second place in Spain and 34th (out of 271) in Europe in terms of GDP per capita, and the region also exceeds the average per capita income in Spain by 30% [Belarra 2009]. Furthermore, Navarra's unemployment rate in 2008 stood at 5.7%, compared to the national rate of 8.3%, and is below the EU average [Government of Navarra 2009].

Economic production in Navarra is generally attributed to the growth of its industrial sector beginning in the 1960's, diversifying the economy away from the dominating agricultural employment. The industrial sector in 2007 accounted for 28.5% of the Gross Value Added (GVA) in Navarra, which puts the region well above the national average of 18% for the country as a whole. Within the industrial sector, a large part of production is characterized by cutting-edge, high value-added technology where car manufacturing, machinery and equipment production are most dominant.

Energy Performance in the Region of Navarra

Until 2003, Navarra was characterized as being dependant on imported sources of energy because the region has no source of traditional primary energy sources such as oil, coal or natural gas. Today, this situation has changed dramatically considering that by the end of 2008 renewables provided 65% of the electricity consumption of the region and wind accounted for 70% of total energy produced from renewables [Belarra 2009]. In terms of renewable energy sources table 19 outlines the breakdown of overall production levels of each renewable electricity source in Navarra for 2007, as well as the 2010 targets for renewables stipulated by *The Energy Plan 2005-2010*.

Table 19 Energy Production from Renewables in the Navarra Region

Renewable Type	2007 Production	Production details 2007	Forecasted target 2010
Small hydroelectric dams (<10MW)	157 MW	-111 installations -Average installation production level: 1.41 MW 10.8% of electrical consumption in Navarra	225MW 30.2% growth between 2007 and 2010
Large hydroelectric dams (>10MW)	18MW	1 reservoir El Berbbel's water reservoir	98MW 81% growth through construction of two new reservoirs
Biomass	25MW	4.3% of electrical consumption	40MW before 2010 37.5% growth
Solar photovoltaic	15.33MW	Combination of solar farms and individual installations	30MW 49% growth
Solar thermal	967 Toes	Still early in the development stage	10MW
Wind power	936MW	16 locations and 38 wind farms. 64% of electrical consumption in Navarra	1400MW

Source: Moreno, 2007

Planning System

There are four levels of government that exist in Spain each characterized by their different spatial planning responsibilities: the State; the regions, consisting of 17 Autonomous Regions and 2 autonomous cities; the provinces, consisting of 50 individual provinces within the delineated borders of the regions; the municipal level, consisting of 8,109 local municipalities. While the Spanish political model is very similar to the federal model, the approval of the Spanish Constitution in 1978 has resulted in a historical process of political decentralization. One result of this is that Autonomous Regions have exclusive competency of spatial planning policy [Dasi & Gonzalez], just as they are responsible for energy-related planning issues such as authorization of energy installations including power stations, the energy network and feed-in tariffs when the tariff is only operated in a limited number of regions [IEA 2005].

Energy Policy

The Government of Navarra has the main competence on energy policy for the region. Specifically the Department of Innovation, Industry and Employment is responsible for the formulation and coordination of energy policy in the region. The development of the current energy plan is based on the work of various sessions, which included representation from the municipalities of Navarra.

Energy policy in Navarra aims at reducing external energy dependency, expanding best practices in renewable energy resources, promoting energy efficiency and contributing to the national environmental goals in terms of international energy and climate change commitments of the *Kyoto Protocol*. These policy goals crystallized in the *First Regional Energy Plan 1995-2000 (FEPN)*. The development of the renewables was also considered in the plan as strategic decision to develop a new industrial sector with good potential for export. Following the FEPN, Navarra continued developing the energy sector under the framework of *The Energy Plan 2005-2010.* The mid-term goal of this plan was to make Navarra the first region in Spain to become independently from foreign electricity supply, and produce 100% of their electricity from renewable energy sources. Whereas wind energy is still the fundamental driver of Navarra's renewable energy policy, the goal is to produce over 75% of the region's total electricity demand from wind energy by 2010. [Fairless 2007]

National polices have also played a important role in the development of wind energy in the region, specifically by internalizing global commitments in energy and climate change in the national policy, setting goals on renewables and the introduction of both investment and operational support for renewables. Most central documents in this regards were among others the Royal Decree on electricity produced by hydro sources, cogeneration and RES established in 1994, the Law of the Electricity Sector established in 1997, the Plan for the Promotion of Renewable Energy in Spain 2001-2010 and the Renewable Energy Plan enacted in 2005. The introduction of feed-in tariffs initially issued by the national government through the Law of the electricity sectors has been considered significantly important as it contributed in making generation of renewable energy a profitable economic activity. More recently the *Royal Decree 436/2004* introduced two tariffs that subsidized energy production from wind and solar energy.

The Deployment Process and Policy Implications

The success of the wind energy industry in the region of Navarra has been regarded as the consequence of three factors; namely a well established energy policy fully supported by the region's authority, the region's historical development of the industrial sector dominated by the automobile industry and the active involvement of the private sector. [Pintor Borobia et al, 2006]

Navarra's renewable energy boom is directly linked to the creation of the Hydroelectric Energy Corporation of Navarra (EHN) by late 1980's. The objective of the EHN was the to promote the development of renewable source of energy, initially funded by public and private investors; the regional government and its dependant Savings Bank contributed 48% of the capital, the local utility company Iberdrola contributed 37% of the funding along with 15% from the company Cementos Portland. [De Miguel

Ichaso 2000]. The interest for wind energy grew mainly as EHN could not further expand the hydro electric infrastructure since new sites for the construction of dams were unavailable. As a response of the Government of Navarra and the EHN built wind measuring stations to investigate the potential of wind energy in the region, leading to the construction of the first wind turbines on the outskirts of Pamplona in 1994. This development was further stimulated by the national regulation on renewable energy as distributors became required to give priority to electricity from wind farms as well as by the introduction of feed-in tariffs on wind and solar energy.

Once the EHN began developing plans for wind energy in Navarra, the Danish turbine manufacturer Vestas was contracted to construct the first turbines to be situated in Navarra. The first industrial factory for renewable energies was a joint venture between the Gamesa Eólica (51%), Vestas (40%) and the government of Navarra (9%). Gamesa Eólica subsequently expanded and now has three manufacturing plants in Navarra, seven throughout Spain and accounts for over 55% of the Spanish wind power sector [De Miguel Ichaso, 2000). By 2003, over 50 companies were active in the renewables sector in Navarra and the steady progress of EHN was enough to attract the attention of the Acciona Group, who, by 2005, had entirely taken over EHN in an effort scale the progress of the Navarrese firm to the international level. [Fairless 2007]

An important factor in the success on the deployment of wind energy was the implementation of the *First Regional Energy Plan 1995-2000 (FEPN)*. This made Navarra the first Spanish region to invest in renewable energy sources, with the wind industry being its primary focus. The regional energy policy in Navarra has been financed by EUR 400 million from the Government of Navarra. The particular focus of this funding, like the aims of overall energy policy, has been towards wind farms and solar farms as well as biomass production. Generally, these investments have originated in the form of tax credits and subsidies. Additionally, the Government of Navarra helped private companies by granting direct subsidies of 20% of total investments to attract renewable energy firms between 1994 and 1999, and increased this amount to 30% since 2000. [Faulin *et al.*, 2006]

In 2001, Navarra was already the second ranked Spanish region in terms of electricity production from wind energy and by 2002 Navarra had already surpassed the EU goal for renewable energy sources as a share of energy production [CENER 2007]. The result of this process has been 38 wind farms in the region, consisting of 1,100 turbines installed and enough power to cover 100% of the regional electricity demand during three months of the year [Belarra 2009]. In 2004 the Government stopped the approval of proposals for new wind farms due to concerns of landscape impacts of wind farms causing conflicts with the public. Whereas the last development of wind farm was culminated in 2005, the installation of experimental parks to test new turbines is still allowed. Further expansion of wind energy in Navarra relies now on improvement in performance and efficiency of the mills and by the so-called repowering, i.e. through the replacement of old mills with modern ones. Being the initial production capacity of wind mills 0.5 MW the new wind mills manufactured by Acciona and Gamesa will produce between 1.5 to 3 MW [Belarra 2009].

Alongside with the establishment of public and private partnership the deployment of wind energy in Navarra has also resulted in important R&D

initiatives. Most notorious was the National Renewable Energies Centre (CENER) established in 2000 as a foundation venture called CENER-CIEMAT. Accordingly, the CENER was funded mainly by the Government of Navarre (37%), the National Research Centre for Energy, Environment and Technology (CIEMAT) (27%), the National Ministry of Education and Science (18%) and the Public University of Navarra (9%). The CENER acts today internationally, nationally and regionally as a institution dedicated to the research, development and promotion of renewable energy. Furthermore, CENER has cooperated with the government of Navarra in the creation of regional energy plans and making specific contributions to the development of wind power in the region [CENER 2007]. In order to ensure the presence of trained technicians and specialists in renewable energy in the region's labour market the Centre for Training in Renewable Energy (CENIFER) was established by the Government of Navarra. CENIFER provides training towards different target groups. The institution also participates in collaborative programmes to train technicians from other countries. [CENIFER 2009]

Impacts on Regional Competitiveness

To some extent the wind energy sector in Navarra has followed a similar development to the automobile, namely new technologies have been adopted and further developed, resulting in the fabrication and assembling of high value products for export. Today, wind energy sector has become an exporting industry covering today 16% of global demand for wind turbines. It is also evident that the development of wind energy in Navarra has laid down the bases for the further technological development of new technologies on solar power and bioenergy, not leas by considering that the same companies originated from the wind industry are now developing these other technologies. [Pintor Borobia et al 2006]

The development of the renewable energy sector has resulted in approximately 6,000 employees of which approximately 4,200 correspond to the wind energy industry [Belarra 2008]. While the absolute numbers of employment are impressive, the nature of the jobs created are equally important. First, the spatial distribution required by wind energy production resulted in the creation of jobs in rural areas leading therefore to a process of decentralization of the region's economy. Second, the employees of the renewable energy firms are comparatively young, with over 46% of them under the age of 30 and 86% under the age of 40. Third, there has been a strong demand for highly-skilled and specialized workforce in companies in Navarra engaged in renewable energy technology as these involved only 9% unskilled labour force [Faulin et al., 2006]. Considering that part of the production of wind turbine components from Gamesa Eólica has been allocated outside the region, the lack of specialized labour force has also represented an important constraint in the further development of this sector whiting the region [Erro Garcés, A. & García Barneche, L., 2006]. Nevertheless the success of the wind energy industry in Navarra has resulted in regular visits by delegations from around the world interested in learning more about these developments in particular wind energy and the transboundary cooperation on renewable energy deployment with other regions of in Spain and Europe, as well as with countries in other continents, most recently Brazil and Chile. [Belarra 2009].

C.3.4.3. Industrial Symbiosis in Kalundborg and Landskrona

Kalundborg, Denmark

Kalundborg's industrial symbiosis (IS) network has evolved over a period of 25 years and today it comprises partnerships in some 25 projects. The IS is built as a network cooperation between seven companies and the municipality of Kalundborg's technical department. The projects concern recycling of water, transfer of energy and recycling of waste products between the independent symbiosis partners. The IS developed as a "bottom-up" initiative in an attempt to exert good management practice and to improve environmental performance.

Spatial Characteristics of the Municipality of Kalundborg

The municipality of Kalundborg is based in the region of Zealand in Denmark approximately 100 km from the capital, Copenhagen. It covers an area of 604 km^2 and holds a total population of 49,743. The population density is 82 per km^2 which is lower than the national average which is 126 per km^2. Approximately 35 % of the municipality's citizens live in Kalundborg which has a population of 17,600, while 14 % live in smaller towns and larger villages of between 200 and 2,000 inhabitants. Finally, approximately 29 % of the population live in the open land or in small villages. Due to the latter the municipality of Kalundborg is designated as a rural. Concurrently, Kalundborg is an industrial municipality with international and high technology companies placed in the town. During the period 1997-2007, the municipality has had an increasing number of industrial workplaces, unlike Zealand as a whole where there has been a decline in the number of industrial workplaces. Kalundborg is distinct in a national context due to its high occupation in the fields of industry, construction, and agriculture. Kalundborg has a coastline of 160 km with significant nature and culture-historical qualities which attract both tourism and settlement, and which also entails a challenge for the town in terms of maintaining the sustainability of the coastline. (www.kalundborg.dk)

The IS exchanges that have been established between the seven companies involved in the network in Kalundborg have developed around physical conditions that are unusual in Denmark. Thus, Kalundborg is characterised by large processing industries situated within relatively short distances. The industries are diverse, not competing and in a situation where they have been able to utilise each other's by-products and waste materials. The location of the power plant in Kalundborg has further strengthened the opportunities for exchanges, notably in terms of the energy savings in the network, and the connection to the district heating system of the town. Consequently, the power plant is a key to a number of energy, water and by-product exchanges. Moreover, the involvement of the technical department of the municipality is characteristic for the network. In the case of Kalundborg, similarly to other Danish municipalities, the municipality is the distributor of water from the local lake, and district heating for the municipality. Water from the lake is key to the water processing industries in town. The construction of pipelines and other costs connected to establishing IS exchanges have been commercially negotiated between the parties involved in each individual project. Public funding has thereby only been involved in connection to the projects that involve the municipality.

The Industrial Symbiosis Exchanges

There are three types of projects in the IS network: exchange of energy (6 projects); recycling of water (12 projects); and recycling of waste products (8 projects). The power plant produces 10 % of the total electricity consumption in Denmark based on coal. Excess heat from the power plant is applied as central heating for the town of Kalundborg. Moreover, the company provides excess heat from the electricity production as process steam to Statoil, Novo Nordisk and Novozymes. This use of excess heat is equivalent to more than 75,000 family households' annual electricity consumption and equivalent to 240,000 tons CO^2. Today, total energy savings through the IS exchanges amount to approximately 20 %.

Treated wastewater is pumped to the power plant for use in flue gas treatment. Water is reused 3 to 4 times between the Statoil refinery and Asnæs Power Plant. The reuse of cooling water as process water, delivery of deionised water and steam, and the final use of treated water in the flue gas treatment process lead to high efficient water usage. Thus, the recycling and reuse of water between the companies saves 3 million m^3 of water from nature. The annual intake of new water is today reduced to 7 million m^3 each year.

More than 98 % of the sulphur in the flue gas from Asnæs Power Plant is removed in the desulphurisation process. The by-product industrial gypsum is produced by adding calcium and recycled treated waste water and delivered to the plasterboard company Gyproc where it replaces natural gypsum. Used plasterboards are collected at Kara/Novaren's collection sites and returned for reuse at Gyproc. In total, these exchanges entail that gypsum equivalent to more than 15 million m^2 plasterboards replace natural imported gypsum at Gyproc. Another example is the insulin production of Novo Nordisk where one of the by-products from the yeast fermentation producing insulin is converted into yeast slurry. The yeast slurry replaces approximately 70 % of the traditional soy proteins in traditional feed mixes, and the feed is produced by adding sugar, water and lactic acid bacteria to the yeast. Novozymes treats industrial waste water, and after inactivation and hygieniation of the water, the approximately 150,000 tons of spent biomass is converted to the fertiliser NovoGro which is delivered to more than 600 farmers on Zealand, thereby replacing up to 60 % of the fertiliser needs depending on the crops produced. The company RGS 90 is treating 250,000 tons of oil and chemical polluted soil in their facility in Kalundborg by using sludge as nutrient to the bio-remediation process. After treatment the clean soil is utilised as filling material at various construction sites on Zealand. Finally, Kara/Noveren, the biggest waste company on Zealand, collects waste from households. The waste is incinerated at the combined heat and power plant in Roskilde. Household waste from more than 150,000 families is providing heat and electricity to more than 1/3 of these families. (www.symbiosis.dk)

Deployment Process and Policy Implications

The county of Western Zealand played a key role as a catalyser for the first initiatives for IS exchanges in Kalundborg. At the time, in Denmark, the county's planning department was responsible for overseeing and ensuring adherence of industry to environmental regulation on issues relating to groundwater.[9] In the beginning of the 1980s, the county of Western Zealand put in force that due to the strain on the groundwater, there could be no further expansion of industrial activities in Kalundborg. The planning and establishment of the initial IS exchanges were carried out by the directors of three large processing industries in Kalundborg: Asnæs Power Plant, the pharmaceutical company Novo, and the oil refinery, Statoil, all familiar with each other and their companies. The trust existing between the parties was an important factor facilitating the development of the network, which in turn severed as the base-line for reaching agreements between partners. The municipality's technical department also joined the IS network as a partner in a number of exchange projects. The initial three directors however, based on the case study analysis, have been the main driving forces in terms of developing the network.

Impacts on Regional Competitiveness

The focus of the companies from the initiation of the IS network was to find a solution to the environmental regulation in order for the industries to be able to expand their activities. If they had not found a solution, based on the fact that some of the companies were planning to expand at that time, one can assume that a possible solution for companies would have been to move their production to another region or another country. Statoil or Novo moving from the region would have entailed loosing a high number of work places and consequently it would have caused implications for the rural municipality. Moreover, the environmental regulation would have stopped potential new companies from setting up production in Kalundborg. The fact that some of the companies are multinationals has also had an impact on the development of the network, especially Novo Group. Thus a story about the IS in Novo's magazine first caught the attention of the international press. As a reaction to the increasing international interest the IS was further institutionalised with the Kalundborg Symbiosis Institute which was established to coordinate the activities of the network. The establishment of the institute entailed that the municipality's development department also became involved through the institute's board of directors.

The international reputation of the IS network took speed in the 1990s, and since 1996 the requests from various international entities, mainly universities and public authorities, have been coordinated by the Symbiosis Institute. Universities and leading researchers ín the field of industrial ecology from around the world have shown interest in the IS network, and visited the IS in Kalundborg to learn from their experiences. Through collaboration with Yale University the symbiosis has become a member of the Industrial Ecology Society, which further strengthens the presence of Kalundborg in the international academic community. Research and development activities are thus carried out in other countries based on the experiences of Kalundborg. The IS network was from the start developed merely as a practical collaboration and by some of the member companies it is still considered as such, and therefore the companies, through the boards of directors, do not agree on the further development potential of the IS. Varying perceptions of the companies involves the alleged role of the network as an international role model. Some companies do not think that the Institute should exploit the potential further opportunities for providing

[9] This structure has changed with the local government reform in 2007. The regional level is no longer involved in environmental and planning issues at the municipal level.

counselling, e.g. to planning authorities that consider establishing similar systems. The municipality's development department has begun using the IS as an asset in terms of dialoguing with companies that consider setting up production in Kalundborg. The municipality uses the IS in a similar manner in its EU office in Brussels. Through this forum, the development department also finds that there is an interest from planning authorities in other countries, giving opportunities to provide counselling to municipalities, e.g. in Poland. Since spring 2009 each partner has been allowed to freely use the IS in Kalundborg in their corporate branding. In September 2009 the regional climate strategy for the region of Zealand enters into force. Increasingly, the region sees IS as relevant in relation to the climate debate, and strategies to implement IS on a regional level have thus been included in the five year climate strategy. The strategy aims to encourage the inclusion of measures for IS in municipal plans. The region of Zealand considers the development of IS as a tool for advancing the development of peripheral regions.

Landskrona, Sweden

The International Institute for Industrial Environmental Economics (IIEE) at Lund University took the initiative to develop industrial symbiosis in Landskrona. Landskrona Industrial Symbiosis Programme (LISP) is the first IS programme which has been established in Sweden. It started with a consultation period in 2002. Some synergistic connections between companies were already in operation at this time. However, LISP aimed to identify further collaboration options by following a systematic approach and facilitating their realisation. In May 2003, the formal LISP was initiated including over 20 companies and three public organisations. The duration of the project was 18 months. LISP was financed by the national authority, the Swedish Business Development Agency (NUTEK).

Spatial Characteristics of the Municipality of Landskrona

The municipality of Landskrona is based in the region of Skåne in the South of Sweden approximately 90 km from the Danish capital, Copenhagen. The municipality of Landskrona covers an area of 141 km² and holds a total population of 40,860. The population density is 289 people per km². The municipality of Landskrona is dominated by industrial activity, and the number of industrial workplaces in the municipality is above the national average. [Statistics Sweden 2009]

The municipality of Landskrona has similarities to Kalundborg with its domination of industrial activity and its location by the sea, but the processing industries of Landskrona are smaller in size than the multinationals which initiated the IS network in Kalundborg. Meanwhile, the industrial composition of Landskrona was considered appropriate by LISP coordinators for developing IS. Another reason why this municipality was selected was that a number of companies approximately 15 years earlier participated in a project with the municipality's environmental department and the coordinating institute, IIEE. Through this project companies had already made internal environmental improvements was considered necessary before IS exchanges could be established. In addition, the municipality of Landskrona has a district heating system in.

Deployment Process and Policy Implications

Academic knowledge about developing IS combined with practical experience from IS initiatives in the UK served as the basis for the initiatives of the IIIEE coordinators in the 18 months project. The coordinators first contacted the head of the municipality's environmental department who assisted in contacting the companies in town. Following, respectively the municipality's technical and business development departments became involved in the project. The technical department was involved as a supplier of district heating to the municipality. At the national level, funding was provided by NUTEK and an employee from the national agency participated in LISP meetings. 20 companies in Landskrona decided to participate in the project, each contributing with in-kind funding. The participant companies belonged to a diverse range of sectors such as chemicals, waste management, metals processing, recycling, agricultural seeds, printing, transport and logistics. [Mirata *et al.,* 2005]

During the course of the project, the coordinators regularly organised meetings, as well as seminars and study tours with the participating companies. They used a participatory approach entailing that companies were encouraged to look for opportunities for IS exchanges themselves supported by academic input from the IIIEE coordinators. It was necessary to convince and engage the companies to see the opportunities themselves. Especially a number of breakfast meetings and tours at participating companies' plants opened up new opportunities and led to discussions between companies. Some companies opted out of the project relatively quickly in the process as they found no opportunities for collaboration. In some cases linkages between companies were rejected because companies did not find them economically feasible. The networking that took place between the companies through the project was essential for the process, since the managers and middle managers did not know each other and each other's companies very well in advance. Previously there had been no natural forum for exchange of experiences and networking, but this was facilitated by LISP.

Actual IS exchanges that came out of LISP were limited, and thus there is only one example of IS collaboration established between a car glass manufacturer, a chemical company, and a wastewater treatment plant. The packaging company have solvent from their production which they send to the producer of car glass. The car glass producer mix this with their cooling water thereby reducing the solvent. Finally, ethanol generated by this process is transported to the wastewater treatment plant using it in its processes. A more collective mindset between the local companies was developed during the course of the project just as internal environmental efficiency solutions were found. During the course of the project, the IIIEE coordinators were the main actors in terms of facilitating and pushing the process of developing IS exchanges. However, after the closure of LISP, IS activities have stopped in Landskrona, and there is no one pushing for further development.

A comparative Perspective on IS Development

This section summarises and discusses main findings of the two cases aiming to point to elements that facilitate the development of IS networks.

The original drivers for establishing IS exchanges vary between Kalundborg and Landskrona. In the former case environmental regulation regarding the consumption of groundwater in the local industries was the catalyser for the development of the first IS exchanges. In the latter case, academic knowledge on Industrial Ecology (IE) and IS and practical experience from the UK were the main drivers behind the initiative of the IIIEE coordinators to establish IS. The case of Kalundborg and research carried out on the development of IS in the UK point to the fact that *environmental regulation* can serve as a strong incentive for IS collaboration. Thus, in the case of Kalundborg, companies were forced to limit the consumption of groundwater, and in the UK companies were forced to institute more efficient waste management. In Landskrona companies did not experience the same pressure to collaborate to find solutions.

According to academic literature, economic and social factors are of importance in the development of IS exchanges [Gibbs, 2008; Deutz *et al.,* 2008; Jacobsen, 2006; Jacobsen, 2007]. Throughout the development of the approximately 25 commercially negotiated IS exchanges in Kalundborg there has been economic viability in the collaboration projects. One of the findings in the Landskrona project was that some companies lost interest in the project because they did not find economic viability in establishing IS connections. The reason for this may be connected to the fact that with the initiation of LISP there had not previously been a forum for networking or exchange of experiences in Landskrona. In Kalundborg it was found that in some cases the economic gain from projects were minor, and collaboration was established more due to the level of *trust* which existed between parties. In Kalundborg, a number of local informal forums existed in the 1980s through which managers and middle managers knew each other on a personal level, whereas in Landskrona in the beginning of the 2000s when LISP was initiated, the companies, managers and middle managers did not know each other. LISP facilitated the initiation of a forum for exchange of experiences and networking. Literature points to the fact that trust should develop before companies develop IS exchanges, especially if they have no legal requirements or other pressure to do so. This process of building trust between companies was initiated through LISP. In conclusion, based on the two cases in question, one may propose that *social factors* are equally important as *economic feasibility* when developing IS networks.

The two cases distinguish themselves by the way they have been developed. Kalundborg IS network was developed “bottom up” by the companies involved. The LISP was neither a directly “top-down” or “bottom-up” managed project. The project in Landskrona was inspired by the academic knowledge in the field of IE and IS, and along with others Kalundborg was used as an example in the introduction of the concept of IS to the companies involved in Landskrona. The IIIEE coordinators used a voluntary and participatory approach to engage the companies in the development of IS.

One cannot evaluate whether one approach is better than the other based on the two cases studied, however one can argue that the study points to strengths in both approaches. The *"bottom-up"* approach applied in

Kalundborg implies a high level of commitment from the companies, as they have entered into commercially negotiated collaboration projects, and in that sense they have “ownership” of the network. The *academic knowledge* approach in Landskrona entailed that companies were able to receive professional counselling based on academic research regarding their opportunities for IS collaboration. In this case, some companies were inspired to find internal solutions instead of collaboration, but nevertheless the academic guidance led to environmental efficiency solutions.

The IS network in Kalundborg is characterised by the commitment of two of the initial “inventors” of the IS network which have been essential in pushing the development of the network and creating and maintaining the international reputation of Kalundborg, not least through their contacts to key persons in the international IE society. In Landskrona on the contrary clear leadership in terms of further developing IS exchanges here, and this may also help explain why the development in Landskrona has been limited.

Finally, the case study indicates that IS deployment demands time. The development in Kalundborg has taken approximately 25 years. The IS project in Landskrona was first initiated in 2002, where there were no existing networking forums for the local companies. Hence, IS Landskrona can be also seen as in its initial state when companies are becoming more aware of the advantages of establishing IS networks.

C.3.4.4. Green Housing in Freiburg, Germany

Spatial Characteristics of Freiburg

The City of Freiburg is located within the State of Baden-Württemberg as one of nine independent cities and 35 districts. The city has a population of 216,300, which amounts to a population density of 1,421 inhabitants/km^2 and is well below the region’s capital city Stuttgart, with a population of over 600,000 residents and a population density of 2,894 inhabitants/km^2 [City of Freiburg, 2009]. The largest reason for population density anomaly is based on the fact that over half of the total area of Freiburg (153.06km2) is conserved within the Black Forest national reserve.

Baden-Württemberg is known as Europe’s leading region in terms of economic performance and innovation. The state leads Germany in terms of GDP per capita – EUR 33,293 compared to a EU average of EUR 27,601 - and in percentage of employers in high-tech sectors - 18% of all employed persons [BW, 2009]. Consequently, Freiburg is identified by its prevalent local knowledge economy. In 2005, Freiburg’s GDP was EUR 7.6 billion, of which manufacturing and service provision accounted for 27.7% and 71% respectively [City of Freiburg 2009]. Dominating the service sector are the twelve tertiary education institutions located in Freiburg; namely, the University of Freiburg, which has an annual enrolment in excess of 28,000 students [City of Freiburg 2009].

The urban structure of Freiburg is distinguished by its clearly defined centre, called the ‘old city’, and a mixed-use periphery. The new building stock in Freiburg has resisted a tendency to generate a sprawling urban structure of differentiated land uses and suburban residential communities, and increased housing demand has been met by the redevelopment of brownfield sites already within the confines of the city’s urban configuration. These medium-density mixed-use communities have been constructed to an environmental standard well above the requirements of the federal state and are the focus of the green housing solutions described in this case study.

Green Housing in Freiburg

To achieve an energy specific definition of Freiburg's green housing, performance should be evaluated based on a structure's total energy requirements measured in kilowatt-hours per square metre per year (kWhm²a). Therefore, three distinctions can be used to objectively analyse the green housing stock in Freiburg. First, to be considered a green home, residential structures should at least meet Freiburg's Low-Energy standard, which involves a maximum energy demand of 65 kWhm²a, approximately 50% of the maximum permitted in Germany [Siegl 2009]. Second, the Passive House Standard was first developed in Germany in 1990 and requires that total energy demand not exceed 40 kWhm²a and total demand for energy for heating and cooling not exceed 15 kWhm²a [Sperling 2002]. Third, the Plus-Energy House Standard is met when a house generates more energy over the course of a year (through some sort of microgeneration technology such as solar photovoltaic panels) than it consumes. To varying degrees, each of these concepts has been employed in Freiburg.

The development of green housing in Freiburg has predominantly taken place in the Districts of Rieselfeld and Vauban. Rieselfeld is a 70ha land plot located 6km from the city centre and when completed in early 2010 will provide 4,000 residential units for 10,000 residents. Completed in 2006, Vauban is a 40ha land plot that is located only 2km from the city centre and encompasses 2,000 units that are home to 5,000 residents. The complete package of energy solutions realised in these developments - from the use of Passive House and Plus-Energy House techniques to community CHP installations - unanimously implies a spatial decentralisation of energy solutions where a close spatial connection between the given solution and the end point of consumption is evident.

Planning System

In Germany, the federal government is primarily responsible for passing legislation on energy and building policy, while the Länder - the sixteen regional states of Germany - are responsible for the administrative implementation of national legislation. At the national level, the Ministry of Economics and Technology is responsible for developing the German energy policy, but they receive considerable support from the Ministry for the Environment, Nature Conservation and Nuclear Safety for implementing policies pertaining to the development of renewable energies and all environmental regulation that affects the energy sector. At the same time, the Ministry for Transport, Building, and Urban Affairs is responsible for spatial planning in Germany as well as being responsible for the application of all climate change, renewable energy and energy efficiency policies relating to the building sector.

The energy policies concerning the residential building sector are defined by relatively strict and progressive national legislation and regional governments are not responsible for drafting binding policy that governs the residential building sector (PL). In reality, the state acts as an intermediary between the federal government's national policies (which can be further concretised at the regional level) and their implementation at the municipal level (SM). State responsibility for governing certain acts and not others is determined on an individual policy basis depending on the scope and nature of each policy.

In terms of the residential and commercial building sectors, the responsibility to institute national energy and building legislation rests on the municipal governments, which possess relative autonomy within spatial planning and building and land-use planning (HK). It is at this scale where building development plans and local land-use plans are created, thereby allowing municipal governments to strengthen binding national policies with their own local standards. Freiburg's comprehensive energy and environmental approach, which was produced by the Freiburg Environmental Protections Agency, and the land-use and building plans forwarded by the planning department have therefore been the chief motivators for the green housing developments in the District's of Vauban and Rieselfeld.

Policy Developments for Green Housing

By 2008, Germany already had a 14.8% share of its total electricity supply coming from renewables the German government have set targets to reduce GHG emissions by up to 40% by 2020 and to double its energy productivity – a measure of economic output per unit of energy – between 1990 and 2020 [BMU 2007b] [IEA 2007]. To meet these targets, a number of energy and climate change policies have been enacted by various departments in the German government. *The Integrated Energy and Climate Protection Programme (2007) and the National Energy Efficiency Action Plan (2007)* were developed with specific tools designed to focus on reducing GHG emissions in the residential sector [BMU 2005]. Within these programmes, it was determined that the residential sector would be responsible for reducing total GHG emission by 120 million tonnes per year between 2008-2012 [BMU 2005] [BMU 2007b]. The following policies specifically relate to the residential sector:

- *The Energy Savings Ordinance (EnEV):* Under the EnEV, the maximum energy demand has been tightened on September 1st 2009, by 30% (from 160 kWhm²a for new residential constructions in Germany. [BMU 2007b]
- *The Renewable Energies Heat Act (EEWärmeG):* This act is binding since January 1st 2009 and mandates that new homes must cover a certain percentage of their thermal energy demand through the use of renewable energies [IEA 2008].
- *The Renewable Energy Sources Act (EEG):* The EEG obliges operators of regional power grids to purchase all available energy from renewable sources at prices above market value [IEA 2007]. The price for energy from each renewable production method is fixed for 20 years, with annually depreciating subsidy rates dependant on the renewable energy production method that is used (SM).
- *The CO_2 Building Redevelopment Programme*: Based on the fact that 73% of the current housing stock was constructed prior to the first thermal insulation standards in 1978, the programme provides direct grants alongside the loan variant for energy renovations to residential buildings. Funding is earmarked at EUR 1 billion through at least 2011 [BMVBS 2009].

At the municipal level, in 1996 Freiburg City Council passed the *Climate Protection Concept*, which called for a 25% reduction in CO_2 emissions in 2010 compared to 1992 (HK). Just recently, council approved the follow-up programme called the *New Climate Protection Concept,* which has an even loftier target of 40% less CO_2 emission by 2030 (HK). Freiburg's Environmental Protection Agency has suggested that the city move forward with their new targets since the national policies for climate protection have been significantly improved in the past year and it has been Freiburg's mission to continually lead Germany's environmental movement. To achieve these targets, specific measures are outlined in the *Climate Protection Concept's 12-point Action Plan,* which highlight priority areas for urban climate change policy and specifically influence green housing [Breyer *et al.,* 2008].

- *The New Energy Standard for Buildings:* In light of the improved national energy standard for houses (e.g., EnEV) and further technical improvements in the building sector, Freiburg's city council has just approved an enhanced new energy standard. Under the new agreement, all newly built houses and apartments must reach near the energy efficiency standards of Passive Houses (HK).
- *Support Programme for Energy-conscious Renovations:* Beginning on January 1st 2009, this support programme promotes the reduction of energy consumption in residential buildings. Grant assistance is a voluntary benefit for any resident of the city who can seek up to EUR 12,000 for insulation improvements, energy advice or the optimisation of heating systems in their home. [City of Freiburg 2009]
- *Public Awareness Campaigns:* Awareness campaigns offer targeted information on how people can reduce their carbon footprint based on personal and residential consumption habits. [City of Freiburg 2009]

The Deployment Process and Policy Implications

The proliferation of Freiburg's green housing movement is the result of several factors. First, historical events over the past 35 years have embedded and engrained a heightened environmental approach to city governance and policy development. Following from this, harmony exists between the goals of the national and municipal government, there is an active network governance mix operating in Freiburg, and also, a mutually beneficial relationship exists between economic development and environmental stewardship in Freiburg.

Freiburg has had a long and storied conflict over the proliferation of nuclear energy. During the early 1970's, the State of Baden-Württemberg pursued plans to construct a large-scale nuclear power plant only 30 km from Freiburg to meet the increased energy demand of the region [Solar Region Freiburg 2009]. The local agricultural community triggered opposition to the prospect of increased reliance on nuclear energy and resistance quickly spread to the Freiburg's student community and the general public [ECA 2009]. This resistance initiated major protests and widespread civil disobedience, and culminated in 1975 with the State of Baden-Württemberg's withdrawal of plans for nuclear development [Solar Region Freiburg 2009].

The termination of plans for the nuclear power plant in Baden-Württemberg had two direct consequences: first, engagement in the protests significantly raised the environmental awareness of Freiburg's citizens, and second, the Baden-Württemberg region was left with a major hole in their future energy plan. This hole was filled by an environmental approach to energy development that new ecological and participatory approach to local politics and decision-making. The result has been that nuclear dependence in Freiburg has been reduced from over 60% to less than 23% and will continue to decrease as the national and regional governments continue their nuclear phase-out programme. Furthermore, over 80% of the electricity consumed in the city is generated by co-generated heat and power (CHP) plants and domestically produced renewable energy. Thus, although Freiburg will fall just short of their target for a 25% reduction in CO_2 emissions from 1992 to 2010, their renewable energy and energy efficiency developments are commendable in light of a simultaneous phase-out of nuclear energy. (HK)

Also, by tracing policies and decision-making that have influenced the development of Rieselfeld and Vauban through the national, regional and local governance structures it becomes evident that Freiburg's environmental governance strategy is partially nested within a traditional multilevel governance typology. This assertion is evidenced by the scaling of binding energy, climate change and building policies from the federal level down to the municipal level, which identifies a top-down notion of policy governance. At the same time, a local environmental focus and relative autonomy over spatial planning and building and land-use plans is clearly a focal driver of Freiburg's green housing initiatives (HK). The focus on local conditions for the development of these systems implies the necessity for a coordinated approach to energy planning that empowers the authorities most in touch with the local environment. This approach, which is highly evident in Freiburg, recognises that while national policy is necessary for establishing binding standards, funding tools and market conditions, it is local administrations that spearhead the development of green housing [Keirstead 2008]. Thus, the growth of green housing in Freiburg has been driven by national energy, climate change and building policies at one end and local policies in the same areas at the other end.

At the same time, the essence of the local environmental movement is also deeply rooted in the non-state institutions within the local environmental economy and non-governmental organisations. One instigator of the non-state movement was in 1981 when Fraunhofer Institute, Germany's leading applied science research institution with over 15,000 staff in 40 locations, opened a research institute for solar energy systems in Freiburg (HK). This was the first solar institute in Europe to operate independently from a university and it has played a key role in local governance of Freiburg's environmental movement by being a central actor in cultivating Freiburg's environmental economy (HK). Freiburg's environmental sector is now comprised of over 1,500 firms that employ over 10,000 people and these firms generate over EUR 500 million annually for the local economy [Breyer *et al.,* 2008]. Thus, Freiburg's economic structure is characterised by the tremendous harmony between the environment and economy where the environmental economy has become the leading business sector in the city.

The strong standing of Freiburg's local governance network has motivated the city to pursue new arenas for acquiring the tools and expertise to lead the fight of cities against climate change. This has led to a second sphere of network governance in Freiburg; the growth of transnational municipal networks (TMN) as globally-local or ‘glocal’ networks. TMNs aim to realise the full potential of local actions for mitigating global environmental issues by scaling up local environmental governance directly to the transnational level. This example of bottom-up governance adds a new global dimension to governing the local environment and creates a new context of multilevel governance for fighting energy and climate change. Considering the strong environmental movement in Freiburg, it comes as no surprise that the city is considered to be a European hub of TMNs. Freiburg is the home of the International Coucil for Local Environmental Initiatives’ (ICLEI) European Secretariat and the International Solar Cities Initiative, is a model city of the ICLEI’s Local Renewables Initiative and is a regional base for the Energie-Cités Association. Although the two environmental governance typologies clearly identify two different ways of governing; the role of government and the hierarchical approach bound by the nation-state on one hand and the growth of horizontally oriented network approach on the other hand; the analysis of green housing in Freiburg has shown that both forms are evident. The result is a mix of state and non-state actors that draw from complimentary scales and spheres of governance simultaneously to reach an advanced level of environmental governance, which is exemplified in part by the pioneering green housing developments in Freiburg.

Impacts on Regional Competitiveness

Considering that the residential sector is responsible for 25-30% of regional energy consumption throughout Germany, the development of green housing is a means toward achieving regional competitiveness in itself because of the overall impact it can have on reducing energy consumption, improving the use of local renewable energy and transitioning the region towards a low carbon future. Furthermore, many of the drivers of green housing simultaneously act as stimulators of regional competitiveness, and therefore, the issues pertaining to the overall governance strategies and innovative capacity of Freiburg can also be seen as indicators of competitive regions.

Freiburg’s environmental governance strategy puts the region at a competitive advantage in two ways: First, it helps to cultivate the socio-political framework and labour force needed to transition the residential stock towards low-carbon energy consumption habits, which will contribute directly toward the goal of regional competitiveness by securing domestic energy sources and reducing overall energy consumption. Second, regional competitiveness and green housing share a mutual dependence on the environmental economy and innovation sector and Freiburg’s strong environmental governance initiatives have been important for attracting environmental firms to the city.

Freiburg’s extensive education sector paved the way for the city’s strong innovative capacity and has provided the knowledge base for a rapidly growing environmental sector, which has helped ensure a diverse and flexible economic base. Furthermore, Freiburg’s green housing is representative of the technologies and innovative systems that have been developed by local firms and local populations, and co-operation between the high-tech environmental sector in Freiburg and the energy technologies deployed in Rieselfeld and Vauban has been well-documented. This shows that while the residential developments benefit from the locally bound innovation, these firms use the residential sector in Freiburg to test, display and diffuse their innovative accomplishments. It has also been laid out that Freiburg's green housing, its environmental sector and the local economic development strategy benefits from network interaction between government and non-government institutions at numerous political scales. The fact that the City of Freiburg and the firms based there play central roles in a number of transnational environmental networks means that Freiburg is well-positioned to benefit from it's networking capacity in terms of promoting/diffusing its technological developments as well as obtaining local and regional best practices from abroad. In depth study of Rieselfeld and Vauban has shown this to be the case; the two districts have been exhaustively used to promote the achievements of the City of Freiburg and market the energy technologies of the local environmental firms.

C.3.5. Survey Results and Agency Analysis

This section uses a regional energy agency questionnaire completed in mid-2009 to address evolving governance structures in response to present and future energy concerns of Europe. The analysis focuses on four key aspects:

5. the distinctions in policy approach between centralised and decentralised public authorities;
6. key differences between mechanisms used to implement policies derived from different political scales;
7. sectoral implications of these varying policy perspectives and implementation mechanisms – in terms of what tends to get governed locally; and
8. how these conditions effect the mode of decentralised governance for implementing green energy initiatives in practice.

Through the analysis, the relationship dynamics between environmentally-aware policy rationales and the relational perspective of decentralised governance are highlighted. It also illustrates the importance of facilitative policy mechanisms and the ability for sub-national authorities to effectively govern the energy consumption patterns of individuals in their everyday lives.

Accordingly, the aim has been to critically analyse green energy governance at decentralised scales to put forward a comprehensive understanding of how it can operate, as well as its constraints and limitations. Put together, the unique characteristics of decentralised energy governance can be identified as opportunities to reduce the socio-economic risks of regional energy poverty; thereby improving regional competitiveness in Europe.

C.3.5.1. Differences in Policy Approach

The questionnaire results indicate a tendency for regional energy experts to prioritize issues of environmental protection and energy efficiency relative to security of supply. In contrast, regional energy experts perceive national authorities as focussing attention on security of supply issues relative to environmental protection and energy efficiency. Also, regions with renewables as a priority (at least 30% of supply) tend to emphasize the environmental and energy efficiency pillars of energy policy relative to those regions that do not prioritize renewables. These trends indicate that regions with renewables as a priority tend to develop these energy sources based on an environmental and efficiency rationale.

To further validate this hypothesis, table 20 shows where survey respondents are questioned about regional drivers of renewable energy. When these responses are analysed - based on a delineation of renewable energy priority - some notable perspectives are revealed:

- While security of supply is still ranked as the predominant driver, it only shows minimal variation in relation to response to the prioritisation of renewables. Consequently its role as a primary driver of renewable energy could be questioned.
- When the change in ranking for each of the regional drivers is analysed it is quite clear that an emphasis on environmental protection is the predominant motivating factor for renewable energy development.
- Interestingly, there is a negative shift for international commitments when renewables are prioritized by regions. This indicates that regional energy governance is not only responding to top-down initiatives when implementing sustainable energy policies.

Table 20 Drivers of Renewable Energy Based on Regional Energy Priority

Question 5: Regional Energy Source Priority:		Question 6: Regional Drivers of Renewables and Efficiency:			
Energy Source Priority	Noted as an Energy Priority	International Commitments	Energy Price	Security of Supply / Self-sufficiency	Environmental Protection
Coal	No	0.93	1.61	2.06	1.42
	Yes	1.20	1.80	1.90	1.10
Natural Gas	No	1.08	1.79	1.92	1.29
	Yes	0.94	1.47	2.18	1.41
Nuclear	No	1.05	1.59	1.97	1.43
	Yes	1.75	2.25	2.50	0.50
Renewable Energy	No	1.50	2.00	1.93	0.71
	Yes	0.78	1.48	2.07	1.67

The policy analysis of the questionnaire indicates that regions appear to confer a general priority to follow national interests related to security of supply. While doing so however, they also portray a heightened awareness of environmental concerns that are a guiding rationale for developing clean energy solutions. Accordingly, green energy development can be viewed as a strategy to mitigate future risks associated with foreign and non-renewable energy dependence.

Policy priorities between governing scales are very likely related to a general trend where certain energy responsibilities are delegated to different territorial scales depending on the policy aim. For example, national authorities tend to have a strategic focus on issues of national importance - such as maintaining or generating security of supply - which are seldom delegated to sub-national scales. However, a regional policy focus on energy efficiency and environmental protection implies that sub-national authorities are in a preferred position to respond to locally-specific and changing opportunities regarding technological, socio-political, and economic issues relating to green energy technologies.

C.3.5.2. The 'Sustainability Impact' of Sub-national Energy Governance

Table 21 illustrates a binary comparison between the level of regional priority for renewable energy sources and the relative autonomy for regional authorities to govern energy issues in their own region. Based on the output, each of the four solution spaces reveals a concomitant relationship between renewable energy production and decentralised energy governance. These include:

- Regions with renewables as a priority are much more likely to have a higher degree of governance autonomy.
- Regions without renewables as a priority are more likely to be governed nationally proportionate to regionally.
- Regions with relatively decentralised energy governance are much more likely to have renewables as a priority.
- Regions with relatively centralised governance show no tendency to develop renewables as a priority.

Table 21 Renewable Energy and Decentralised Governance

	Regions with decentralised energy governance	
Question 5: Regions with a renewables priority:	**Yes: 24 (71%)**	**No: 17 (29%)**
Yes: 26 (63%)	18	8
No: 15 (37%)	6	9

C.3.5.3. Structural Characteristics of the Regional Grouping

A grouping of the respondents has been done by means of a cluster analysis which was based on a combining of five questions from the questionnaire regarding regional energy policy distinctions, regional energy source priorities, degree of decentralised governance, and the importance of decentralised renewable energy sources. The results show the distinction of three primary groups. From here, the individual regions were analysed based on the internal consistency of their survey responses; and specifically on the degree of governance decentralization and renewable energy priority they indicated. Accordingly, 'robust clusters' of each primary grouping were delineated to reveal three distinct groupings (Table 22) with the following representations:

Table 22 Robust Regional Grouping of Respondents to Questionnaires

Group 1	Group 2	Group 3
1: Austria, Burgenland	3: Belgium, Flanders	6: Cyprus, Cyprus
2: Austria, Voralberg	5: Bulgaria, North East	10: Finland, Central
7: Czech Rep., Zlin Region	16: Greece, Central Macedonia	15: Greece, Crete
8: Denmark, Midtjylland Samsoe	27: Poland, Podlaskie	17: Hungary, National
14: Germany, Freiburg	29: Portugal, North Alentejo	18: Ireland, Cork
25: Netherlands, South	34: Spain, Basque	19: Ireland, Midlands
38: Sweden, Kalmar	39: Sweden, Örebro	33: Slovania, Podravje
40 UK, South West		

Group 1:

- High overall policy focus where efficiency and environmental protection are emphasised relative to security of supply
- Unanimous priority for renewables
- Very strong emphasis on sub-national scales of energy governance
- The importance of pursuing all opportunities for producing renewable energy, including smaller scale and decentralised solutions
- High Diversity of economic activities and a low energy intensity of the economy

Group 2:

- High overall policy focus where efficiency and environmental protection are emphasised relative to security of supply
- High priority for renewables
- Relatively high priority on coal within the energy mix
- Moderate emphasis on sub-national scales of energy governance
- Low diversity of economic activities and a higher energy intensity of the economy

Group 3:

- Relatively low policy focus where security of supply and efficiency are emphasised relative to environmental protection
- Relatively low prioritization for renewables
- A strong emphasis on nationally-governed energy policy
- Low diversity of economic activities and higher energy intensity of the economy

When the details of these findings are coupled with the previous analysis, a correlation between increased governance decentralization, an emphasis on the environment and energy efficiency as guiding policy rationales, and the preferential support for green energy technologies is apparent.

C.3.5.4. Case Examples of Regional Energy Governance

The use of regional case studies and a theoretical approach that acknowledges the relational and network perspectives of governance can help to understand the unique characteristics of decentralised governance. They also reinforce findings of the questionnaire and identify limitations and constraints on the potential sub-national institution building for guiding European regions toward more sustainable energy profiles. Accordingly, three case studies previously completed in the ReRisk project and three case examples for each of the clusters are summarized.

Navarra, Spain: The Regional Government in Navarra has the main competence on all energy matters for the region and success of wind energy is based on three key factors: high wind energy potential, a well-established energy policy that aims to reduce external energy dependency and a clear linkage between renewable energy and regional economic development [IEA 2005]; [De Miguel Ichaso 2000]; [Fairless 2007]. In regards to the latter, it is specifically noted that rapid development of renewables in Navarra is closely related to regional efforts to diversify the economy away from energy intensive manufacturing and develop a knowledge economy centred on renewable technologies.

Freiburg, Germany: Within a federalist system in Germany, regional authorities of Baden-Württemberg have the main control over energy matters in Freiburg. At the same time, the District of Freiburg has developed a strong local competency for emphasizing clean energy technologies. This process was initiated by a local environmental movement surrounding plans to expand nuclear energy production in the region. It has subsequently evolved into a comprehensive environmental movement that shapes the local political situation, economic growth and the development of the built environment [Hoppe 2009].

Samsø, Denmark: The national government has the main responsibility for energy planning in Denmark, but through the principle of subsidiarity extensive decision-making power is left to local actors [Pettersson 2006]. As such, local initiatives in response to a strong feed-in tariff and other national subsidies led to a focus on wind energy development to a point where the island of Samsø is a net-producer of energy. Citizen acceptance was a direct result of local ownership where local farmers and citizen cooperatives have taken up ownership of the eleven land-based turbines. The growth of wind power has built a strong local competency for wind energy technologies, which has helped diversify the economy toward knowledge-based sectors and a well-developed eco-tourism sector [Hermansen 2009].

Group 1: Kalmar County, Sweden: Kalmar's regional energy policy is predominantly rationalized by an enhanced regard for environmental protection and adherence to international climate change commitments at both the national and regional levels. In addition to realizing their strong wind energy potentials the region currently focuses on three branches related to energy efficiency management: transport and mobility, the building sector, and learning and lifestyles. Each of these has a direct focus on altering energy consumption behaviours of the general citizenry and local businesses. The aim is for an improved awareness of the externalities of energy production and consumption, as well as the potential for efficient investments in clean energy technologies [Eckerberg 2010] .

Group 2: Central Macedonia, Greece: As a unitary state, Greek energy policy is formulated nationally and disseminated to the individual regions. One result of this is that administrative challenges tend to engrain national interests of security of supply and economic growth, and these have hindered the development of locally bound green energy initiatives [IEA 2007]. Consequently, the energy intensity of Central Macedonia is notably high. The perception is that many local energy savings programmes are representative of municipal authorities who decide to "go it alone" by attempting their own green energy schemes [Konstantinou 2010]. However, these actors wishing to pursue environmental initiatives on their own appear to be limited in the action they can take due to a lack of available resources from senior political scales.

Group 3: Cyprus: The ability of sub-national actors to facilitate local initiatives is limited by the centralised nature of overall governance in Cyprus, which is tied to the spatial characteristics of the small island state. Energy policy has the primary focus of safeguarding healthy competition of the internal market and ensuring security of supply. In 2009, renewable energy production covered 4% to total energy supply and less than 1% of total electricity supply. However, Cyprus is one of the leading countries in the use and construction of solar water heating systems. 92% of households are equipped with solar water heaters and 53% of hotels have installed large solar water heating systems. According to the ESTIF (European Solar Thermal Industry Federation), Cyprus has the largest number of solar collectors per capita in the EU. The potential for marked growth of large-scale renewable energy production is constrained by low potentials for wind power and concern over landscape and “environmental” impacts of renewables. This is very likely connected to the nature of service sector dependence in the Cypriot economy, where the tourism sector is prioritized [Vlachos 2010].

Unique Perspectives from the Case Studies

The case findings describe the varying relations between national and sub-national governing authorities, the actors involved in governance processes and the specific energy activities that tend to be approached by decentralised governance. Therefore, the cases can be used to indicate some of the characteristics of decentralised governance as well as its constraints and limitations. This provides an opportunity to position decentralised approaches within a conceptualization of governance that operates between the EU and community levels. Accordingly, notable points of interest include:

Political context: Centralised political structures do not dissolve governing responsibility of energy matters to sub-national authorities which limits their ability to act autonomously from national interests.

Policy integration: Case examples of Navarra, Freiburg, and Samsø clearly show the potential of locally-bound energy movements to integrate sustainable energy development, regional competitiveness and long-term planning to mitigate the risk of energy dependence and fuel poverty

Spatial context: The green energy capacity of regions is tied to uncontrollable spatial characteristics – e.g. island regions, sparsely populated regions or other geographical specificities. These conditions inherently shape renewable energy potentials, but they can also affect the underlying governance frameworks that prevent decentralised institution building from taking place, or limit its ability to act. For example, Cyprus and Ireland are both characterized by centralised governance that appears to constrain the development of green energy solutions. At the same time, the Samsø case shows that under the certain political conditions, geographical specificities can decisively shape local approaches with notable results. This indicates that while geographical barriers are often seen as a point of constraint for advancing local energy approaches, there are exceptions where spatial context is important for motivating green energy movements.

Historical context: It is necessary to recognize that the early stages of a green energy movement can have important implications on who tends to be involved in the governing process. A clear distinction is noted between Navarra - where the process was initiated by agents operating under a clear economic competitiveness rationale; and Freiburg, where a movement emanated from social resistance to nuclear energy development is noted.

Changing development norms: Countries with higher levels of economic development are more likely to pursue sustainable energy development based on the socio-political grounds of enhanced environmental stewardship [Oreg and Katz-Gerro 2006]. Accordingly, a driver of their governance approach could be an ideological shift toward an environmental conservation that is not solely based on an economic rationale. Therefore, the level of socio-economic development could be an obstacle for the facilitation of citizen engagement in green energy initiatives.

Decentralised governance cannot act alone: Sub-national governance is dependent on policies and legislation derived from senior institutional scales. In particular, renewable energy promotion is usually dependant on national feed-in tariffs and EU policy analysis shows that decentralised institution-building is reliant on the dispersion of Structural Funds.

Regional accountability: A comprehensive account of regional and local energy consumption is a prerequisite for justifying any investments in improving energy efficiency [Rutland and Aylett 2008]. Results of the survey show that energy governance in European regions must make major improvements in terms of accounting for regional energy consumption in all sectors.

Capacity building translates into growth: The Freiburg case provides an example of how an initial focus on non-economic rationales for green energy development sectors can pave the way for long-term growth as economies diversify and transform due to changing development goals and local demands.

Policy Mechanisms and Sectoral Implications

The distinctions between operative policy mechanisms of centralised versus decentralised authorities appear to affect the energy activities that tend to be governed sub-nationally. This is indicated in the analysis of EU energy policies, questionnaire results, case examples and literature reviews. For example, the Emissions Trading System (ETS) is the EU's principle mechanism for meeting energy policy goals in the most energy intensive sectors [EC 2010a]. It operates based on a clear economic rationale in which green energy investments either imply a cost savings or are a source of revenue. In contrast, the EU's other main policy tool is the distribution of Structural Funds for sub-national institution building. EU policy documents indicate that this is often directed towards initiatives that promote information and awareness of energy issues associated with residential and commercial buildings, local transport and behavioural change [EC 2010b].

Table 23 Governance Responsibility for Energy Information and Awareness Dissemination per Sector

Governance responsibility for energy information and awareness			
Sectors	Local government	Regional government	National government
In the Industrial Sector	4.88%	31.71%	63.41%
In the Energy Sector	4.88%	21.95%	73.17%
In the Transportation Sector	7.32%	21.95%	70.73%
In the Residential Sector including the consumption patterns among the general population	29.27%	24.39%	46.34%
n = 41			

This is reaffirmed by the questionnaire (table 23), which indicates that the residential sector – i.e. green energy investments and consumption behaviours in the home and during the exercise of individuals' everyday lives – as the only sector where sub-national authorities have a dominant governing role over national authorities. Likewise, analysis of the cluster results from this same sectoral perspective shows that increased sub-national priority on the residential sector is highly correlated with an increase in the relative degree of governance decentralization.

The main indication from the analysis of contrasting policy mechanisms and their sectoral impacts is that it implies a paralleled contrast in the mode of governing. On one hand, the evolving ETS - and its market-based rationale - governs sectors that are directly connected to the production capacity of regions. On the other hand, Structural Funds are directed towards regional and local authorities for promoting improvements in sectors that are not directly tied to regional economic production. Consequently, empirical research through the case examples and literature reviews shows that this can be linked to a view of sub-national authorities as "facilitators" of local initiatives. This in turn relates back to the prioritization of environmental protection and energy efficiency by decentralised governance as central issues that are incorporated into the energy governance and the promotion of green energy technologies.

As shown in the Navarra case example, without decentralised governance that proactively emphasizes the environment and energy efficiency as issues to be governed, key energy issues can tend to go relatively 'ungoverned'. As a result, impressive gains in renewable energy growth can be offset by increases in regional energy demand and energy intensity of the economy.

Similarly, table 35 (in Annex II of this section of the Scientific Report) highlights that energy consumption activities surrounding the residential sector provide the most energy saving *potential* and *opportunity.* Yet, it also indicates (part 12d of the table) that these potentials and opportunities are constrained by significant *challenges* that the residential sector entails. The fact that a sector with such a great overall energy saving potential, as well as conceivable opportunity could also be facing notable challenges insinuates that a method of recognizing the unique abilities of decentralised governance is lacking.

However, innovative ways of emphasizing environmental externalities of energy production and consumption can make a difference. Just a few examples of governments facilitating awareness include: real-time displays of local GHG emissions in high traffic areas, local climate programmes to reduce residential energy consumption or local governments leading through example by incorporating green energy solutions in all their city operations. These types of facilitative efforts promote energy and the environment as mediating issues that influence the consumption behaviours of citizens and provide a level of green energy development that may not otherwise be possible.

C.3.6. The Scenarios

This section presents the four scenarios resulting from the scenario building activity. As explained in the methodology the scenarios consist of hypotheses that were formulated according to the results of the analysis completed in Workshop I, the questionnaires, the case studies and the policy review. Furthermore, as the hypotheses were defined during an internal workshop at Nordregio, the cross-consistency assessment was carried by the same groups using the matrix in next page. The resulting scenarios from the morphological analysis were further evaluated and four scenarios were selected in terms of their internal consistency, plausibility, uniqueness, likelihood and relevance for European regional policy during workshop II and III.

The context in which the cross-consistency analysis was carried out was:

- The scenarios were given for 2030;
- The scenarios were at a European scale;
- Energy prices were at a “high” level, which has caused structural changes in regional economies (an oil price (real price) of $200USD per barrel as indicated in the questionnaire in annex III of this part of the scientific report);
- Policies on climate change aiming at reduction of CO_2 emissions of at least 30% prevail in 2030;
- Policy goals on both regional competitiveness and cohesion prevail in 2030.

Despite common policy goals among the scenarios, orientation of each varies depending of the development paths given by their internal and external drivers as well as the chosen policy responses to these drivers. For example, in the energy sector the overarching goal is to reduce CO_2 emissions, but this is not necessarily achieved only through expansion of renewable energy. Moreover, scenario 4 varies from the outset as it presupposes negative economic growth.

It is important to point out that the following scenarios are only a small sample of a large number of very complex plausible visions of the future in Europe. Therefore, the scenarios shall not be viewed as recommended pathways but instead as illustrations of the likely impact of rising energy prices on regional competitiveness and cohesion in Europe as well as different policy responses to cope with this challenge. Nevertheless, these scenarios have not been tested quantitatively but instead have been based on qualitative methods. The figures presented are based on the views and judgements of the experts as well as the literature reviewed. Thus, the figures serve only as references to indicate the direction of policy development in the scenarios and not for indicating the actual potentials regarding renewable energy, reductions of emissions, etc. Notwithstanding, the technologies presented in the following chapter are either already available in markets or are considered to become commercialised in the near future.

		Energy mix			Energy demand		International agreemetns on GHG		Technological accessibility		Innovation			Industrial divelopment			Settlement patterns	
		Emphasis on renewable energy	Emphaisi on fossil fuels	Emphasis on nuclear energy	High decoupling between economic growth and energy demand	Low decoupling between economic growth and energy demand	Enforced international agreements on GHG emissions	Weakly enforced international agreements on GHG	Clean energy technologies are accessible to **most** producers/consumers	Clean energy technologies are accessible to **few** producers/consumers	High innovation capacity	Moderate innovation capacity	Low innovation capacity	High presence of the service and knowledge economy	High precence of the primary and manufactory industry	Balanced presence of all sectors	Increased settlement centralization (Urban gwoth)	Increased settlemetn descentralization (Urban and rural growth)
Energy demand	High decoupling between economic growth and energy demand																	
	Low decoupling between economic growth and energy demand																	
International agreemetns on GHG	Enforced international agreements on GHG emissions		X															
	Weakly enforced international agreements on GHG																	
Technology accessibility	Clean energy technologies are accessible to **all** producers/consumers					X												
	Clean energy technologies are accessible to **few** producers/consumers	X			X													
Innovation	High innovation capacity																	
	Moderate innovation capacity																	
	Low innovation capacity	X		X	X				X									
Industrial divelopment	High presence of the service and knowledge economy												X					
	High precence of the primary and manufactory industry																	
	Balanced presence of all sectors																	
Settlement patterns	Increased settlement centralization (Urban gwoth)																	
	Increased settlemetn descentralization (Urban and rural growth)																	
Passenger transport	Emphasis on public trasport												X					
	Empahsis on private car transport	X					X											
	Emphasis on both public and private car transport																	

Exclusions

Figure 13 Cross Consistency Assessment Matrix

The Matrix shows the drivers (variables) and their hypotheses (values) as well as the pairs of consistent (empty boxes) and inconsistent (red boxes) hypotheses. The field marked in grey is excluded because it corresponds to repeated pair of hypotheses and those hypotheses that are compared with each other.

C.3.6.1. Scenario 1: Green High-tech

Energy mix: Emphasis on Renewable Energy

The development and utilisation of renewable energy technologies is a top priority in Europe in 2030. Although considerable economic growth has prevailed in Europe, total energy demand has declined considerably, with CO_2 emission reductions of more than 40% compared to 1990 levels. Energy production from renewable sources has grown most extensively, while the demand of coal and oil has been almost excluded in the industrial, residential and energy sectors. The demand of natural gas has shown a modest decrease while the phase-out programmes on nuclear reactors have continued resulting in a progressive reduction of energy supply from this source. Nevertheless, the transport sector has become notably less energy intensive and oil dependant.

Europe shows now a new balance between centralised vs. decentralised sources; with particular emphasis on integration of energy systems adapted according to different territorial needs and characteristics as well as potential hazards, among others resource depletion and exposure to extreme whether. The large renewable energy systems mainly solar-thermal, wind and wave; are located in places away from urban areas, a development which has been accompanied by the enlargement and modernization of the power grid.

Across Northern Europe a new network of ocean and land-based power grids is interconnecting wind parks, hydroelectric plants and tidal and wave energy installations. In the South, wind power is complemented by photovoltaic (PV) and solar-thermal power plants. Alongside with a further liberalization of the energy market, the deployment of intelligent power grids has resulted in a more diversified energy market comprised now by many small and large actors that are permitted to feed-in into the power-grid and sell the surplus of electricity resulting from the operation of renewable energy systems.

Among the renewable energy sources, bioenergy has shifted away from agricultural crops towards the use of only residual materials. Nevertheless, biomass is transformed into heat and biogas rather than biofuels for the transport sector. This has been the consequence of higher food prices which has made food production more competitive and strategically important.

International Agreements on GHG: Enforced International Agreements on GHG Emissions

International GHG emissions quotas have been agreed upon and a global Emissions Trading Scheme (ETS). This has strengthened the European-ETS (EU-ETS) as emission quotas can be reduced without the concern of carbon leakage of energy intensive industries. Initially the EU-ETS becomes a contributor to high energy prices though by 2030 it has resulted in a greater availability of energy efficient technologies and renewable energy sources which now are considerably cheaper than fossil fuels.

The incorporation of the transport sector in the EU-ETS in mid 2010’s was an important driver in the development of more energy efficient transport systems. However, the application of the ETS on the transport sector has been limited by its continued dependency on oil, especially in occasions when oil prices have reached their highest levels.

Energy Demand: High Decoupling between Economic Growth and Energy Demand

Consumer response to high energy prices, their awareness on climate change and the availability of energy efficient technologies has resulted in a considerable reduction of energy consumption in all sectors. This process has also been accompanied by programmes, incentives and regulations on the modernisation of industries and old building stocks. The general public awareness on energy consumption has also been the result of the emphasis of public participation in energy planning.

Technology Availability: Clean Energy Technologies Available to most Producers/Consumers

A diverse set of renewable energy technologies are available, accessible and economical for large, medium and small producers, including households. Similarly, energy efficiency technologies are available and affordable for users in all sectors. Nevertheless, economic prosperity has made possible for companies and persons to invest in these technologies.

The availability of energy efficient heating and cooling systems (air and ground heat pumps), appliances, as well as increase use of photovoltaic (PV), solar-thermal and geothermal installations have played a fundamental role in reductions of energy consumption in the residential sector. In addition to subsidies applied to theses technologies, consumers also have access to soft loans for retrofitting houses and apartments.

Industries have gone through a process of modernization comprising the substitution of fuel-based processes by electric driven technologies (e.g. electric arc furnace in the metallurgic industry), better reactor and motor designs, the optimisation of industrial processes, the internal recycling of spill energy, the use of recycled raw materials and the establishment of industrial symbiosis networks between neighbouring companies, urban settlements and energy producers and distributors.

Thanks to the availability of small and medium scale renewable energy systems, clusters of energy generation installations have been developed, such as wind and PV installations that are operated centrally by a single control unit. Technologies for storing electricity have also been developed and are widely implemented. For example, excess heat can be stored by pumping heat in to the ground during the summer which can be used during winter time.

Innovation: High Innovation Capacity

Europe continues to move towards a knowledge-based economy and has increased its innovation capacity relative to the rest of the world by improving its ability to create, develop and export high value-added products and services. Education and R&D remain as a top priority and therefore public investments in these areas have increased notably. R&D centres have proliferated and Energy management is now an integral part of education programmes at all levels resulting in the creation of a strong green industry that exports technology globally.

Economic Development: Higher Presence of the Service and Knowledge Economy

The continued economic growth in 2030 is dominated by the service sector and the knowledge economy because of increased competitiveness in technological consulting and high-tech manufacturing. Due to high transportation costs and a well-functioning global ETS system, manufacturing industries have been retained in Europe. Stronger emphasis on self-sufficiency and local production in many regions has also contributed to this development. Recycling industries now act as large producers of energy and materials to industries, farmers and households.

Settlement Patterns: Urban and Rural Growth

Economic and social growth is still concentrated in large urban areas due to the abundance of job opportunities in these areas, particularly in the context of the growing knowledge-based economy. High energy prices also motivate the population to live within proximity to public transport infrastructure and jobs resulting in compact and polycentric urban structures. Moreover, the quality of life in urban areas has been improved through further development of infrastructure and services, mainly transport, health care, education and recreation.

A process of decentralisation is also taking place as energy-independent regions have emerged, in which settlements have benefited from investments in infrastructures and services. Private and governmental interests in developing these regions have in many cases led to the foundation of innovation centres and of companies specialised in the manufacture and deployment of renewable energy technologies. Many of these companies have conquered remote markets, e.g. Asia and South America, on equipments as well as consultancy on renewable energy deployment and planning.

Due to increasing prices on raw materials regions rich in natural resources have also become economically more important. Population growth in these areas is rather limited due the domination of big farmers and companies as well as the reduced labour intensity of modern industrial and agriculture practices.

The process of depopulation of many remote regions has continued due to the lack of natural resources and innovation capacity. High transport costs have affected remote tourism regions in particular. Though, some of the most attractive tourist areas have experienced an influx of elderly population as well as distance workers seeking lower residential prices, comfortable living conditions and the availability of services remaining from the tourism bonanza. Distance workers in particular are able to perform their daily work by using ICT solutions.

The presence of renewable technologies has changed the rural, coastal and urban landscape of Europe. The acceptance towards the visual impact wind farms, solar installations and biogas plants as well as the deployment of new of power grids has increased significantly thanks to innovative measures to integrate these infrastructures into the rural and urban landscapes and minimize their environmental impact. Other important incentives have been economic compensation and extensive information campaigns, particularly on the socio-economic benefits of renewable energy. Most significant, is the increased autonomy that regions and municipalities have gained in terms of energy decision. This has resulted in the integration of local approaches in energy planning in which local communities and companies are active in developing local energy projects.

Transport: Emphasis on Public Transport

The transport sector has become notably less energy-intensive and reduced its oil dependence, mainly due to a considerable increase in the use of public transportation. Preference towards public transport has partly been a consequence of high oil prices and taxation on fossil fuels alongside the increased awareness of climate change.

Considerable investments in urban areas and implementation of new participatory planning concepts and processes have generated new infrastructures and services that facilitated the use of street by pedestrians, bikers and public transport users. Affordable hybrid and electric cars have substituted petrol cars as the norm. Contrary to urban areas, residents in rural areas are particularly dependant on private cars for short distance travel, and high-speed trains for travelling longer distances. Therefore, significant investments have been made on efficient road and railway networks interconnecting the main rural settlements and the urban areas.

The total number of airline passengers has dropped, especially on short distance flights, as a consequence of high oil prices and increasing competition from high-speed trains. The demand of air travel on long distances has however shown modest declines due to retained high incomes among European citizens. Despite of the expansion of railways freight transport has been seriously affected because it continues to be highly dependant on fossil fuels transport modes, primarily boats and trucks. In this regard, optimisation in logistics has played a key role in compensating these costs.

C.3.6.2. Scenario 2: Energy Efficiency for a Future Europe

Energy Mix: Emphasis on Fossil Energy

Due to a political emphasis on energy efficiency, the energy intensity of Europe has decreased significantly, but, despite of further deployment of renewables, demand for fossil fuels is still dominant. Renewables have mainly served to compensate the closure of nuclear power plants. This development has resulted in a reduction of the total energy demand while reductions of CO_2 in 2030 have been limited to 30% relative to the 1990's.

Large renewable energy projects were built mainly between 2010 and 2020, but further development was hampered by lack of public support, declining innovation capacity, conflict of interests, lack of investments and lack of proper information. Scepticism towards nuclear energy has also prevailed due to its high costs and perceived risks, resulting in the continuation of the phasing out of old nuclear plants.

Global GHG agreements have not been reached, and Europe is still facing fluctuating energy prices because of the high dependency on natural gas. New deposits of natural gas have been discovered while the Nord Stream, the South Stream and the Nabucco gas pipelines have been built increasing the availability of natural gas to Europe. To this adds the fact that relations with between Europe and Russia have been improved, giving a stable ground for investments on natural gas. The demand of coal has on the contrary declined mainly because of climate change policies as well as its use has become much more efficient. Oil demand as a source of primary energy has been extensively reduced which is now performed almost exclusively by the transport sector, specifically for freight and air transport.

International Agreements on GHG's: Weakly Enforced International Agreements on GHG Emissions

The most energy intensive global economies have not signed a unified global agreement on GHG emissions. This has limited the ability for European economies to proactively develop renewable energy technologies while simultaneously remaining economically competitive globally. Initially, the EU-ETS was an important measure that promoted the deployment of renewable energies and energy efficiency but the lack of international commitment, coupled with high oil prices and the continued dependency on fossil fuels, has increased the risk of carbon leakages. This situation has therefore greatly limited the feasibility of EU-ETS for European economies. The results of each member state with regard to climate change mitigation policy has been very dependant on governing structures that draw out the roles and responsibilities of the public sector at each administrative level to form an integrated energy and climate change approach.

Energy Demand: High Decoupling between Economic Growth and Energy Demand

The energy intensity of the European economy has been reduced in large part because high energy prices have resulted in the "commodification" of energy. This has motivated energy producers to invest in efficiency improvements for energy production and transmission while consumers have changed their consumption behaviour and invested in energy efficient technologies and small renewable energy installations.

Governments have adopted support mechanisms, standards and directives to stimulate energy savings among consumers in all sectors by adopting energy efficient technologies. Creative and effective information campaigns have raised awareness on the negative consequences of high energy consumption and the potentials for reducing energy expenditure. Also, the development of new professions, primarily energy technicians, auditors and consultants has helped to monitor, assess and inform consumers about the benefits of energy efficiency technologies. Further, the integration of spatial and energy planning has been central factor for achieving energy efficiency by all sectors.

Technology Availability: Clean Energy Technologies Available to most Producers/Consumers

High energy prices and important technological advances have made new energy efficient technologies as well as small scale renewable energy solutions more competitive. Conversion and electricity transmission technologies have become highly efficient reducing therefore energy losses in the generation and distribution of electrical power.

In the industrial sector most fossil fuel driven processes have been substituted by electricity-driven technologies alongside with the acquisition of energy efficient furnaces, reactors and engines. Also the incorporation of recycled materials in industrial production and the deployment of industrial symbioses have resulted in important energy saving.

In the residential sector a shift away from oil in favor of the use of electricity, CHP, and heat pumps has taken place. The efficiency improvements of the building sector have also been pronounced, as efforts have been made to retrofit old houses and build passive energy buildings since early 2010's. However, the slow turnover rates in the building sector and its high costs has resulted in a small proportion of the total building stock been modernized. Major reductions of the energy intensity in this sector have instead been the consequence of the acquisition in households of energy efficient electrical appliances and illumination, intelligent heat and electric systems as well as the connection of most buildings to district heating and cooling networks.

Innovation: Moderate Innovation Capacity

The innovation capacity of countries such as China and India has increased rapidly relatively to Europe which is now facing heavy competition in the knowledge-based industries. Increased costs for imports and prevalent EU policies on climate change and regional competitiveness has meant that R&D investments continue to be oriented towards energy technologies, especially related to efficiency. Public R&D expenditure has however decreased due to increasing social spending originated by an aging populations and increasing food prices.

Economic Development: Balanced Economic Growth by All Sectors

Economic growth has continued during the last 20 years but losses in the service and high-tech industry have resulted in a slow down of the economy. Higher energy, food and transport prices have materialized in overall decreases in consumption.

While the service sector continues to dominate the European economy, increased wage rates overseas have also made local manufacturing and agriculture more competitive. In addition, industries have found ways reduce production cost by becoming highly efficient through automated and scrutinized production methods and the utilization of recycled materials.

The recycling industry has particularly showed marked growth due to higher prices of raw materials as well as transport costs and the adoption of efficient production processes that make separation of high valued materials from residues less expensive. In agriculture particularly, new techniques, food crops and policies have helped to improve its productivity and sustainability.

Settlement Patterns: Urban and Rural Growth

Socio-economic growth in European urban areas is still unavoidable due to the importance of agglomeration in the service sector and knowledge based industry. In lieu of this it is increasingly important that urban spatial and land-use planning is integrated with energy planning to produce spatial arrangements and built environments that meet high energy standards. Accordingly, city planning now includes binding energy and environmental protection policies that governs energy consumption across sectors. This integration has motivated urban growth as polycentric, mixed-use and properly planned dense urban environments that reduce energy intensity of the building and transport sectors.

Growth in the industrial and agricultural sector has been an important component in igniting some rural areas. This, in combination of policies supporting the development of these areas, and the lack of suitable land for industrial production in urban regions, has resulted in the interruption of the process of depopulation of many rural regions. Areas close to urban regions or with good accessibility to natural resources have become more economically important, while new rural functionalities have increased the demand of skilled working force. Similarly, ICT developments allow more people to live predominantly in attractive rural areas while being able to work from distance. Remote and insular tourism regions have, on the contrary, experienced important economic and population losses due to the high cost of flights. Therefore, tourism is now concentrated in attractive costal and mountain regions in the proximity of urban areas.

Transport: Emphasis on Private Car Transport

While the overall transport intensity has decreased, the dependence on the private car has increased, which is particularly related to the growth of rural environments that do not have the populations of scale to rationalise public transit infrastructure.

The perception of freedom that car ownership implies, in combination to high oil prices and technological advances have made hybrid and electric cars the common choice in car purchases in Europe. At the same time, the high costs associated with car ownership have also resulted in new perspectives on car ownership. Primarily, co-operatives have become commonplace, especially among families and individuals that cannot buy new cars. These solutions are found in both urban and rural areas where suitable population densities exist. Nevertheless, the high presence of hybrid and battery cars have motivated the construction of appropriate infrastructures, among others car-charging at parking lots and battery exchange stations, and the expansion and modernization of the road network.

C.3.6.3. Scenario 3: Nuclear Energy but for Big Regions

Energy Mix: Emphasis on Nuclear

In this scenario nuclear energy is the main priority for energy development in many European countries. Nuclear phase-out programmes have been shelved and replaced by new programmes on the construction of nuclear reactors. These programmes have resulted from the decision-making of national governments coupled with intensive information campaigns aimed at creating public acceptance towards nuclear energy; specifically as a measure to mitigate climate change. In overall reductions in CO_2 emissions have consequently reached 30% relative to the 1990's, though the total energy consumption continues to increase.

While the new generation of nuclear plants was under construction until early 20's, renewable energy deployment witnessed a significant expansion; primarily large-scale renewable energy systems such as offshore wind, solar farms, and CHP networks. Though, renewable energy deployment slowed down rapidly as result of increasing investments on nuclear reactors, lack of public acceptance and decreasing innovation capacity. Nevertheless, a new balance between centralised and decentralised energy systems became apparent not only due to the presence of renewable energy, but also because technological developments in nuclear energy which have allowed smaller reactors to generate electricity from nuclear waste. This scenario also presupposes a high expansion of the transmission grid for whole Europe.

Initially, the high presence of nuclear energy in Europe created abundance of electrical power but as the demand for uranium increased world-wide the production capacity of nuclear energy have been hampered by 2030. Uranium is primarily imported from Australia and Canada, and to a minor degree from the Middle East and Russia.

The demand for fossil fuels has been reduced significantly in 2030 as coal use in industries and thermoelectric plants have been replaced. Also, the use of oil for heating has almost been entirely replaced by electricity and district heating. Consequently, the transport sector, primarily freight and the airline industry are the primary consumers of fossil fuels in 2030.

The energy sector is dominated by few big producers, partly as consequence of the large investments required for the construction and maintenance of nuclear rectors, distribution grids and nuclear waste storage facilities. The centralization of energy systems has resulted in both technical and economic vulnerabilities. On one hand, Europe is vulnerable to large blackouts caused by failures in a highly centralised system and, on the other hand, national governments have acquired important debts resulting from large capital investments necessary for the construction, the operation and the maintenance of the nuclear energy infrastructure.

International Agreements on GHG's: Weakly Enforced International Agreements on GHG Emissions

Despite the fact that some of the most energy intensive countries in the world have not signed proposed global agreements on GHG quotas, Europe has maintained its energy and climate change goals. However, the lack of international commitment, combined with high energy prices and a political emphasis on industrial production has resulted in a limited scope and breadth of the EU-ETS which now only applies to industrial activities that can be electrified, while the transport sector has been completely exempt.

Energy Demand: Low Decoupling between Economic Growth and Energy Demand

Increases in energy demand are regarded as the consequence of the relative growth of manufacturing and primary industries and the abundant availability of electricity which has hampered behavioural changes on energy consumption by households. Persistent energy efficiency improvements have also been difficult to achieve due to the lack of incentives, lack of dissemination of information and the limited availability of energy efficient technologies. However, reductions in the energy intensity in some sectors have been achieved due to consumers' responses to higher oil prices; especially in the transport sector but also in some industries thanks to the increased use of recycled materials.

Technology Availability: Clean Energy Technologies are Available to few Producers /Consumers

The prolific growth of nuclear power generation after 2020 has made renewable energy and efficient technologies less competitive. The deployment of medium and small scale renewable energy technologies has also failed in urban areas due to inadequate information about their benefits and reliability. Medium and micro-scale energy solutions - roof-top wind mills, household PVs, fuel cells, etc. - are found almost exclusively in remote and isolated areas that are not connected to the central distribution grids of Europe. Moreover, large and small-scale renewable energy technologies have not benefitted from effective national support mechanisms and subsidies. The main measure of promoting further energy efficiency has been made through directives which have only benefited the deployment of some few technologies.

Innovation: Moderate Innovation Capacity

The innovation capacity of Europe in creating high valued products and services has been moderated relative to Asia, which now is the leader of high-tech R&D. At the same time, improved conditions in Europe for manufacturing and primary industries have materialized in incentives to large companies to deploy heavy manufacturing industries.

Economic Development: Major Growth by the Primary and Manufacturing Industry

The outcomes of increased competition from Asia have been mainly losses in the service and the high-tech industry in Europe. While the service industry is still dominating in the European economy, the primary and heavy manufactory industry has shown major grown relative to other sectors due to new favourable conditions. The slow down of the knowledge based industry resulted initially in unemployment and reduction in consumption but the emerging industries have progressively absorbed part of the unemployed population giving new force to the European economies.

Increasing transport costs have opened the opportunities for locally based industries to recover European markets as local production become more profitable. Manufacturing industries have also been benefited by the large availability of nuclear energy generated especially during 2020's. Not withstanding this, production costs have been notably reduced through automation of industrial processes.

High prices on raw materials have paved the way for the expansion of the recycling industry, which now collects various solid materials; mainly metals, but also organic waste that can be converted into heat and fertilizers. The recycling industry has therefore become one of the main providers of raw materials for manufacturing industries. Moreover, industries are now organized in compact industrial complexes in order allow the exchange of waste materials and reduce transport costs. The agricultural sector has also witnessed growth due to higher demand of locally produced food crops as well as improvement of agricultural practices which now are performed by mainly big farming companies.

Settlement Patterns: Urban Growth

Immigration and economic growth has continued to be concentrated in urban areas where most working opportunities are found. Urban regions have benefited from continued investments in infrastructure and services, including the electrical power supply. Most of the industries are concentrated in compact complexes located in peri-urban areas or neighbouring regions. Increasing population densities coupled with industrial concentration in urban regions has put pressure on land and water resources. Housing prices have risen in attractive areas, while other areas have witnessed a reduction in quality of life and increasing public expenditure on social aid. Also signs of poverty are tangible in large cities caused by the slowdown of the economy and increased costs of basic products.

Few rural regions rich in natural resources, especially those with good access to large cities have witnessed economic growth. Here the population is concentrated in compact settlements where investments have been made to deploy and improve public and private services. Industrial and agriculture activities are however performed exclusively by large multinational specialized companies. Conversely, remote and isolated regions lacking natural resources have experienced sever depopulation;

caused not only by the lack of economic activities but also by the lack of investments in local electric power supply. Other regions phasing similar problems are insular regions depending on the tourism industries.

Due to the fact that nuclear waste has accumulated quickly during the last ten years, inter-regional disputes on which regions should carry the burden of processing and storing nuclear waste have become tenuous.

Transport: Emphasis on both Public and Private Car Transport

As a result of the high price of oil, progressive efforts are made to electrify transport systems, especially in urban areas. However, the balance between public and private car transport from the 2010's has been maintained as developments in public transportation are still insufficient. High speed trains connect main urban nodes in Europe while trams and subways are predominant in the urban core of major cities. Also, a rapid transition towards hybrid and electric cars has taken place which is dominant in peri-urban and rural areas where the availability of public transport is limited. However, users who cannot afford to buy new cars and lack access to public transport have been seriously affected by high fuel costs generated by the use of old cars.

The freight and air transport will continue to be heavily dependant of fossil fuels and face therefore important problems. The freight transport had made important improvements in logistics while railways have become a more common transport mode. Most affected has been airline industry despite it has become significantly more efficient. The incapacity to absorb increasing fuel costs and reduced buying power by citizens has resulted in important reduction of passengers. This has had a profound repercussion in the tourism industry in remote and insular areas. On the contrary, tourism industry is now based in areas close to urban settlements.

C.3.6.4. Scenario 4: Business as usual?

Energy Mix: Emphasis on Fossil Fuels, mainly Coal and Natural Gas, Moderate Increase in Renewables, Decrease in Nuclear Power

In this scenario, only a moderate transition to renewable energy sources has taken place. Energy systems are dominated by centralised solutions and coal use for electricity generation has increased. Central Asian, Russian and Arctic gas deposits have become increasingly important for Europe's energy supply. This has meant major capital investments in natural gas pipelines and storage. The construction and operating costs associated with nuclear power, the public concerns about waste storage, insecure uranium supply, and security concerns have all contributed to the phase-out of nuclear energy programmes.

Large scale gas and coal are dominant, even though awareness over diminishing supplies is mounting. Multi-national energy corporations now dominate the energy sector more than ever, despite protectionist schemes of several European countries. The market power gained by large energy producers has limited the number of actors able to invest in energy production and the effective lobbying of energy corporations has strangled the market for small-scale energy alternatives.

International Agreements on GHG Emissions: Weakly Enforced International Agreements on GHG Emissions

Efforts to reduce GHG emissions have been hindered by the lack of political commitment from the USA and China, which has negatively affected Europe's willingness to cooperate internationally. This has made other countries hesitant to make large concessions during periods of economic stagnation or recession. Accordingly, precedence to protect local jobs over climate control is the common trend. The absence of international agreements on GHG emission, high energy prices and the prolonged economic crisis, has also resulted in the removal of the EU-ETS.

Energy Demand: Low Decoupling between Economic Growth and Energy Demand

Improved energy efficiency was achieved mainly during early 2010's, but further improvements have not been persistent. The loss of political will to combat climate change, along with a lack of investment capital for retrofitting industries, houses and the transport system has resulted in marginal efficiency gains. Overall, energy consumption has decreased as a consequence of a reduction of GDP since the national economies cannot sustain the burden of high energy costs and their negative impact on private consumption.

Technology Availability: Clean Energy Technologies Available only to a few Producers and Consumers.

Stagnant economic conditions have also hampered the development of affordable clean energy technologies. Consequently, technologies on the market are expensive, implying that economies of scale have not been achieved. The general lack of capital has also resulted in very slow retro-fitting of existing building stock, and there is relatively little new construction due to the prolonged economic downturn. The subsidies that some countries have created to encourage investment in retrofitting and energy efficient buildings have been unsuccessful, primarily because they did not provide secure, long term subsidies. The lack of capital and political emphasis on infrastructure for energy generation has also resulted in the absence of efficient energy production systems. As such, no new district heating systems have been built since mid 2010's.

Renewable energy feed-in tariffs applied by several European countries for generating residential energy production have simply not caught on as public trust in these long term investments has been minimal. Now only a few big actors with venture capital are investing in high-tech solutions as attempts to build cooperative schemes have failed. Large scale solutions on renewables are also hampered by the "not in my backyard" attitude of the public.

Innovation: Low Innovation Capacity

Once the centre of knowledge economy, Europe has become a net importer of technology. The stagnation of GDP growth has been mirrored by a lack of investment in R&D. European scientists are now moving to China, India and Brazil, where income possibilities are better. Smaller companies that closed after the economic crisis in 2008 never reopened and their workforces went into unemployment rather than contributing their tacit knowledge to new opportunities for growth. Now, very few companies can afford to invest in research and development, and public stimulation schemes are few and under-utilised. The education sector has received minimal investment, and students are scoring poorly on international comparative tests. Universities cannot attract top students and a downward spiral in quality is becoming increasingly apparent. The regions of Europe, in their protectionist stance, have failed to pool resources and to learn from one another.

Economic Development: Negative Growth by all Sectors

A pervasive, structural economic problem – rooted in dependency on costly energy – has hindered any economic growth potential of Europe. Consequently, there has been no significant economic restructuring in terms of diversifying the economic base of Europe. Industrial production has also been hampered by outdated infrastructure and high prices for scarce raw materials. Decreasing buying power and the lack of investments has resulted in the stagnation of the private and public sectors. In combination with unfavourable framework conditions this situation has resulted in start-ups enterprises failing at a high rate.

Income and price levels are de-coupled; some consumer goods are cheaper due to lack of demand, but food and other transported goods are expensive due to higher transport and production costs. The "buy local" movement from the early years of the century has truly taken hold, but now the motivation is based on protectionism rather than environmentalism. The only blossoming business ventures are based the second-hand market, as more people choose cheap used options rather than the high prices of new goods. Incomes have stagnated and governments have to address the issues of public dissatisfaction and unrest rather than have a proactive stance toward development. Lack of tax revenue for social support contributes to this unease. Protectionism is also apparent in immigration policies which have become increasingly restrictive.

Settlement Patterns: Urban Growth

The rural exodus that once characterised outlying areas of Europe has become a general phenomenon. The protectionist stance is also apparent in the attitudes of cities and regions. Cooperation is weak and competition is strong. In spite of the decline in the quality of urban life due to unrest, poverty, crime and homelessness, the urban areas represent the only labour opportunities now available for individuals; and therefore, are still growing. This phenomenon has been strengthened by the lack of services, social areas in rural regions as well as higher transport costs caused by the oil prices and the lack of alternative modes of transportation. Moreover, the elderly and poor population is suffering of heat and cold waves because they cannot afford the costs cooling and heating systems.

Urban planning has stagnated, and the response to growing populations is inadequate. There are some attempts to retro-fit the cities, but new building is not keeping pace, so crowding and sprawl to the immediate environs are apparent. Some spots of wealth and innovation do exist, but these are not integrated into the urban fabric, but instead are outposts of international companies. The hardest hit is on the tourist-dependent regions far from major population centres. These simply cannot compete for the fewer tourists that still have the money to travel, while mass-tourist traffic decreases each year. The only rural areas that are doing well are those with recreational amenities that are quite near large population centres, as short distance vacations replace international trips.

Transport: Emphasis on Private Cars

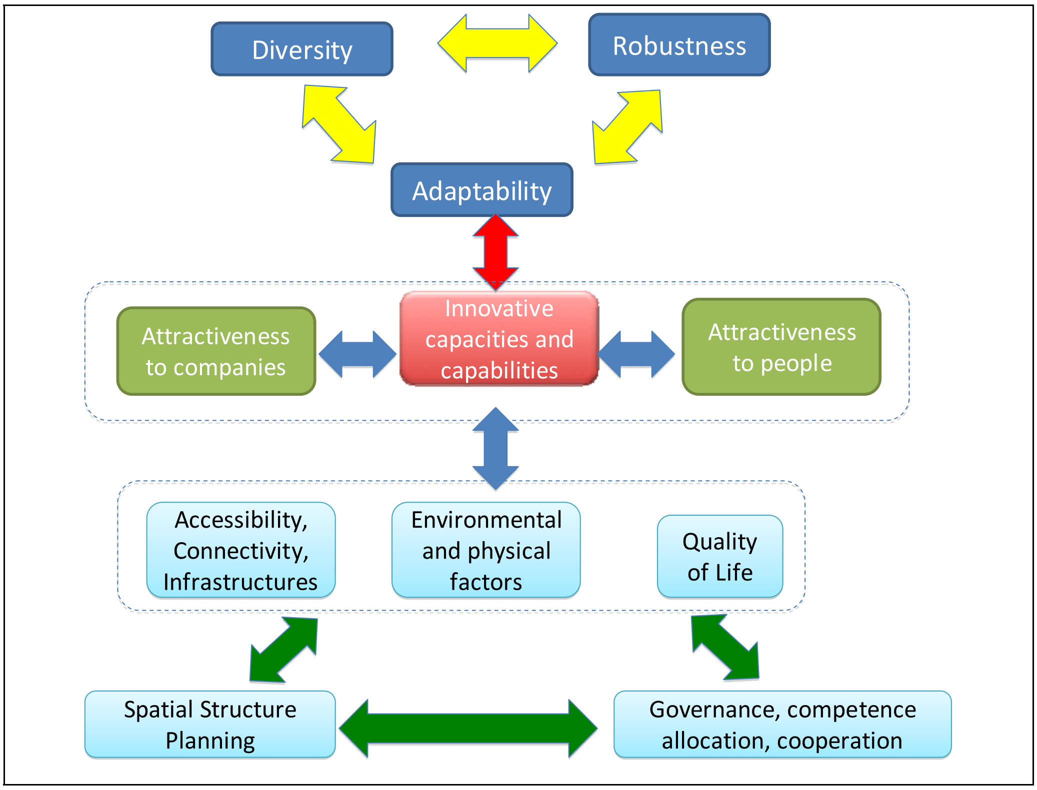
A lack of investment in good, competitive public transportation options has resulted in increased use of cars in proportion to the public transport. The concentration of cars and trucks, combined with urban growth, has therefore resulted in more cities having to deal with the "all-day rush hour" – with traffic jams, slow-downs and pollution increase as the new norm. Economic stagnation has also meant that the car-stock is becoming older. Even though high fuel costs offset initial cost of hybrid cars the general population cannot afford the initial investment; therefore making hybrids a viable option only for the rich. The shift to electric cars that seemed to be in the offing some years ago has not materialised due poor investments in infrastructure that might have stimulated their adoption. The combination of high prices on transport fuels and the saturation of the public transport in urban areas have however resulted in the substantial use of bicycles as a mode of transportation.

Annexes to Scenario Report and Agency Analysis

Annex I. Definition of Drivers of Regional Competitiveness

Below are the more detailed definitions of drivers of regional competitiveness and energy development from Workshop I.

Figure 14 Drivers of Regional Competitiveness



Drivers of Regional Competitiveness

Regional competitiveness can be defined as *"a range of factors from measures of income and prosperity to economic creativity and innovative ability that describe the performance of one economy relative to others".* Furthermore, regional competitiveness can also be defined from two different perspectives:

- Short term competitiveness: is the capacity of a region to maintain a high level of economic performance in a short term perspective (in a 5 to 15 years perspective);
- Long term competitiveness: is the capacity of a region to maintain a high level of economic performance in a long term perspective (in a 15 to 25 years perspective). Long term competitiveness chiefly relies on the adaptive capacity of a region, which in turn is dependant on economic robustness, but also the diversity of the regional economy.

Innovative Capacity

Innovative capacity was defined as "the capacity of generating new ideas". The innovative capacity of a region reduces economic vulnerability because it diversifies economic structures by fostering the creation of new industries and products. The capacity to create new ideas is determined by three factors; the openness of the society towards new thinking, the knowledge capital, and the accessibility to this knowledge.

Knowledge accessibility is comprised of the availability and quality of the education system needed to transfer knowledge to new generations, bring in new sources of knowledge and to foster new ideas through R&D. In order to allow these factors to adequately materialise social, physical and financial infrastructures are needed. Moreover, regional densities of scale are an important factor for innovation because it helps to promote a collective commitment among individuals on attaining competitiveness.

The networking capacity is also an important factor for achieving and maintaining innovation capacity. It allows for the exchange of information and experiences necessary for both the creation of new services and technologies and the formation of trans-boundary cooperation between regions, and the firms and research institutes within them. The accessibility to a qualified labour force also plays a central role in the short and long term. In this regard, education not only serves to build the social capital of a region by forming young professionals, but also attracts both students and professionals from other regions. The access of financial resources is also important because it provides the bases for public and private investments on R&D, education and entrepreneurship.

Attractiveness

Aspects of attractiveness are closely linked to the innovative capacity of regions, which fundamentally relies on good living conditions and highly-developed business environments to attract and retain skilled workers and high-tech firms to the region. As the core driver for innovation, skilled labourers seek good living conditions, and more specifically, good quality of life, which are inevitably determined by cultural perceptions of achieving lifestyle ideals and opportunities for individuals to develop. The most commonly cited factors determining quality of life are: efficient and affordable internal and external transport, accessibility to the social, natural and built environment, accessibility of health services and affordable and available housing.

Robustness of Regional Economy

Economic robustness is "*the ability of a region to withstand fluctuations in the markets".* Economic robustness is generally determined by the presence of territorial capital, namely economic, social and resource capital, as well as diversity in the region's economic structure. The ability of regions to attract companies and labour force is also closely dependent on the region's economic robustness, and therefore these two factors are closely interrelated. In the long term, especially during market changes, the innovative capacity becomes central as it generates flexibility in the regional economies through generation of new industries and services. Here, energy is seen as a resource that serves the region's economy.

Governance

In order to promote and sustain the innovative capacity of a region all factors should be embedded within political stability and good governance. This is performed by well-functioning authorities through the creation of proper policy frameworks for innovation and entrepreneurship. Thus, governance puts forward the framework conditions and the directions in which the internal and external factors of competitiveness may interact proactively.

Spatial Characteristics

Spatial factors are of two kinds; environmental and physical. Environmental factors correspond to the quality of the environment; specifically, the availability of basic resources for living, such as clean air and water, food and land, as well for performing economic activities. Physical factors pertain to the nature of the residential, transport and communication infrastructure, as well as infrastructure for energy and water distribution. Not least, spatial factors are also internal factors of competitiveness as explained above.

Internal and External Markets

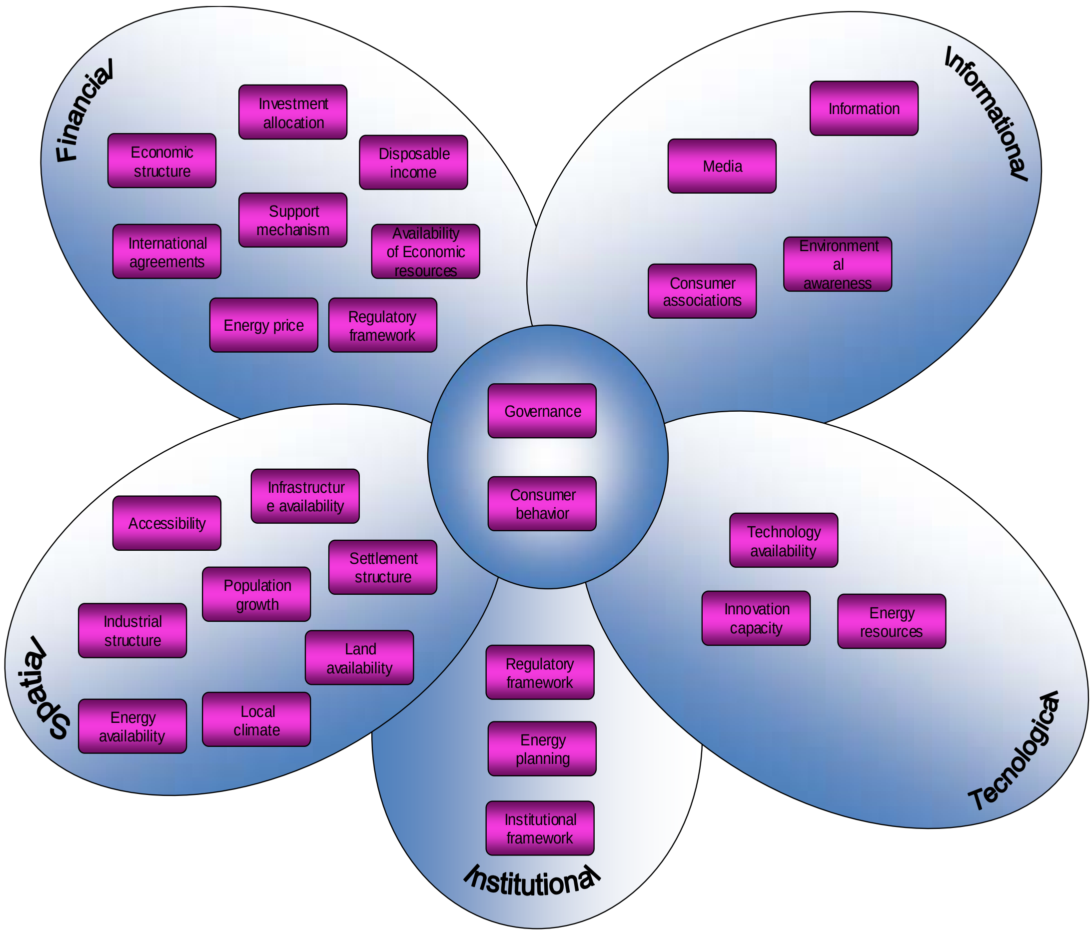
Competitiveness is defined by the balance between internal and external trade in regions; namely, the balance between import and export of tangible and intangible resources between regions. Tangible resource flows are goods and intangible resources flows are represented by knowledge and services. More specifically, regions' competitiveness is influenced to by three key market elements; "where" the served markets are located, "what" is the nature of the products and services offered by a region, and "how" these offers are presented (e.g. through marketing) and delivered to the markets. As markets are formed by consumers, the acceptance of new products and services will be determined by consumer openness towards new products and the availability of those produces. Generally, this availability hinges not only on the physical presence of these products in the market, but equally decisive are price factors - the economic capacity of consumers to pay for a particular product or service - and qualitative factors such as ideologies, life styles and behaviour.

Drivers of Energy Development

Energy development can be defined as "*the endeavour to provide sufficient primary energy sources and secondary energy forms to fulfil societies' needs. It involves both deployment of already available energy technologies as well as research, development and deployment of new technologies*".

Traditionally, considerations in energy development include security of supply, energy efficiency, natural resource management and environmental impact. As illustrated, however, the results from workshop I illustrate that energy development comprises a large number of elements that can be grouped into clustered loops that are mutually dependant on each other. These clustered loops are institutional, financial, spatial, informational and technological. Moreover, two elements are intimately related to each of the loops: governance and consumer behaviour.

Figure 15 Clustering of Drivers in Scenario Exercise



The Institutional Loop

Institutions can be governmental, non-governmental and commercial institutions. Furthermore, these institutions can be centralised or decentralised; an important factor in terms of energy development, especially regarding policy orientations and energy development decisions in regions. Regulatory frameworks comprise of the legislations that regulate production, transmission and consumption of energy, and assigns governing powers to authorities in the energy sector. The regulatory framework also steers the exploitation of energy sources and sets limits through, for example, building restrictions, caps on GHG emissions, etc. Energy planning sets the directions for the development of the energy sector and serves the interests of national, regional and local actors depending on the institutional framework for energy planning.

The Financial Loop

While energy production and transmission is an essential element in industrial production and quality of life, they implicitly involve the availability of economic resources for investment. The manner in which these investments are made is a central issue in energy development. The significant elements in this regard are:

- Market price for energy: is an important factor influencing the investment choices of energy consumers, and therefore it plays an important role in determining which energy sources are exploited. Moreover, the prices traditional energy sources act as drivers for the exploitation of new alternative energy sources.
- Profitability: on one hand, it determines the choice of energy source exploitation for producers, while, on the other hand, it determines whether or not new sources of energy will need financial support.
- Availability of economic resources: has a direct impact on investments in new technologies as well as the allocation of investments. For instance, in research and development for alternative sources of energy and infrastructure deployment.
- Disposable income: determines the price that consumers are willing to pay for energy.
- Financial system: is determined by the legal and policy frameworks for the finance sector.
- Support mechanisms: are widely used by governments as market based instruments to subsidise renewable electricity. Support schemes are of two categories; investment and operating support mechanisms. Operating support (support per unit of electricity produced) promotes the generation of renewable energy, while investment support plays a more determinant role during de development stage and market introduction of renewables as considerable market uncertainties prevail.
- International Agreements on GHG emissions: are of high importance since they create commitment towards common goals on caps for emissions and help to internalize the externalities of energy production from fossil fuels. These agreements are tied to emissions trading schemes, which is an administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. A cap trading system is a quantity instrument because it fixes the overall emission level (quantity) and allows the price to vary.

The Spatial Loop

Settlement structures affect energy consumption patterns due to several factors; for instance, the location of jobs and dwellings, as well as commercial and recreation areas. In this regard, two elements are particularly important:

- The distribution of living and working places: regards the distances between living and working areas (the distance, ICT and transport mode), as well as the aspect of time for transportation and commercial activities associated with everyday life (the spatial arrangement of cities and regions).
- Accessibility to commercial and living areas plays an important role in energy demand, specifically through the availability of infrastructure and technologies that enable energy efficient modes of transportation both for passenger and goods transport. The availability of, and accessibility to, infrastructure define peoples' transport patterns to-and-from work despite the availability of different working arrangements today.

The size of the population also affects total energy demand since each individual requires energy for living. At the same time, reduced per capita energy consumption can be achieved through greater population densities because of the denser living arrangements and increased transportation opportunities they infer.

Economic Structure shapes the energy mix and intensity of a region mainly in the short term. Regions with heavy industries will consume more energy relative to regions with high proportions of the economic mix dominated by the service sector.

The accessibility to energy is critically important because energy independent regions have little pressure to go through structural changes in the economy due to pressures in terms of energy production, consumption or provision. Further, accessibility to energy can be centralised or decentralised. In centralised energy systems settlements and industries will rely on long distance transmission infrastructure for electricity and gas, while decentralised energy systems provide locally produced energy that is transmitted over short distances. Thus, centralised solutions may fit well in areas lacking energy resources while areas rich in energy resources are able to generate energy in situ. Furthermore, land availability plays a fundamental role for the use of renewables. For wind energy for example, vast areas exposed to suitable wind conditions are needed and the conflict between landscape conservation and wind energy development is well established.

Local climates also play a significant role in the ways energy is consumed and generated. Seasonal cold and heat periods, and extreme weather events increase energy demand in order to maintain comfortable temperatures of homes and workplaces.

The Technological Loop

The nature of technology availability is delineated between domestic technology developed through innovation, and imported technology. Access to technological solutions not only helps facilitate the shift towards the utilization of alternative energy sources, but it also makes these sources competitive in markets. An important characteristic of technologies is that they are tied to the availability of endogenous energy resources. The Innovation Capacity is a central driver in energy development as it serves the energy sector through the creation and development of technologies on energy efficiency and renewables. Specifically, regions exposed to fluctuations in energy markets due the lack of domestic energy sources can find ways to reduce their dependency though the creation of innovative solutions on energy production and efficiency. Also, innovation enable energy-rich regions to be able to further this by exporting excess energy created by a reduced internal demand and increased energy production from alternative energy sources.

The Informational Loop

Environmental awareness is part of the culture, but also it can be inculcated through information and education programmes. In this regard information influences consumer's habits by creating awareness on the benefits or negative consequences of the irrational use of energy, as well as the use of unsustainable energy sources. The media works as the link between information sources and energy consumers, and it determines how consumers perceive the information. Consumer associations have also proven to promote environmental awareness among both the general public and government institutions.

Governance and Consumer Behaviour

Governance relates directly to all the loops by setting the institutional, policy, legal and planning framework for energy production, transmission and consumption, as well as for regional development. The governance style has a direct impact on the Institutional Loop, especially in terms of the regulatory framework and the structure of energy prices (consumer prices, production prices and energy price mechanisms). Therefore, the Governance Loop reflects the particular actions and their respective actors that are embedded within the overall governance style of energy development. Not least, governance styles have a fundamental role in setting up taxation and trade schemes, reaching international agreements, allocating investments and promoting the future development of the economy. Consumer behaviour is crucial for supporting a transition in energy development. Consumers are able to reduce their energy consumption to a large extent through behavioural changes on energy use as well as through their purchase by selecting energy efficient technologies for households and transport. As explained in the Informational Loop section, consumer behaviour tied to cultures and dependant on the level of awareness not only on the negative effects of excessive energy consumption or the use of fossil fuels, but also on how to apply these technologies and consume less energy through behavioural changes.

Annex II: Results from the Survey of Regional Energy Agencies

The preliminary aim of the questionnaire was to get an understanding of the distribution of perceived and actual responsibility of energy management between different levels of governments. Both issues are crucial in order to understand details of the dynamics of changes to the energy structure. The question of actual responsibility enables the identification of the governmental level that is permitted and obliged to make decisions and take action in relation to changes to the energy structure. In contrast, the question of perceived responsibility identifies potential bottlenecks in relation to potential changes. The tables indicated in this section are available in Annex 2 of this part of the Scientific Report.

Policy Measures in Relation to the 3 Pillars of Energy Policy

The first set of questions were directed towards the division of labour between national and regional energy policies in order to see to what extent differences in policy measures may apply generally, and if there are sub-national variances amongst different regions. The focus is on the 3 pillars of energy policy - security of supply, energy efficiency, and environmental protection - and the level of authority is indicated through values from 0 - indicating no emphasis, to 5 - indicating highest emphasis. As shown in table 24 (1a), the state is perceived as being the government level that places the most emphasis on security of supply (avg. 4.1) while the level of responsibility is considered lower in relation to energy efficiency (avg.3.5) and environmental protection (avg. 3.1). Further, the role of the national policies in relation to security of supply and energy efficiency are much more concentrated in levels 4 and 5, while environmental protection is much more diverse with a fairly evenly spread of values between 2, 3 and 4.

Table 24 National and Regional Energy Policy Objectives

1a: Character of emphasis of your current NATIONAL energy policy in relation to the 3 pillars of energy policy?							
Response	0	1	2	3	4	5	**Response average**
Security of Supply	0%	4.88%	4.88%	12.20%	31.71%	46.34%	4.1
Efficiency	0%	7.32%	9.76%	19.51%	48.78%	14.63%	3.54
Environmental Protection	0%	0%	24.39%	26.83%	31.71%	17.07%	3.41
n = 41							
1b: Character of emphasis of your current REGIONAL energy policy in relation to the 3 pillars of energy policy?							
Response	0	1	2	3	4	5	**Response average**
Security of Supply	2.44%	4.88%	21.95%	12.20%	24.39%	34.15%	3.54
Efficiency	2.44%	2.44%	7.32%	21.95%	34.15%	31.71%	3.78
Environmental Protection	0%	2.44%	19.51%	21.95%	31.71%	24.39%	3.56
n = 41							

While the state appears to emphasize security of supply, the regional responses are much more varied, as shown in table 24 (1b). In the case of security of supply close to 60% of respondents indicated a high emphasis (levels 4 or 5), while a relatively large group are at level 2 (22%). In relation to both energy efficiency and environmental protection, a majority of the regions emphasize relatively high values for the role of regional policies. At the same time, the character of emphasis of regional policies appears to favour energy efficiency concerns (avg. 3.78) relative to environmental protection (avg. 3.56) and security of supply (avg. 3.54).

Prioritized Energy Sources

The responses to the previous questions indicate a marked division of labour between the national and the regional energy policy level. This division is made even clearer when it comes to prioritizing energy sources in national and regional energy policies, as shown in table 25 (2a and 2b) With percentages ranging from 37% emphasizing Nuclear and 39% emphasizing Coal, to 54% emphasizing Natural Gas and Renewable Energy, national energy policies are clearly identified as treating each energy source with relative importance. Comparatively, the regional involvement is much more concentrated on the Renewable Energy (66%) and Natural Gas (41%) relative to Coal (24%) and Nuclear (10%). In all likelihood this is strongly connected to the previous table showing the national policy with focus on strategic resources in order to generate energy security, while the regional focus is much more on questions in relation to energy savings and environmental issues.

Table 25 Prioritized Energy Sources on National and Regional Level

Response percent	**2a: What energy sources are prioritized in your NATIONAL energy policy?**	**2b: What energy sources are prioritized in your REGIONAL energy policy?**
Energy type	Percent	Percent
Nuclear	37%	10%
Coal	39%	24%
Natural Gas	54%	41%
Renewable Energy	54%	66%
Other, please specify	17%	22%
n = 41		

Drivers of Renewable Energy and Energy Efficiency

The importance of regional perspectives in relation to environmental protection become even more clear in table 26 where this response gets the second highest score. Furthermore, energy price and security of supply score much lower as drivers in relation to the development of renewable energy and energy efficiency. What it most surprising, however, is the highest ranking given to international commitments, indicating that international agreements and international relations are the main drivers behind both renewable energy deployment and energy efficiency at the regional level. This connection is quite interesting and should be looked further into in relation to this question in the scenario building.

Table 26 Drivers of Renewable Energy Development and Energy Efficiency in the Regions

3: What drives Renewable Energy and Energy Efficiency development in your REGION?	
	Ranking Average
Security of Supply/Energy Self-Sufficiency	2.02
Environmental Protection	2.66
International Commitments	2.98
Energy Price	2.34

n = 41	

Energy Policy Development

As shown by table 27, while state institutions have been identified as the determining level in relation to national energy policies in the previous questions, the state is also identified as being crucial in relation to the development and governance of energy policy at the regional scale. While some kind of regional authority seems to have been delegated to the region, 68% of respondents still perceive energy policy development and governance as being a national obligation, which may be considered surprisingly high. In this respect, regional autonomy in terms of energy policy seems to be relatively limited in 2/3 of the regions. The regions in this group are, to a relatively large extent, representatives of situations where strategic energy planning seems to be dominating, while the other group representing 1/3 of the regions are dominated by regions where the renewable resources have been developed more than average.

Table 27 Distribution of Competences in Energy Policy

4: What level of government has the main role in developing and governing energy policy in your region?	
	Percent
The national level	68.00%
The regional level	32.00%
n = 41	

Table 28 Standard-setting by Regions

5: Are REGIONAL governments able to implement binding policies beyond standards set at the national level?	
	Percent
Yes	41%
No	44%
Don´t know	15%
n = 41	

Based on the previous response in table 28, the result of question 5 on the ability of regional governments to implement binding policies beyond standards set at the national level is quite surprising. While the state is considered to be in charge of the energy policy development by 2/3 of the regions, 41% of them are still able to implement binding policies beyond the standards set at the national level. This puts the question above regarding regional autonomy in relation to energy development issues in another perspective, and accordingly, should be scrutinized further. Another question in relation to policy development has to do with responsibilities for communicating information and the development of awareness in relation to energy efficiency (i.e. turning policies into practical action). As options for the responses, the following sectors are highlighted: The industrial sector, the energy sector, the transportation sector; and the residential sector.

Table 29 shows the results and indicates several interesting patterns. A clear result is the fact that the national governments have an overarching role in relation to all sectors – generally from around 1/2 to 2/3 of the cases - while local governments have minimal roles outside the residential sector (which includes general concern regarding the consumption patterns among the population). It is quite obvious that the role of the local governments in almost all the municipalities is limited to this sector. The only exception is a slightly higher involvement in the transportation sector, compared to the industrial and the energy sectors. In contrast, regional governments are indicated to be responsible in approximately 1/3 of the regions, and as already mentioned, the involvement of the regions seem to be closely connected to regions with a high emphasis on renewable energy development relative to traditional strategic resources. Delegation of responsibility is in this connection is clearly related to the overall policy goals defined at the state level.

Table 29 Distribution of Competences for Awareness-raising

6: In your REGION, which levels of governing institutions are primarily responsible for the dissemination of information and awareness in energy efficiency?			
Sectors	Local government	Regional government	National government
In the Industrial Sector	4.88%	31.71%	63.41%
In the Energy Sector	4.88%	21.95%	73.17%
In the Transportation Sector	7.32%	21.95%	70.73%
In the Residential Sector including the consumption patterns among the general population	29.27%	24.39%	46.34%
n = 41			

Table 30 Effectiveness of Regional Policies for Awareness-raising

7: In your opinion, are the governing institutions in your REGION doing an effective job in spreading energy efficiency awareness to the populace?	
Response	Percent
Yes	29%
No	22%
Only in some sectors	49%
Don't know	0%
n = 41	

The question regarding the quality of dissemination of energy efficiency awareness to the population is outlined in table 30. Only a limited number of regions consider the present spread of information to be sufficient, while the majority - 49% - considers current dissemination levels to be acceptable only in some sectors, and 22% consider it to be generally inadequate. When looking into details regarding which regions are satisfied with the dissemination level there seems to be connection to the regions where this responsibility has been delegated to regional authorities. In this way, there seems to be a close connection between regional responsibility and regional energy efficiency in this respect. While the question of responsibility in relation energy policy has already been determined as a national responsibility in question 1a and 1b, the actual inclusion of this aspect in the energy policies are reflected in table 31 (8a). The inclusion of this policy at the national level is quite obvious with a score of 4.32 out of 5. Surprisingly, however, the inclusion of the security of supply aspect at the regional level is also quite clear, as almost 60% of the regions have emphasised this with a score at least 4 out of 5. With that said, there are still regions where this aspect is more or less absent.

As an addendum to the security of supply perspective in table 31 (8a), the role of renewable energy solutions - and especially the question of decentralised compared to centralised solutions - has been put forward in table 31 (8b). While none of the regions consider decentralised energy solutions as insignificant, only 14% consider it as a top-priority (level 5) and only 41% have it as priority 4 or 5. The key perspective in this connection, however, is the question of centralised versus decentralised solutions. Even though one can think of renewable energy solutions in relation to small scale and decentralised conditions, most regions view the development of these renewables in connection to centralised decisions. Therefore, the answer appears to be more or less the recognition of the status quo.

Table 31 Importance of Security of Supply

8a: How is security of supply for the future considered in your current energy policies?						
Response	1	2	3	4	5	Average
At the national level	2.44%	2.44%	7.32%	36.59%	51.22%	4.32
At the regional level	10.26%	7.69%	23.08%	30.77%	28.21%	3.59
n = 41						

8b: How important are decentralised energy solutions compared to centralised renewable solutions?						
Response	1	2	3	4	5	Average
Relative Importance	0%	24.39%	34.15%	26.83%	14.63%	3.32
n = 41						

Renewable Energy Development

Only 17% of the regions state that investments in non-renewable energy resources are prioritized over investments in renewable energy technology (table 32 - 9a). This clearly shows that renewables are emphasised as a priority for most regions. When comparing the types of regions represented in this connection it is quite clear that combinations of all types of renewables exist, and there are vast differences in the level of involvement depending on the type of renewable resource is exploited as the top priority. Similarly, table 32 (9b) shows that three out of four regions have established operating support instruments to help the development of renewable energy technologies. This distribution shows that the regions providing these instruments utilise many combinations of renewable and non-renewable energy systems in parallel. Consequently, the main energy systems chosen by governments are not shown, in general, to influence the option of looking for renewable alternatives.

Table 32 Support to Renewable Energy Sources in Regions

9a: Investments in non-renewable energies are prioritized over investments in renewable energy technology		**9b: In your REGION, do effective operating support instruments exist to help grow renewable energy technologies?**	
Response	Percent	Response	Percent
Yes	17%	Yes	76%
No	83%	No	24%
n = 41		n = 41	

Economics of Energy Sources

Two questions have specifically focussed on the relationship between economic development and access to energy resources. The first, table 33, relates to the linkage between energy consumption and economic growth. Here, 51% of the respondents consider economic growth in their region as dependant on energy intensive sectors. Furthermore, it is interesting to note that 22% of the respondents are either undecided or unaware of the nature or extent of the linkage between these two variables. Both findings indicate that the process of de-coupling economic growth from energy consumption should be considered a major issue.

Table 33 Economic Growth and Energy Intensive Sectors

10: Is economic growth tied to energy intensive sectors	
Response	Percent
Yes	51%
No	27%
Don't know	22%
n = 41	

As a consequence of the previous question, table 34 looks into the potential impact of higher energy prices on consumer decisions and energy demand. Three levels of future oil prices have been suggested: USD$100, $150, and $200 per barrel. In the first case only 12% view the price level as having serious and/or very serious impact on consumer decisions and energy demand, and in the second case only 20% consider a price of $150 as having very serious impact. However, almost 70% of the regions consider an oil price of $200 per barrel to be very impactful, while less than 10% consider it to be of limited or moderate importance. Accordingly, there is a close connection between the choice of basic energy system and oil price development, where the regions with high emphasis on renewable and other alternative energy resources are those least worried about substantial increases in energy prices. Also, most of the regions believe the effects of such price increases will provide a strong impetus for change in specific sectors of the economy.

Table 34 Expected Impacts of Higher Energy Prices

11: What impact would a higher energy price have on consumer decisions/energy demand in your region?						
Total Response	1	2	3	4	5	Average
USD$100 per barrel of oil	14.63%	34.15%	39.02%	4.88%	7.32%	2.56
USD$150 per barrel of oil	0%	12.20%	29.27%	39.02%	19.51%	3.66
USD$200 per barrel of oil	0%	4.88%	4.88%	21.95%	68.29%	4.54
n = 41						

Development Perspectives

In relation to the question of reacting to changes to energy prices it is quite clear in table 35 (12a) that the effect on the residential sector and consumer choices is predominant. With a score of 2.76 it appears that residential sector expectations towards energy efficiency are greater than each of the other sectors (energy sector: 2.56, transport sector: 2.44, industrial sector: 2.24). In sum, there seems to be a relatively close relationship between two components in this connection. First, the issue of relatively high adaptability of private/individual consumption versus the relatively low adaptability of public/business relations is reflected in the energy consumption pattern; which likely affects the abilities and complexities of adjusting to consumption pattern changes. Second, the practical experiences with policy development in the regions seem to indicate that it is easier to develop and implement policies targeting the individual consumers relative to those targeting the public and business sectors.

Table 35 Opportunities and Challenges of Economic Sectors

	12a: Which sector would the previously mentioned price increases have the greatest impact on reducing energy consumption?	12b: Which of the following sectors provides the greatest energy saving POTENTIAL in your region?	12c: Which of the following sectors provides the greatest OPPORTUNITY for energy saving in your region?	12d: Which of the following sectors provides the greatest CHALLENGES for energy saving in your region?
Sector	**Ranking average**	**Percent**	**Percent**	**Percent**
The industrial sector	2.24	20%	17%	10%
The energy sector	2.56	7%	10%	12%
The transportation sector	2.44	27%	10%	41%
The residential sector including general lifestyle changes	2.76	41%	59%	34%
Other		5%	5%	2%
n = 41				

In relation to the previous, the role of the residential sector and lifestyle perspectives is also identified as the sector with the greatest potential for energy savings. Here, 41% of the regions emphasize this sector as having the highest savings potential, while the transport sector is the closest follower at 27%, followed by the industrial sector at 20% of the regions. Lastly, the expectations of the energy sector are viewed as having the greatest savings potential by only 7% of the regions. In relation to energy savings opportunity, the residential sector is again the clear leader with 59% of the regions viewing it as having the most straightforward path to higher energy efficiency. However, what is somewhat surprising is that the industrial sector is ranked second at 17% while the energy and transportation sectors are valued equally at 10%. In terms of challenges 41% of respondents view the transportation sector as providing the greatest obstacle for regional energy savings. This is an important indication of the recognized need for changes to transportation systems and the realization of the need for more efforts directed towards developing efficient transport solutions. Most interesting however, closely following transport, is the residential sector where 34% of the respondents emphasised challenges related to it. This is most interesting because it seems as inherently inconsistent that the sector with the greatest energy saving potential and opportunity is also the same sector with the most challenges. Accordingly, this discussion is taken up in the Agency analysis within the main text.

Information Availability

Due to the nature of the ReRisk project the question of access to relevant information regarding energy consumption has been an important issue. Accordingly, this is addressed in table 36. In Contrast to our own experiences in accessing energy consumption data, 61% of the respondents emphasize that this type of statistical information are currently gathered, while 29% indicate that it is not, and 10% do not know whether they keep this type of data. In relation to future planning of energy dependent relations at the regional level it is crucial to stress that while access to this type of detailed information is already of great importance, it will be even more crucial in the future.

Table 36 Regional Statistics on Energy Consumption

13: To account for energy demand, are detailed statistics of energy consumption collected for all sectors in your REGION?	
Response	Percent
Yes	61%
No	29%
Don´t know	10%
n = 41	

Annex 3: Respondents to Survey of Regional Energy Agencies and Questionnaire

Response	Country	Region
1	Finland	Central Finland
2	Poland	Podkarpackie
3	Cyprus	Cyprus
4	Latvia	Zemgale
5	Spain	Basque Country
6	Netherlands	South Holland
7	France	Rhône-Alpes
8	Slovenia	Savinjska, Šaleška and Koroška
9	United Kingdom	East of England
10	United Kingdom	South West
11	Poland	Podlaskie
12	Slovenija	Podravje
13	Germany	Schleswig-Holstein
14	Sweden	Jämtland County
15	Austria	Burgenland
16	Finland	Central Finland
17	Bulgaria	Energy Agensy of Plovdiv
18	Bulgaria	Nord East
19	Ireland	Cork
20	Denmark	Midtjylland Samsø
21	Czech Republic	Zlin region
22	Germany	Northern Bavaria
23	Germany	Freiburg
24	Luxembourg	Canton of Redange
25	Portugal	Center
26	Spain	Asturias
27	Sweden	Kronoberg, Blekinge and Kalmar
28	Sweden	Örebro
29	Romania	Central region, Harghita county
30	Belgium	Flanders
31	Ireland	Midlands, Laois, Offaly, Westmeath, Longford
32	Italy	Umbria
33	Italy	Abruzzo
34	Portugal	North Alentejo
35	Malta	Malta
36	Hungary	National
37	Greece	Crete
38	Austria	Yorarlberg
39	Scotland	Highlands and Islands
40	Greece	Central Macedonia
41	Spain	Madrid

Energy Agency Questionnaire to NUTS 2 Regional Energy Agencies

1. We would appreciate if you provide us with the following information to structure our analysis.

Country:

Region:

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2. What is the specific character of emphasis of your current NATIONAL energy policy in relation to the 3 pillars of energy policy? *

Rank the given options; where 0 = not an important consideration, and 5 = a prime consideration

	1	2	3	4	5
At the national level	○	○	○	○	○
At the regional level	○	○	○	○	○
At the local level	○	○	○	○	○

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3. What is the specific character of emphasis of your current REGIONAL energy policy in relation to the 3 pillars of energy policy?*

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4. What energy sources are prioritized in your NATIONAL energy policy? *

	1	2	3	4	5
At the national level	○	○	○	○	○
At the regional level	○	○	○	○	○
At the local level	○	○	○	○	○

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5. What is the specific character of emphasis of your current NATIONAL energy policy in relation to the 3 pillars of energy policy? *

Please rank the given options; where 0 = non-factor, and 5 = primary factor

	0	1	2	3	4	5
Security of Supply	○	○	○	○	○	○
Efficiency	○	○	○	○	○	○
Environmental Protection	○	○	○	○	○	○

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6. What is the specific character of emphasis of your current REGIONAL energy policy in relation to the 3 pillars of energy policy? *
Please rank the given options; where 0 = non-factor, and 5 = primary factor

	0	1	2	3	4	5
Security of Supply	○	○	○	○	○	○
Efficiency	○	○	○	○	○	○
Environmental Protection	○	○	○	○	○	○

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7. What energy sources are prioritized in your NATIONAL energy policy?*
You may select more than one if more than one source if it accounts for over 30% of your NATIONAL primary energy supply.

- ☐ Nuclear
- ☐ Coal
- ☐ Natural Gas
- ☐ Renewable Energy
- ☐ Other, please specify

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8. What energy sources are prioritized in your REGIONAL energy policy?*
You may select more than one if more than one source if it accounts for over 30% of your REGIONAL primary energy supply.

- ☐ Nuclear
- ☐ Coal
- ☐ Natural Gas
- ☐ Renewable Energy
- ☐ Other, please specify

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9. What drives Renewable Energy and Energy Efficiency development in your REGION?*
Rank the items below, using numeric values starting with 1.

- Security of Supply/Energy Self-Sufficiency
- Environmental Protection
- International Commitments
- Energy Price

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10. Are regional governments able to implement binding policies beyond standards set at the national level?*

- ◯ Yes
- ◯ No
- ◯ Other, please specify

11. When did your NATIONAL energy policy experience radical changes in terms of what energy sources are prioritized and what factors caused the changes?

12. When did your REGIONAL energy policy experience radical changes in terms of what energy sources are prioritized and what factors caused those changes?

13. What level of government has the main role in developing (and governing) energy policies in your REGION? *

- ◯ The national level
- ◯ The regional level

14. Are REGIONAL governments able to implement binding policies beyond standards set at the national level?*

- ◯ Yes
- ◯ No
- ◯ Don´t know

15. In your REGION, which level of governing institutions are primarily responsible for the dissemination of information and awareness in energy efficiency?*
In the following matrix, please identify which level of government is responsible for the sectors listed below.

	Local Governments	Regional Government	National Government
In the Industrial Sector	◯	◯	◯
In the Energy Sector	◯	◯	◯
In the Transportation Sector	◯	◯	◯
In the Residential Sector (including the consumption patterns among the general population)	◯	◯	◯

16. In your opinion, are the governing institutions in your REGION doing an effective job in spreading energy efficiency awareness to the populace? *

◯ Yes

◯ No

◯ Only in some sectors

◯ Don't know

◯ If no, please specify which sectors do not spread energy efficiency awareness effectively.

17. How is security of supply for the future considered in your current energy policies?*
Rank the given options; where 0 = not an important consideration, and 5 = a prime consideration

	1	2	3	4	5
At the national level	◯	◯	◯	◯	◯
At the regional level	◯	◯	◯	◯	◯

18. Private corporations and public-private-partnerships are generally responsible for developing large-scale renewable energy solutions. Relative to these, how important is the role of citizens, either acting individually or within a community dynamic, for achieving the overall renewable energy goals in your REGION?*
For example, individual and communal renewable energy solutions could include: wind communes, individual solar pv and solar thermal installations, community CHP plant, biofuel plants, etc. Please rank the items below; where 1 = unimportant, and 5 = most important.

	1	2	3	4	5
Relative Importance	◯	◯	◯	◯	◯

19. In your REGION, does the situation exist where investment support in non-renewable energies - such as nuclear, nuclear fusion or CCS - are prioritized over investments in renewable energy technologies? *
For example, sources of investment support could include capital grants, tax exemptions or the reductions on the purchase of goods.

- Yes
- No
- If yes, please specify which non-renewable energy(s)

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20. In your REGION, do effective operating support instruments exist to help grow renewable energy technologies? *
For example, operating support instruments could include market based solutions; such as price subsidies, green certificates, tender schemes,tax exemptions or feed-in tariffs.

- Yes
- No
- If yes, please specify which operating support instrument(s).

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21. In your REGION, is economic growth - in terms of GDP - dependent on a similar relative increase in total energy consumption? In other words, is economic growth tied to energy intensive sectors(s) in your REGION? *

- Yes
- No
- Don´t know

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22. In your opinion, what impact would a higher energy price have on consumer decisions regarding energy demand in your REGION?*
Provide a numeric ranking; where 0 = no effect, and 5 = fundamental changes to overall consumption patterns.

	1	2	3	4	5
$100 per barrel of oil	○	○	○	○	○
$150 per barrel of oil	○	○	○	○	○
$200 per barrel of oil	○	○	○	○	○

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23. In your opinion, which sectors will the previously mentioned price increases have the greatest impact on reducing consumer demand in your REGION?*
Please rank the following sectors, where 1 = the greatest impact.
Rank the items below, using numeric values starting with 1.

The industrial sector

The energy sector

The transportation sector

The residential sector (including general lifestyle changes)

24. To account for energy demand, are detailed statistics of energy consumption collected for all sectors in your REGION?*

- Yes
- No
- Don´t know

25. Which of the following sectors provides the greatest energy saving POTENTIAL in your region?*
POTENTIAL refers to the sector that, in it's current form, is consuming the greatest excess energy due to a lack of policies, regulations and/or systems in place to reduce energy demand.

- The industrial sector
- The energy sector
- The transportation sector
- The residential sector (including general lifestyle changes)
- Other, please specify

26. Which of the following sectors provides the greatest OPPORTUNITY for energy saving in your region?*
OPPORTUNITY refers to the sector that, in its current form, possesses a clear and identifiable path towards making significant reductions to its consumption patterns in the short-term (5-10 years). In this regard, the same sector may have both the greatest energy saving POTENTIAL and OPPORTUNITY.

- The industrial sector
- The energy sector
- The transportation sector
- The residential sector (including general lifestyle changes)
- Other, please specify

27. Which of the following sectors provides the greatest CHALLENGES for energy saving in your region?*

- The industrial sector
- The energy sector
- The transportation sector
- The residential sector (including general lifestyle changes)
- Other, please specify

Close Done

C.4. Policy Recommendations for Reducing Regional Exposure and Increasing Adaptive Capacity

The policy recommendations elaborated in the context of the ReRisk project take into account the main findings from the initial analysis of regional vulnerability, and the clustering and scenario exercises. The recommendations do not focus on energy policy only, since energy is a cross-cutting issue and therefore has to be approached from many different angles. The recommendations are addressing decision-makers on regional level with the objective of

- reducing the regions' vulnerability on the short term
- improving the regions' adaptive capacity on the medium and long term

C.4.1. General Policy Recommendations (Good Governance)

The first set of policy recommendations addresses measures, which could increase their influence on decision-making in the energy field, by strengthening the ties between regions and reducing their vulnerability through "energy solidarity".

- Promote energy solidarity between regions and territories

Energy solidarity between regions and territories is in line with and regions and expresses the commitment to apply a cohesive and integrated approach adapted to territorial diversity when influencing or deciding on the priorities and funding of territorial and urban development policies at European Union, national, regional and local levels. Such interregional agreements are especially important for the development and the improved compatibility of infrastructures.

- Strengthen regional and local networks

The modernization of transport and energy networks is one of the actions to be reinforced by the "EU 2020 Strategy" and, according to the Association of European Border Regions [AEBR 2010], should take into account the territorial dimension. The findings from the ReRisk project confirm that this is a central issue for reducing the vulnerability of regions with a high level of commuting and for the development of broader and complementary portfolios of renewable energy sources in neighbouring regions.

Local energy networks, both for district heating and cooling, would help to make a much more efficient use of energy. Financing and organisational models for promoting these networks should be made available. There is also a need for modernizing infrastructures and the inclusion of innovative technologies. Even in non-industrial cities or neighbourhoods, planning concentrated but decentralized heating and cooling facilities is the best means for making a more rational use of energy efficiency in the medium and long term.

- Fund and stabilize transnational research agencies

Regional "research-driven clusters" are an important means to promote and boost solid and solvent regional research activities. They also help to bring together the public bodies, sector collectives, research institutions and other stakeholders, and to strengthen their cooperation. They are useful for identifying policy needs in the field of renewable and alternative energy sources and for overcoming the gap between theory and practice. Particularly in regions with obsolete industrial sectors, this form of cooperation can help attract necessary investments. These research-driven clusters should be lead by the less vulnerable regions and those having the strongest adaptive capacity to face the impact of increasing energy prices.

There is also room for regional specialization within the SET Plan (European Strategic Energy Technology Plan), but most of the technologies promoted presently by the SET plan are large-scale.[10]

- Promote awareness among regional policy makers on the impact of rising energy prices and the need for economic diversification

According to the survey, 51% of the respondents consider economic growth in their region as dependant on energy intensive sectors. However, it is interesting to note that 22% of the respondents are either undecided or unaware of the nature or extent of the linkage between these two variables. The survey of regional decision-makers also looked into the potential impact of higher energy prices on consumer decisions and energy demand. Three levels of future oil prices were suggested: USD$100, $150, and $200 per barrel. In the first case, only 12% view the price level as having serious and/or very serious impact on consumer decisions and energy demand, and in the second case only 20% consider a price of $150 as having very serious impact. However, almost 70% of the regions consider an oil price of $200 per barrel to have a very high impact, while less than 10% consider it to be of limited or moderate importance. Accordingly, there is a close connection between the choice of basic energy system and oil price development, where the regions with high emphasis on renewable and other alternative energy resources are those least worried about substantial increases in energy prices. Also, most of the regions believe the effects of such price increases will provide a strong impetus for change in specific sectors of the economy. The best measure to address this issue is to actively promote diversification of the regional economic structure towards economic activities with lower levels of energy consumption and spending.

- Define a vision for a regional energy model 2050

The transition towards regional economies, which are less vulnerable to rising energy prices, requires long-term planning on regional level. Visions and scenarios can be helpful tools for regional policy makers both to make better-informed decisions and to help communicate and attract citizens, involving society into a shared plan. However, such exercises, which could be financed in the context of the National Energy Efficiency Plans, should be carried out on a sound methodological basis and as a participatory process.

- Push municipal leadership in public-private partnerships

PPP help encourage investment in alternative energy production, increase public awareness and promote the involvement of private companies and

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[10]http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/07/493&format=HTML&aged=1&language=EN&guiLanguage=en

society. This is particularly interesting in regions with high potential for the development of renewable energy sources. Some experiences already exist at neighbourhood level, where citizens have joined and made private investments thanks to public support. For example, roofs of public buildings can be made available by the administration so that residents from large apartment buildings or tenants in rented flats also have an opportunity to support the deployment of PV installations. However, financing schemes must be revised to account for the diminishing investment capacity of households after the prolonged economic recession.

C.4.1.1. Spatial Planning Policies and Strategies towards a more Sustainable Territorial Management

- Develop integrated spatial planning instruments

The integration of cross-sector policies of land use, energy and water management into a single planning instrument at regional level, based on an understanding of territorial dynamics, will help regions to advance towards a more sustainable territorial management, in line with § 10, § 11, § 23 and § 27 of the Territorial Agenda. The adoption of this principle expresses the acknowledgement of the specific responsibilities of sectoral policy-makers and the will to cooperate with and influence them in order to ensure a stronger territorial and urban focus when conceiving and delivering the thematic policies. The goal is to better fine-tune specific thematic actions, to facilitate their coordination and to reduce undesired externalities. Initiatives with this perspective have already been established, for instance the Integrated Coastal Zone Management or ICZM [DG Environment 2010]. This is a necessary tool for planning the development of coastal areas, where conflicts may arise when planning off-shore wind parks or other ocean technologies, which may interfere with security issues, fishing interests, cargo traffic, tourism or protection of marine biodiversity.

- Establish urban planning principles for solar energy use

Experimental instruments are available to plan the deployment of solar energy applications more effectively on municipal level [Gadsden et al 2003]. Planning tools need to predict the baseline energy consumption of domestic properties and to determine the potential for using the three key solar technologies of passive solar design, solar water heating and photovoltaic (PV) systems. A new dwelling classification system needs to be developed to address the major problem of data collection for city-wide domestic energy modelling.

- Implement Urban Metabolism procedures

“Urban metabolism” is a new way of describing the functioning of modern cities and could be an interesting tool for local energy planning. “The concept of an urban metabolism provides a means of understanding the sustainable development of cities by drawing analogy with the metabolic processes of organisms. The parallels are strong: “Cities transform raw materials, fuel, and water into the built environment, human biomass and waste” [Decker et al. 2000]. In practice the study of an urban metabolism (in urban ecology) requires quantification of the inputs, outputs and storage of energy, water, nutrients, materials and wastes. “[11]

Procedures related to urban metabolism assess urban dynamics, services, functions, flows and cities’ capacity of response with two purposes: a) to avoid alteration of the ecological, social and economical conditions of a city and also b) to reduce vulnerability by optimizing energy consumption. This is particularly interesting in highly urbanized regions with severe ecological footprints.

- Promote industrial symbiosis and/or industrial eco-parks

Industrial symbiosis refers to loop cycles, in which energy consumption, production and waste management are integrated in industrial developments aiming at using the residues from one industrial process for the production of other products. By-product synergy is then exchanged in a circular flow, which, in the best cases, provides settlements with energy surpluses through district heating. This is particularly interesting when renovating older industrial sites, usually linked to other obsolete urban areas, but it is also a valuable tool when planning new industry parks. As the two case studies on industrial symbiosis have shown, such projects are easier to implement and have greater success if the companies involved have or develop a relationship of trust and recognize the mutual benefits, so project design is an important element in this policy.

All these initiatives require **good governance** understood as a) horizontal coordination of sector administrations and policies b) vertical coordination of different levels of responsibilities and also c) public participation which in term will increase regional capacity of response. Extended bottom-up participation processes are necessary to guarantee the efficiency of many long-tem developments. A responsible and involved neighbourhood is also a key response capacity when facing risks and hazards.

C.4.1.2. Environmental Protection and Risk Prevention

The importance of a regional perspective in relation to environmental protection is very clear, as environmental problems usually have regionally dispersed effects. The determination of the political agenda at European level with clear environmental objectives is of particular relevance in the area of energy and sustainability. The current lack of sustainability of the European and World energy models, and specially their climate change consequences, require an urgent action in this field with a long term vision in order to prevent the exhaustion of local and regional energy sources.

- Sustainable use of biocrops

Making extended use of biofuels in the region could lead to social and ecological problems [EEA 2005]. Biocrops compete with other uses for scarce resources, such as land and water, in agriculture, forestry or natural sites. Specializing on certain types of plants with high energy yield could jeopardize other objectives of agricultural policy, such as that of promoting a

[11] Encyclopaedia of Earth http://www.eoearth.org/article/Urban_metabolism

higher level of regional sufficiency with regard to food production (by growing subsistence crops). Large-scale biomass plants could accelerate deforestation or endanger the local biodiversity. Apart from choosing technologies and crops that are appropriate in a given regional context and robust with regard to possible climate change impacts (droughts), attention must also be paid to the parallel development of local social and educational skills, which will be needed to manage and maintain the installed facilities.

- Prepare for climate change impacts in the regional energy infrastructure

Climate change will vary from region to region - with coastal and mountain areas and flood plains particularly vulnerable – and therefore many of the adaptation measures will need to be carried out regionally[12]. Impacts are likely to be severe in the Southern regions belonging to Spain, Greece, Portugal and France, both in terms of energy production and demand. In these regions, summers are going to be complicated for energy companies, due to diminishing water reserves, higher average temperatures and heat waves, and consequently, forest fires. The supply problems will coincide in time with higher peaks of electricity demand, derived from a more extended use of air-conditioning.
The need for new, expensive and under-used peak load capacities for electricity production will be greatest in regions, which have not yet reached full market saturation of air-conditioning appliances. However, much of this may be avoided by promoting passive cooling techniques or solar-based appliances in buildings and cities or by defining a minimum threshold for their installation in offices and public buildings. It is important to design sustainable, low-energy buildings which provide thermal comfort. The main focus should be on buildings that are ‘free running' for some part of the summer, either being entirely naturally ventilated or mixed-mode (where mechanical cooling is only used when thought to be essential). Solar cooling technologies will play a decisive role for energy demand development in these regions [Holmes et al 2007]. Actions in this field could also be considered when the national emergency plans for the prevention of heat waves are extended to the regional and municipal level.

C.4.1.3. Policies to Accelerate Deployment of Renewable Energy Sources

- Evaluate the feasible potential of all renewable sources in the region

Regions should thoroughly evaluate the “feasible” potential of the different technologies available, including concentrated solar, geothermal, wave / tidal technologies, biomass, and hybrid solutions. Regions with different types of potential for renewable energy can cooperate to improve the reliability of energy supply from these sources. The generation of “maps of untapped energy reserves” can be of great use for developing longer-term plans in the regions.

[12] For further information, please see the discussion paper on climate change impacts in the energy sector, submitted along with the Updated Interim Report

- Incorporate solar and wind facilities in urban areas

In densely populated urban areas, wind and solar applications should increasingly be incorporated in the built environment. Small-scale technologies are already available to be installed on roofs and at various wall orientation and façades. Bioclimatic urbanism has a solid set of measures to assist designing urban areas having in mind these natural resources.

C.4.1.4. Policies to Promote Energy Efficiency

Energy efficiency is becoming an important policy issue at regional level. Several European policies are already in place, like the “Action Plan for Energy Efficiency: Realising the Potential”, the Green Paper on energy efficiency, the “Intelligent Energy for Europe” programme, etc.[13] However, there are serious concerns that the Member States are not implementing their National Energy Efficiency Action Plans (NEEAP) on time and that the 20/20/20 objective might not be reached [EESC 2009a].

The following recommendations can be made based on the findings in the ReRisk project and other relevant policy documents:

- Improve the data on energy use and efficiency in Europe

A comprehensive account of regional and local energy consumption is a prerequisite for justifying any investments in improving energy efficiency [Rutland and Aylett 2008]. The European Social and Economic Committee (EESC) is “disappointed and concerned at the shortage of homogenous, detailed information and data on end-use energy efficiency”, which hinders the development of appropriate strategies for improving energy efficiency. The lack of data also makes it difficult to measure and monitor progress and, ultimately, to enforce policies in this area. However, more detailed information on energy consumption is being gathered in 61% of the regions, which responded to the questionnaire (29% of the respondents indicate that it is not, and 10% do not know whether they keep this type of data). The main problem is therefore not data collection, but harmonization of the data and the selection of the right indicators for European comparison.

- Accelerate the transition to non-fossil fuels in the aviation industry

The aviation industry is expected to face serious supply problems in the coming decades, even if the present level of air traffic is maintained and efficiency improvements of 5% per year to 2026 are achieved [Nygren 2008]. Peripheral and island regions with a high dependence on air traffic, as well as regions specialized in air transport will be hardest hit by these developments. They should cooperate with the aeronautic industry to prepare the transition from fossil fuel use in air transport to alternative sources (biofuels not competing with food production such as algae, jatropha, babassu, synthetic fuel from coal, etc), both in terms production of these fuels and the needed infrastructure adjustments.

- Create a market for energy efficiency (White certificates)

The EESC also points to white certificates [EC 2005] as a means of enhancing energy efficiency. “White certificates” and similar regulations, which oblige energy companies to either invest in energy efficiency or buy “certificates”, have already been introduced in some Member States. The analysis carried out on the implementation of this policy in Italy[14] shows that as a consequence of this regulatory change, the number of energy service companies (ESCOs) offering services aimed at reducing energy consumption increased considerably and the market for energy efficiency services became much more dynamic. However, the implementation and monitorization of these programmes is complex and requires a high level of institutional cooperation. Pilot projects could be launched on regional level to evaluate the energy savings which can be achieved through white certificates and to identify the most efficient interventions for different types of industrial and residential markets.

- Improve efficiency of office design and work arrangements

Changes that are occurring in work arrangements may present an opportunity for making a more efficient use of energy in offices and reduce the need for transport by extending the opportunity to work at home. The average office worker spends 30 percent of the workday at a workstation—be it the corner office with a skyline view or an interior cubicle. Changes to how, where, and when we work have led current office design to the “networked office.” The majority of workspaces still emulate older versions of the building type, dedicating a lot of space, lighting, and climate control to increasingly mobile and immaterial work that does not really need it [Hanley 2008].

- BAT (Best Available Technologies) for industrial energy efficiency

Solid knowledge and sound technologies are available for improving energy efficiency in certain industries, but their implementation might be quite complex when looking at the entire production process. Table 37 shows the technologies with the highest efficiency potential in some of the industrial sectors with highest energy consumption, assuming only technical improvements. The “current best practice” values indicated below should be completed for all NACE subsectors and constantly updated, as they can serve as a reference benchmark for companies in the same sector / subsector. This measure is especially important for regions, in which energy spending in some sectors – and therefore the risk of carbon leakage – is higher than average.

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[14] Lorenzoni, A. (2008), “ The Italian Experience. White certificates in electricity and gas. A regulatory review”. http://www.catedrabp.upcomillas.es/Documentos/Actividades/Foro/2008/Lorenzoni.pdf

Table 37 Technologies with the Highest Efficiency Potential in Some of the Industrial Sectors

		Specific energy consumption (GJ/tonne)	Current best practice	Thermo-dynamic minimum	Technical potential in [r]evolution scenario			Refer-ence scenario
Sector	**Unit (specific final energy**	**2005**	**2005**		**2020**	**2030**	**2050**	**2050**
Iron and steel	Primary steel BF/BOF route (GJ/tonne crude steel)	10	6.4	1.3				
Iron and steel	Primary steel OHF route (GJ/tonne	23						
Iron and steel	Secondary steel EAF route (GJ/tonne crude steel)	2.2	1.6	1.3				
Iron and steel	Hot/cold rolling (GJ/tonne crude steel)	2.9	2.2	0.05				
Iron and steel	Share secondary steel	35%	35%		41%	48%	60%	
Iron and steel	**GJ/tonne crude steel**	**12.5**	**5.5**	**1.3**	**10.3**	**8.0**	**3.5**	**8.0**
Iron and steel	*Index (GJ/tonne crude steel)*	*100*	*44*	*10*	*82*	*64*	*28*	*64*
Non-metallic minerals	GJ/tonne clinker	4.2	3.1	1.8	3.9	3.5	2.8	
Non-metallic minerals	Clinker to cement ratio	80%	25%	<25%	75%	70%	60%	
Non-metallic minerals	Electricity use grinding/blending (kWh/tonne cement)	110	105	<100				
Non-metallic minerals	**GJ/tonne cement**	**3.7**	**1.2**	**<0.5**	**3.2**	**2.7**	**1.7**	**2.4**
Non-metallic minerals	*Index (GJ/tonne)*	*100*	*31*	*<14*	*86*	*73*	*45*	*64*
Aluminium	Primary aluminium (MWh/tonne aluminium)	15.3	12.5	6.4	13.85	12.4	9.5	
Aluminium	Secondary aluminium (GJ/tonne aluminium)	0.8	0.8	<0.8	0.7	0.7	0.7	
Aluminium	Share secondary aluminium	33%	33%	100%	40%	47%	60%	
Aluminium	**GJ/tonne aluminium**	**10.5**	**8.6**	**<0.6**	**8.9**	**7.4**	**4.2**	**6.7**
Aluminium	*Index (GJ/tonne aluminium)*	*100*	*82*	*<6*	*85*	*70*	*40*	*64*
Ammonia production	GJ/tonne ammonia	15	8					
Ammonia production	Ammonia (index)	100	53					
Chlorine production	MWh/tonne chlorine	3.6	2.6					
Chlorine production	Chlorine (index)	100	72					
Ethylene production	Ethylene production by naphtha (GJ/tonne)	25-40	18					
Ethylene production	Ethylene production (index)	100	60					
Chemical and petrochemical	Index best practice implementation (GJ/tonne)	100	62		89	77	55	
Chemical and petrochemical	Index improved material efficiency and recycling (GJ/tonne)	100			95	90	80	
Chemical and petrochemical	*Index (GJ/tonne)*	*100*			*86*	*72*	*45*	*64*
Other industries	*Index (GJ/tonne)*	*100*			*84*	*68*	*35*	*64*
Total industry	Index (GJ/tonne)	100			84	69	38	64

Source: Umweltbundesamt, Germany, 2009 [UBA 2009]

C.4.1.5. Policies to Fight Energy Poverty

As indicated in the introduction to this report, concerns about energy poverty are growing in Europe. The Parliament warns “that special attention must be paid to consumer protection and that safeguards must be put in place in order to prevent grid disconnection” [EP 2008] of customers who cannot pay their energy bills. Some of the recommendations issued by the Parliament are further developed in this chapter:

- Improved transparency and information on energy consumption

The liberalization of the electricity and gas sectors has worked against transparency, as remarked in the Updated Interim Report. Companies purchase energy on the basis of private contracts, which are confidential, and prices have started to fluctuate considerably in the residential sector, with growing differences between regions and even cities. It is in this context that the Parliament and NGOs insist on the need for comparable bills and tools, such as smart meters and tariff simulators to help customers choose the lowest-cost supplier.

- Consumer awareness and education; involvement of end-users

According to the survey of regional decision-makers, the present spread of information on energy efficiency to the population is insufficient. 49% of the respondents consider current dissemination levels to be acceptable only in some sectors, and 22% consider it to be generally inadequate. When looking into details regarding which regions are satisfied with the dissemination level there seems to be a connection to the regions where this responsibility has been delegated to regional authorities. This should be taken into account when implementing the European strategy on “education and training needs for the carbon-free energy society” [EESC 2009b]. In this context, the EESC stresses the need for action not only on school level, but also in the field of (continued) vocational training. Involve end users in energy efficiency programmes and policies. The EESC also gives a series of recommendations on how to “enhance energy efficiency policies and programmes by end users”. The first set of measures proposed by the Committee refers to the relevant EU programmes (CIP, and particularly IEE), which need to be simplified to make them more accessible to very small businesses and their representative associations and to administrations in disadvantaged areas (mountainous and peripheral regions). Moreover, it is worth encouraging public-private partnerships and ESCOs (energy service companies), in particular at European, national and local levels, by facilitating the involvement of SMEs in the actual implementation of the European Green Public Procurement policy.

- Social policies

Energy poverty in households must be addressed in the context of social policies, which are generally implemented on the local level. However, there is a need for setting a common definition of public service obligations, which are specific to the energy sector, as foreseen by the European Charter on the Rights of Energy Consumers. Work in the area is just beginning, since, according to the Parliament, the notion of energy poverty still needs to be defined and an “appraisal should be made of the extent to which the individual national social security or tax systems take account of the risks associated with energy poverty.” However, it is clear that policy measures must prioritize investment in energy efficiency in low-income households, rather than on subsidizing energy consumption.

C.4.1.6. Relevance of Policy Measures for Regional Typologies and Scenarios - Conclusions

Although all policy measures proposed in this report are considered important to fight the different forms of energy poverty in the regions, some have a higher priority for certain types of regions and under different scenario assumptions. Typology 2, for example, groups the regions with the most unfavourable economic structure, so that industrial diversification strategies are vital to conserve competitiveness. Since this typology is also characterized by high demand for heating and cooling, the construction of efficient networks is also a priority. Likewise, regions with high level of commuting (typology 3) or at the periphery (mainly typology 1a and 4), with an important dependence on air travel, have a greater need for action in the field of mobility and freight transport.

Social policies – so far rather underdeveloped with regard to energy poverty – play a crucial role for regions in typology 1b and 2 and under the assumptions of the “Business as Usual?” scenario and could be combined with innovative financing measures on municipal level. For regions with low disposable income, but considerable PV potential, urban solar planning tools may provide the information necessary to achieve the greatest deployment of these technologies at the lowest cost possible. In Member States that opt primarily for building new nuclear plants and will therefore have a large baseload capacity (electricity that is being produced 24 hours a day), overall energy efficiency may not be the determining aspect in the corresponding policies, but rather the shift from fossil fuel use to the constant consumption of electricity. A critical question in this context is acceptance and consumer preferences, for example for “green tariffs”.

European initiatives are especially important when benchmarks are needed, for example in industries with high energy spending, and for promoting regional cooperation through network extension, energy research and the development of a joint and more reliable renewable portfolio. The European framework will furthermore be decisive where major transition processes need to be implemented, mainly with regard to air and freight transport.

Governance levels and priority actions for the 5 regional typologies are summarized in table 38, using the following colouring code:

	Top priority; Optimal Recommendation.
	Makes sense to include this measure with a high priority; it seems appropriate to recommend it.
	It is an ambiguous measure, depends on the region or the time lapse, or it might result an irrelevant recommendation.
	This measure must be handled with care as it might result counteractive; it is not recommended.

Table 38 Evaluation of Policy Measures for Regional Typologies and Governance Levels

Policy recommendations		Regional Typologies					Governance level			
		1a	1b	2	3	4	local	regional	national	EU
General policy recommendations (Good Governance)	Promote energy solidarity between regions and territories							●	●	●
	Strengthen regional and local networks						●	●		
	Fund and stabilize transnational research agencies								●	●
	Promote awareness among regional policy makers on the impact of rising energy prices and the need for economic diversification							●	●	●
	Define a vision for a regional energy model 2050						●	●		
	Push municipal leadership in public-private partnerships						●			

Policy recommendations		Regional Typologies					Governance level			
		1a	1b	2	3	4	local	regional	national	EU
Spatial and urban planning	Develop integrated spatial planning instruments						●	●	●	●
	Establish urban planning principles for solar energy use						●			
	Implement Urban Metabolism procedures						●			
	Promote industrial symbiosis and/or industrial eco-parks						●	●		
Environmental protection and risk prevention	Sustainable use of biocrops							●	●	●
	Prepare for climate change impacts in the regional energy infrastructure						●	●		
Policies to Accelerate deployment of	Evaluate the feasible potential of all renewable sources in the region							●		

Policy recommendations		Regional Typologies					Governance level			
		1a	1b	2	3	4	local	regional	national	EU
renewable energy sources	Incorporate solar and wind facilities in urban areas						●			
	Accelerate the transition to non-fossil fuels in the aviation industry								●	●
Policies to promote energy efficiency	Improve the data on energy use and efficiency in Europe								●	●
	Involve end users in energy efficiency programmes and policies						●	●		
	Create a market for energy efficiency							●	●	●
	Improve efficiency of office design and work arrangements						●	●		
	BAT (Best Available Technologies) for industrial energy efficiency									●

Policy recommendations		Regional Typologies					Governance level			
		1a	1b	2	3	4	local	regional	national	EU
Policies to Fight Energy Poverty	Improved transparency and information on energy consumption						●	●		●
	Consumer Awareness and Education; involvement of end-users						●	●		
	Social policies						●	●	●	

Annexes to the Scientific Report

Annex 1: Discussion and Maps of Individual Indicators

All data used in the ReRisk project has been collected for the NUTS II regions in the EU 27 and, when possible, for Norway. Switzerland and Denmark, however, had to be excluded in most cases, due to the following reasons: after an administrative reform, regional accounts in Denmark are elaborated for NUTS III units, due to the small size of the country, and aggregated data for larger regions is not produced any more[15].

The Swiss Statistical Offices divides the country in 106 Swiss “MS = Mobilité spatiale” regions, a classification that is not comparable to the NUTS II categories. Some information on regional disparities in Switzerland can, however, be obtained from a recent publication of the National Statistical Office[16].

As a general rule, only harmonized data has been used for regional comparisons. National data sets have not been added to the indicators, since, without the necessary harmonization process, it cannot be guaranteed that the data has been collected according to common standards. However, references to relevant sources for national data are given below for those indicators, for which data coverage was not complete.

AN.1.1. Temperature Data

AN.1.1.1. Relevance

Mean maximum and minimum temperatures are rough indicators for cooling and heating demand in the regions, and it was necessary to obtain longer-term data for that purpose. The mean minimum temperature for January reflects the harshness of winters in the region and can be used to calculate the days when heating is required. Eurostat [EUROSTAT 2007], in cooperation with the Joint Research Centre, has started to tackle this issue by calculating “heating degree days”. Heating and cooling degree days can be calculated on-line for each weather station, but for the ReRisk project, it was necessary to access the data prepared by the JRC’s Mars Unit, which has converted the temperature data from selected weather stations to NUTS II level.

The mean maximum temperature for July refers to the highest temperatures measured in a given location over the last 15 years. It is

[15] See explanation at http://www.dst.dk/homeuk/Statistics/focus_on/focus_on_show.aspx?sci=563
[16] Bundesamt für Statistik BSF (2009, “Regionale Disparitäten in der Schweiz. Schlüsselindikatoren”

relevant for identifying the regions with high cooling demand in the summer time and will become more important as temperatures rise as a consequence of climate change. Growing demand for air-conditioning is putting serious strains on the electricity grids in Southern countries, as indicated in the discussion paper con climate change published by the ReRisk project partners [ESPON ReRisk 2009], but energy consumption for this purpose is not quantified. Estimates for current and present demand on national level were elaborated in the context of the Ecoheatcool[17] project, but only on national level.

AN.1.1.2. Data Source

The Joint Research Centre's Ispra - IPSC - MARS Unit kindly prepared the data for the last 15 years and made it available to the ReRisk project. The data is calculated as follows: "The raw temperature data from 1500 weather stations are collected and processed by the Joint Research Centre (JRC) - IPSC / Agrifish Unit / MARS-STAT Action. Using a fine grid (50 km x 50 km), the JRC applies a meteorological model to establish the best set of weather stations for the interpolation of temperature data at regional level (according to NUTS - Nomenclature des unités territoriales statistiques)."[18]

AN.1.1.3. Data Quality and Gaps

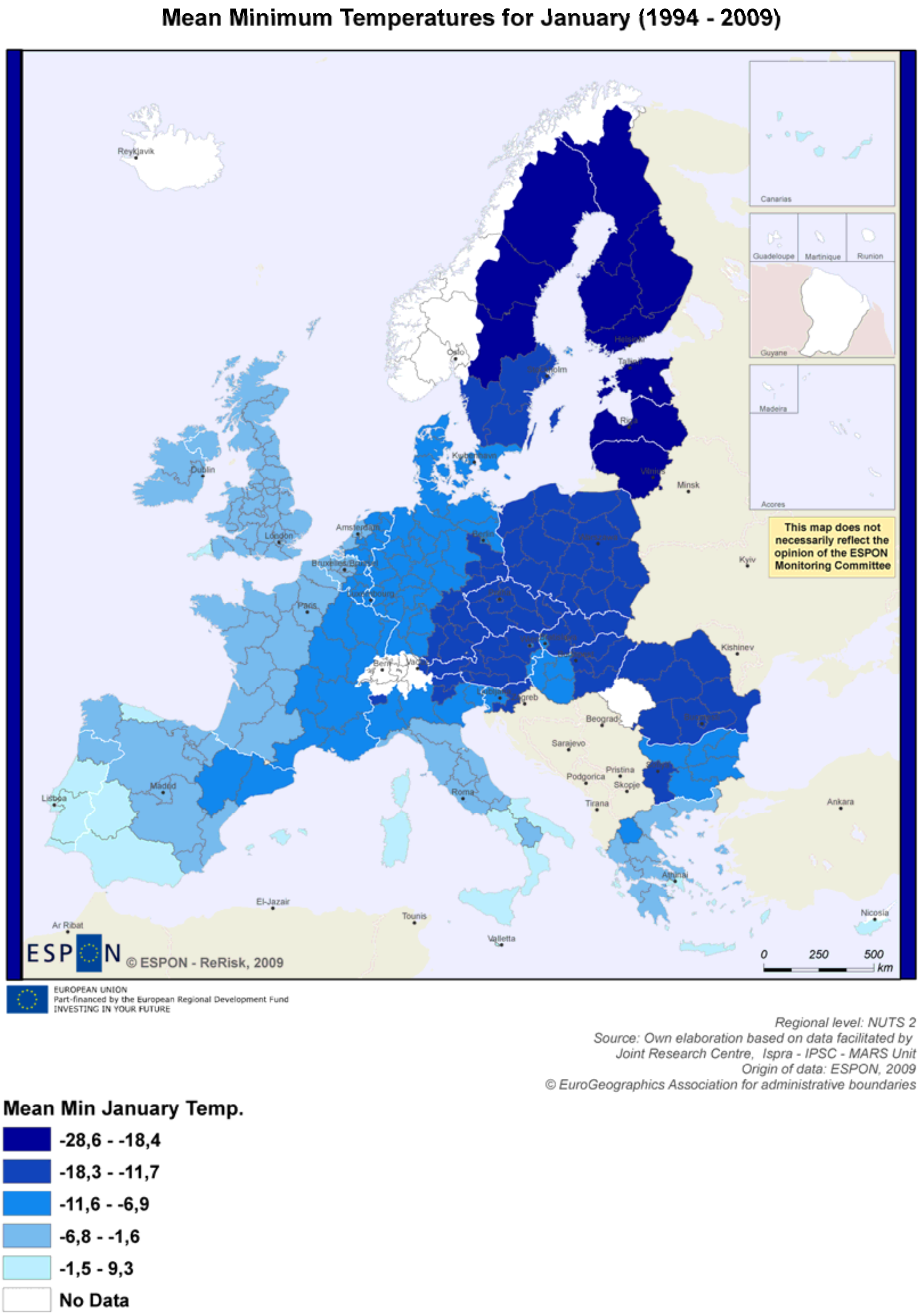
The GIS data used by JRC Ispra covers the EU Member States, but not Norway nor Switzerland. The data coverage for the EU 27 is complete, but it should be taken into account that the larger NUTS II regions can include various climate zones, as well as housing and heating markets with different characteristics and equipment.

AN.1.1.4. Information from National Sources

Statistics Norway offers temperature data from weather stations, including averages for the years 1961-1990, collected by the Metrological Institute. The coverage is, however, determined by the location of the weather stations and not necessarily identical with the NUTS II regions in the country. The situation is similar in Switzerland: long-term data is available, but not related to the NUTS II classification.

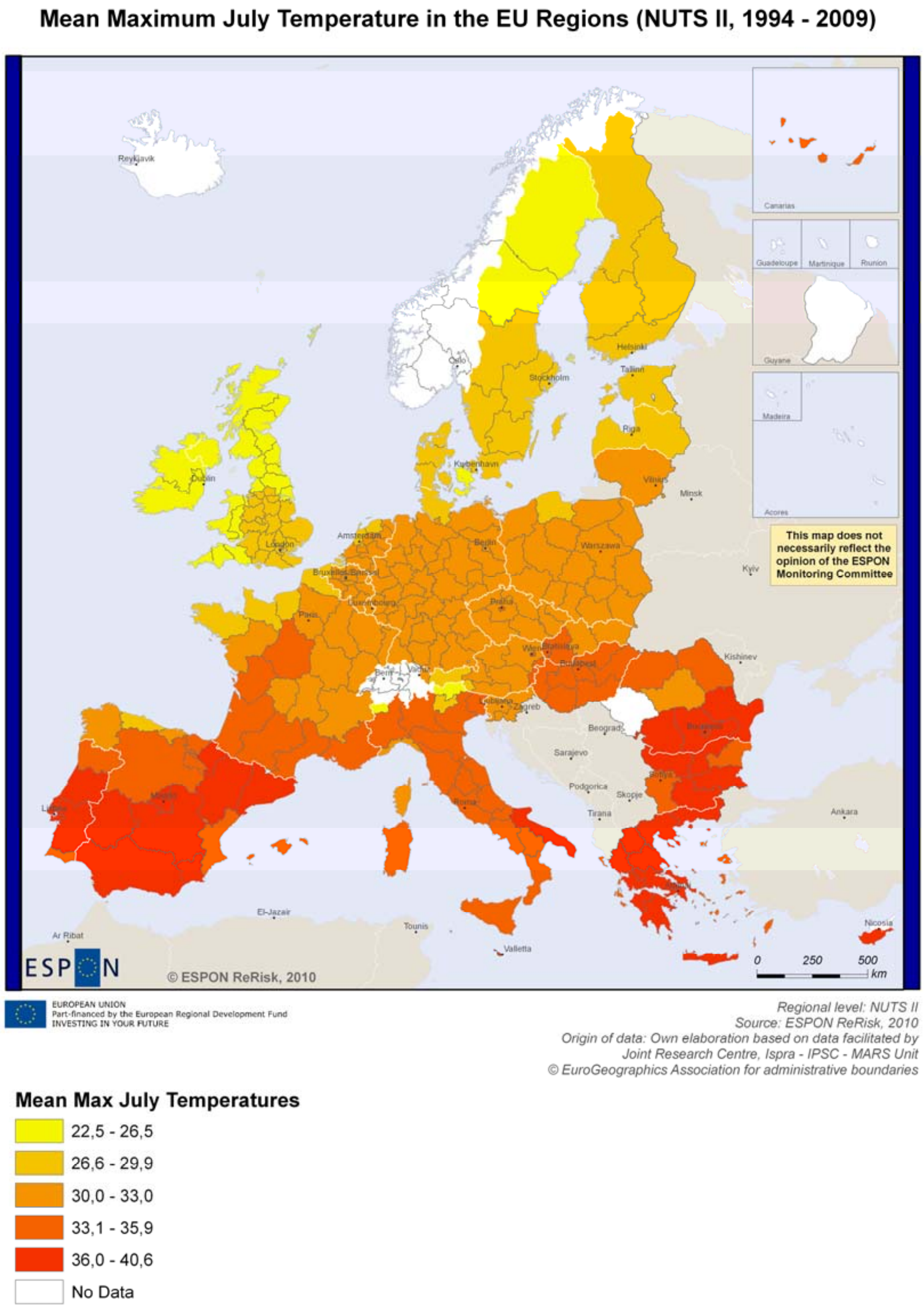
[17] Ecoheatcool Workpackage 2, "The European Cold Market. Final Report" http://www.euroheat.org/Files/Filer/ecoheatcool/documents/Ecoheatcool_WP2_Web.pdf
[18] Eurostat (2007), "Panorama of Energy"

AN.1.1.5. Map



Map 12 Mean Minimum January Temperature in the EU Regions (NUTS II)

Source: Own elaboration based on data facilitated by the Joint Research Centre, Ispra - IPSC -MARS Unit



Map 13 Mean Maximum July Temperature in the EU Regions (NUTS II)
Source: Own elaboration based on data facilitated by the Joint Research Centre, Ispra - IPSC -MARS Unit

AN.1.2. Wealth Creation and Employment in Industries with High Energy Purchases

AN.1.2.1. Relevance

The greatest methodological challenge in the first phase of the project was to measure and compare the economic vulnerability of regions in the absence of harmonized data on energy consumption. This problem was solved by using data on *industrial energy purchases*. For companies, energy is one of the main cost factors in the production process and therefore the amount companies spend on purchasing energy is more relevant in terms of competitiveness than their actual energy consumption. The following approach was chosen in order to determine the sectors and regions that are most vulnerable to energy price increases:

1. First, we estimated, for the EU 27, the sectors with the highest spending on energy products on NACE 2 digit level, and which, combined, represent 63% of industrial energy spending (figure 16).

Figure 16 NACE Sectors with Highest Overall Energy Spending

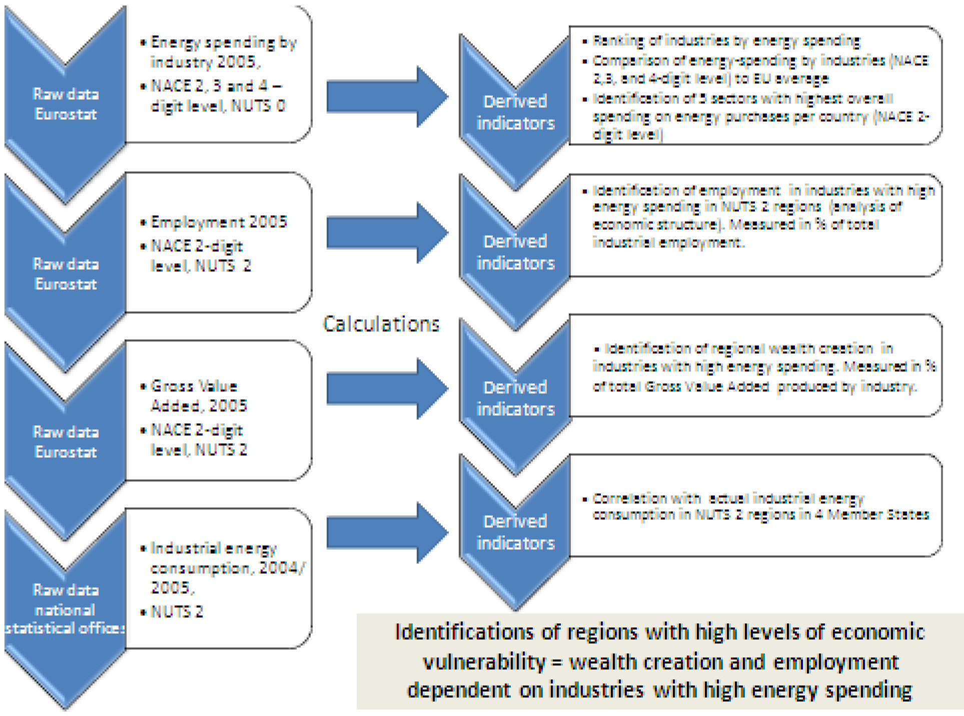
Source: Own elaboration based on Structural Business Statistics

Furthermore, it was checked if the national data diverges significantly from the EU average and if some adjustments had to be made for countries with a different profile of industrial energy spending.

2. In a second step, we calculated the ratio between "total purchases of goods and services" and the energy purchase in each sector (down to NACE 4 digit) for those EU countries, for which complete data sets were available for both categories. This made it possible to identify the subsectors and processes with the highest energy purchases, and also to determine the relative position of these sectors in each EU country in terms of energy spending.
3. Then, we identified the EU regions, in which large part of the industrial employment and gross value added (GVA) depends on these sectors with high energy spending and which may therefore be more vulnerable to energy price increases.

4. Finally, using actual consumption data from 4 Member States, we confirmed that there is a significant correlation between the industrial energy spending in the regions and their energy consumption.

Figure 17 Methodological Approach for Analyzing the Regions' Economic Vulnerability



The calculation described above permits to understand the industrial structure in the regions and to identify the need for action in this economic sector. Industry is, however, not the only source of employment and wealth creation in the regions - services, transport and agriculture also provide work opportunities and income, and highly diversified regional economies are likely to be more robust to rising energy prices than energy-intensive ones. This fact can be accounted for by relating employment and GVA in industries with high energy spending to the overall employment and total regional GVA, which were the indicators the ReRisk project finally settled for.

AN.1.2.2. Data Source

The raw data for this indicator is available at Eurostat – Structural Business Statistics (energy purchases by industry, NACE 4-digit level), while data on regional wealth creation (GVA) and employment on NACE 2-digit level can be downloaded from the "General and Regional Statistics" database.

AN.1.2.3. Data Quality and Gaps

Some countries could not be covered in this analysis due to missing data, mainly with regard to industrial energy purchases. However, the collection of this information is obligatory for the Member States, so that data should become available in the future.

Table 39 Countries Excluded from the Analysis for Lack of Data

Country	Data Availability
AL Albania	No data
BG Bulgaria	No data on energy purchases
CH Switzerland	No data
LT Lithuania	No data
MT Malta	No data
PL Poland	No data on energy purchases
SI Slovenia	No data on energy purchases

Source: Own elaboration based on Structural Business Statistics

For some countries and sectors, there is no aggregated data on industrial purchases at NACE 2-digit level, but this has generally not been a major problem for carrying out the analysis, since 3-digit level data could be used. Finally, for a few sectors, data on NACE 3 and 4-digit level was insufficient to estimate a meaningful EU average (less than 10 values for EU 27), so these sectors have not been taken into account in the analysis. This, however, did not affect the calculations for the regions, which were carried out at NACE 2-digit level.

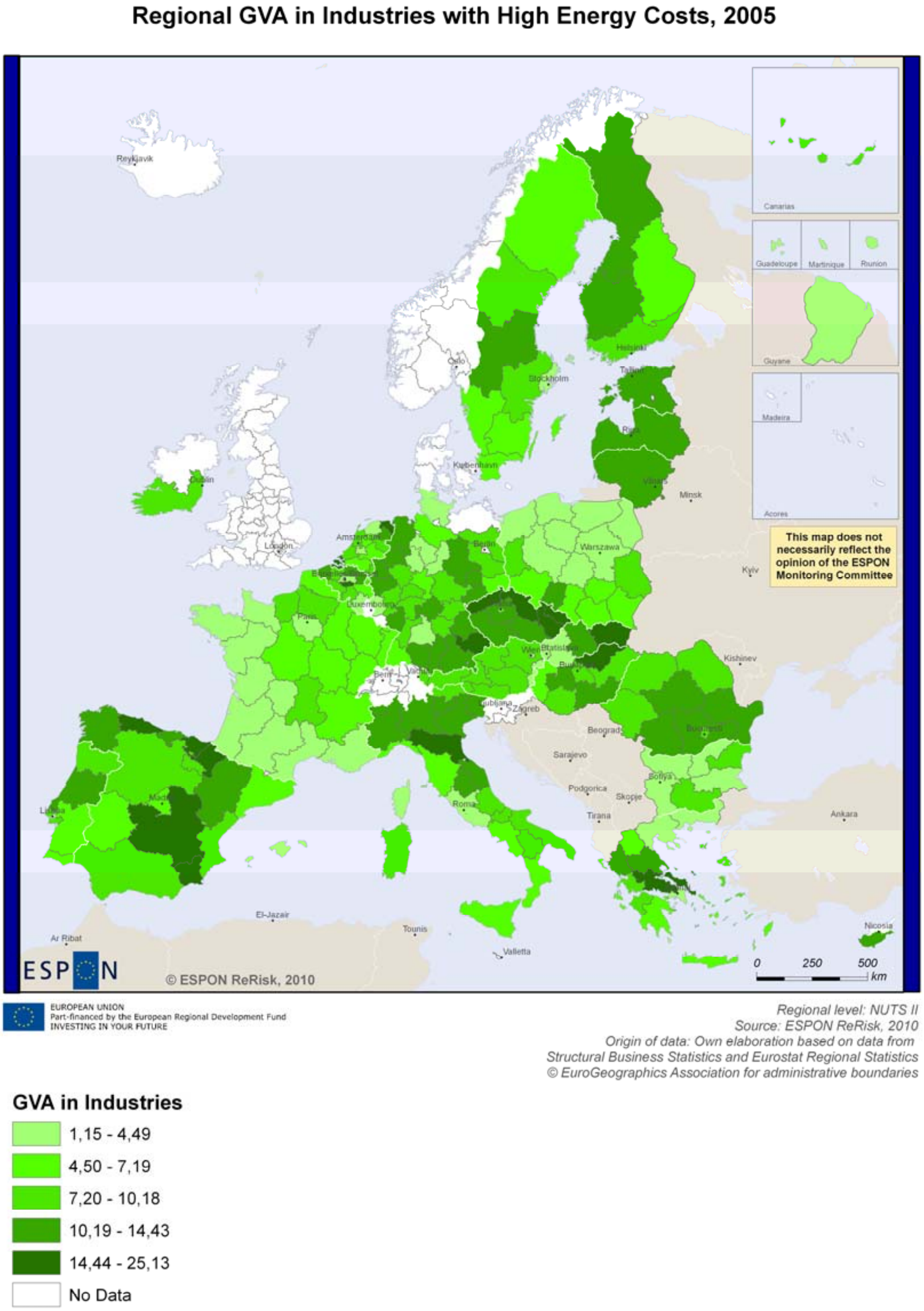
Data coverage is better for employment than for regional GVA, since in Poland, Slovenia and UK, GVA data is not available or incomplete at NACE 2-digit level.

AN.1.2.4. Information from National Sources

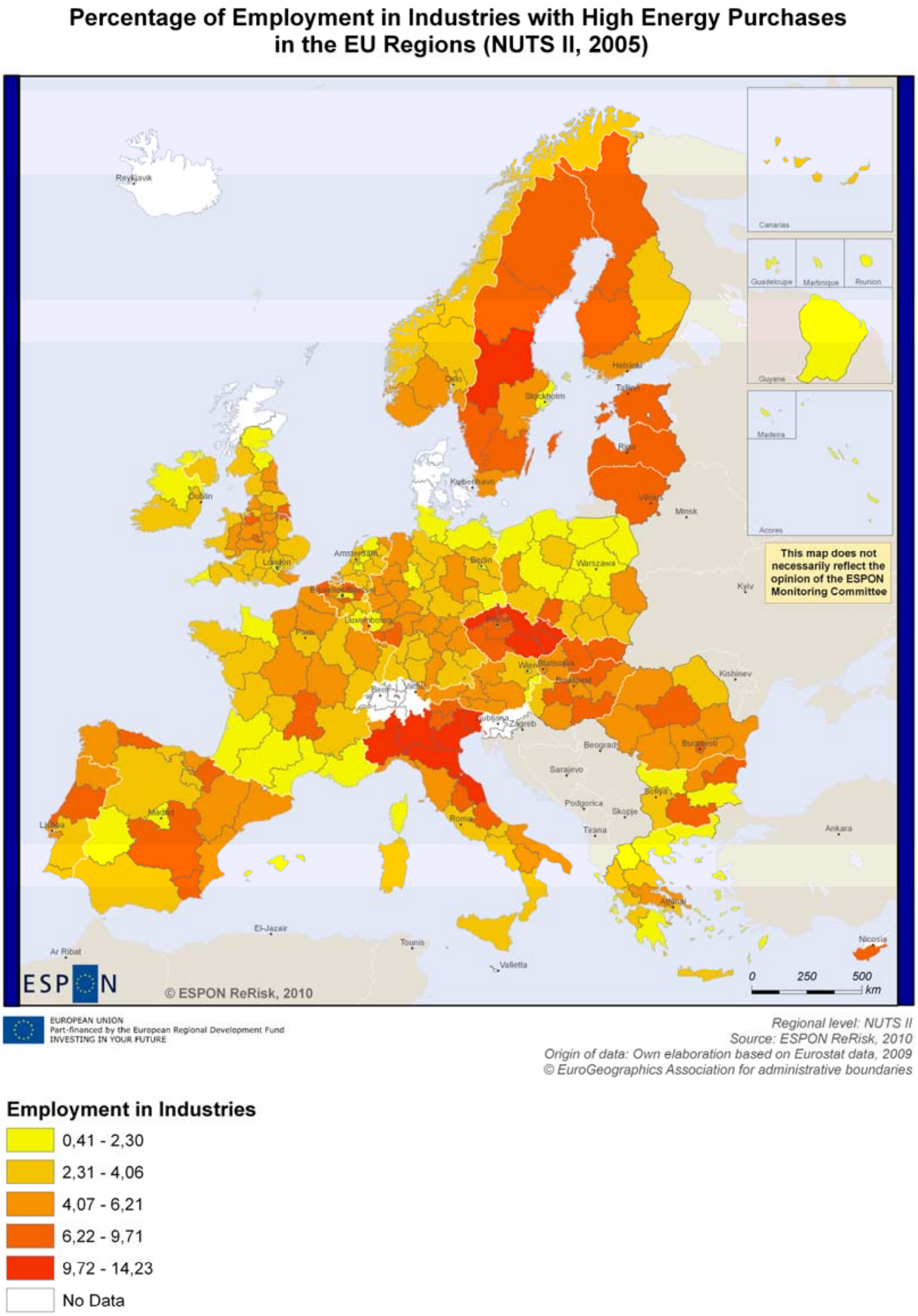
As this indicator has been calculated specifically for this project based on three different sets of harmonized data, national data could not be incorporated, since it cannot be guaranteed that data from national sources is collected in a comparable way.

For Norway, excellent data is available on industrial energy purchases and consumption on national level for 2008, but there is no regional breakdown for this data.

AN.1.2.5. Map



Map 14 Percentage of Gross Value Added in Industries with High Energy Purchases in the EU Regions (NUTS II, 2005)



Source: Own elaboration based on Eurostat data

Map 15 Percentage of Employment in Industries with High Energy Purchases in the EU Regions (NUTS II, 2005)

AN.1.3. Employment in the Transport Sector

AN.1.3.1. Relevance

The transport sector is an important source of employment and income in many regions. During the time of steadily rising oil prices, many companies and sector organisations such as the International Road Union warned that the "dramatic price hikes in fuel during the last two years, due to rising oil prices and burdensome taxation, accounting for up to 56% of the price at the pump, are having a devastating impact on road transport operators, as the road transport sector cannot always pass on fuel price increases immediately to its clients"[19]. Regions that have specialized in transport services, especially in road transport, may therefore be especially exposed to the impacts of rising energy prices.

AN.1.3.2. Data Source

Raw data was again obtained from Eurostat's Structural Business Statistics. The percentage of employment in the transport sector (NACE sector I - Transport, storage and communication) was calculated by the project team.

AN.1.3.3. Data Quality and Gaps

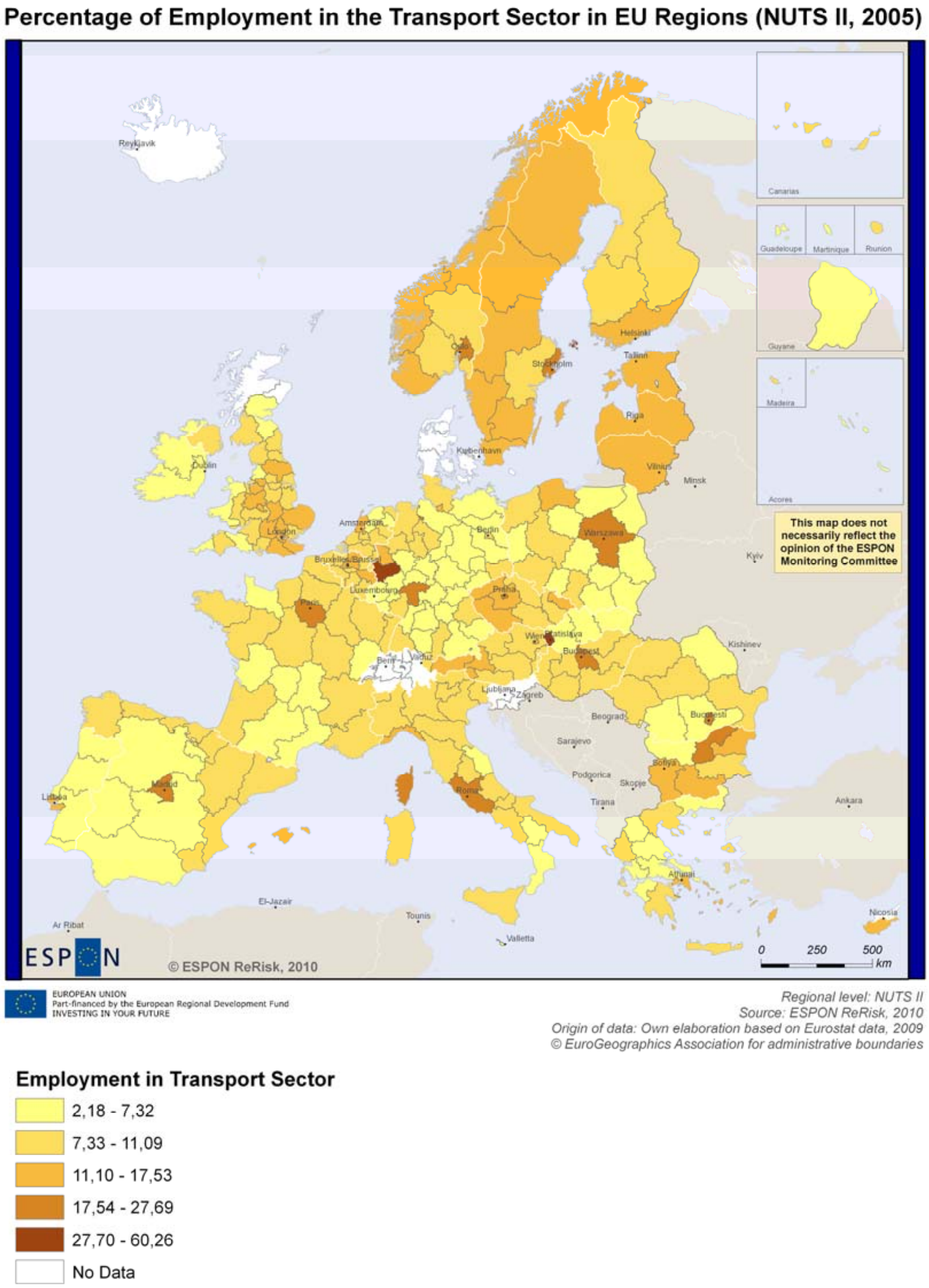
Employment data is not available for Slovenia, Denmark and Switzerland.

AN.1.3.4. Information from National Sources

In Slovenia, the latest data on regional employment available from the national statistical office refers to the year 2004, but the data is not organized according to the NACE code of activities, so it could not be taken into account for the calculation of this indicator.

[19] See, for example, IRU's "RESOLUTION ON THE FUEL PRICE CRISIS" of 26 June 2008

AN.1.3.5. Map



Source: Own elaboration based on Eurostat data

Map 16 Percentage of Employment in the Transport Sector in EU Regions (NUTS II, 2005)

AN.1.4. Regional Spending on Transport Fuel

AN.1.4.1. Relevance

This indicator measures which percentage of the regional gross domestic product is dedicated to fuel costs for freight transport. These costs do not only affect the regional economy as a whole, but also individual businesses and households, as these increments are passed on to final customers upon purchasing a transported good.

AN.1.4.2. Data Source

The data was facilitated by DG Regio and was originally used to calculate the “energy vulnerability index” for the “Regions 2020” report[20].

AN.1.4.3. Data Quality and Gaps

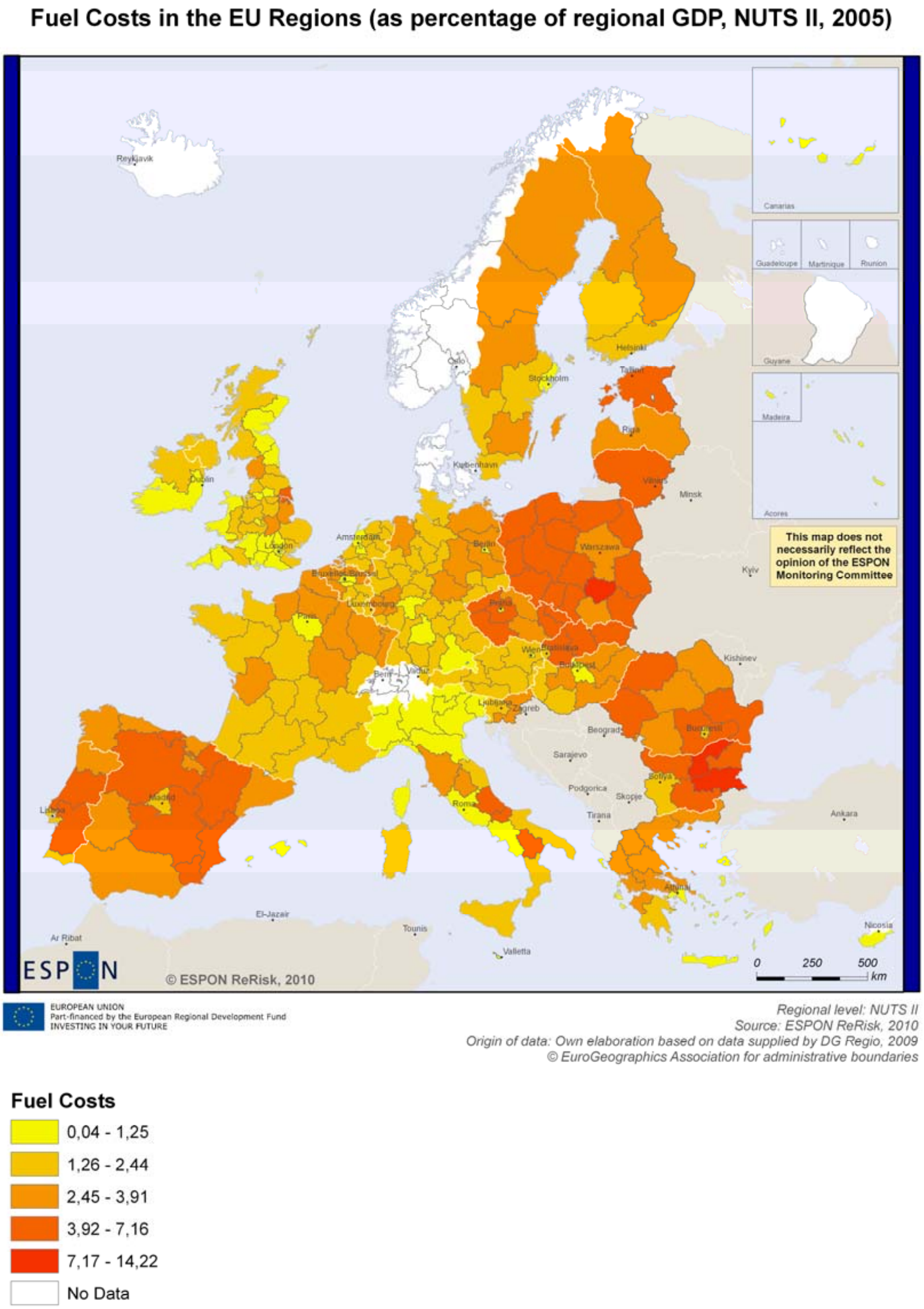
Data coverage is complete for the EU 27, but does not include Switzerland and Norway.

AN.1.4.4. Information from National Sources

GdP values (in national currencies) are available for the Norwegian regions, but information on regional fuel costs could not be found at the Norwegian Statistical Office’s database.

[20] Commission Staff Working Document (2008), “Regions 2020. An Assessment of Future Challenges for EU Regions”

AN.1.4.5. Map



Source: DG Regio

Map 17 Fuel Costs in the EU Regions (as percentage of regional GdP, NUTS II, 2005)

AN.1.5. Commuting between Regions

AN.1.5.1. Relevance

This variable measures the relation between the population commuting to other regions and the population working in the same region. The daily movements of workers are closely associated to energy demand in the transport sector. Obviously, the percentage of people working in another region tends to be greater in smaller regions, but the ReRisk results show that the area size of the region is not the determining factor for high levels of commuting, but rather the access to job and growth centres in nearby regions. Some of the regions with high levels of commuting have a close to average size, and some of the smallest regions have low levels of commuting. Furthermore, the main argument with regard to policy recommendations is independent from the area size, since improving public transport networks to offer cheaper alternatives to commuting workers, requires *interregional cooperation*, which, in the past, has often been a serious obstacle to unifying transport services.

AN.1.5.2. Data Source

Both data sets (workplace in the same region and workplace in another region) are available from Eurostat in the section of "Regional employment - LFS series". The ratio was calculated by the project team.

AN.1.5.3. Data Quality and Gaps

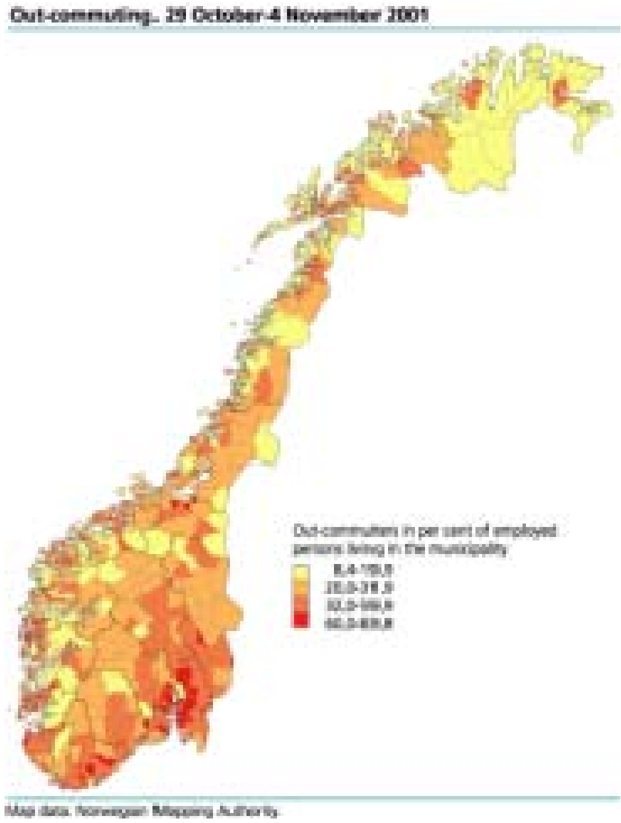
Needs for commuting within a region can presently not be identified on the base of Eurostat data, nor is information available on the transport modes used for commuting. The regional data on passenger transport available from Eurorostat includes the use of railways, but does not distinguish between the motives of trips, i.e. daily commuting or travel for leisure.

Data coverage is quite complete for this indicator, with the exception of the French Overseas Territories and some Greek islands. However, the smaller Member States that are not divided into NUTS II regions (Malta, Latvia, Lithuania) are not considered by Eurostat.

AN.1.5.4. Information from National Sources

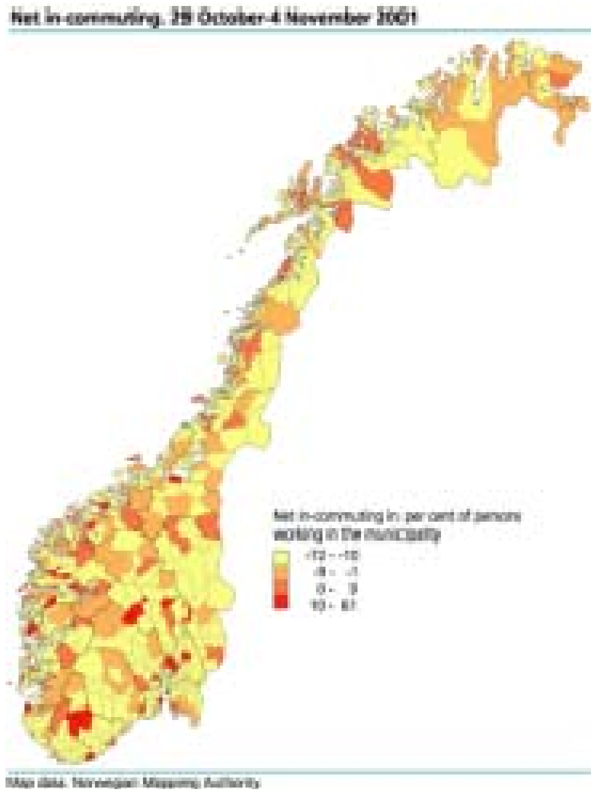
In some regions, for example in Wales, the data collected for the Labour Force Survey is processed to analyse the level of commuting within the area. Further research on this issue is therefore highly recommended.

Statistics Norway also offers interesting information on commuting patterns on the level of municipalities, although the reference year is 2001 (Census data), as shown in Maps 13 and 14.



Map 18 Commuting in Norwegian Municipalities (Out-Commuting 2001)

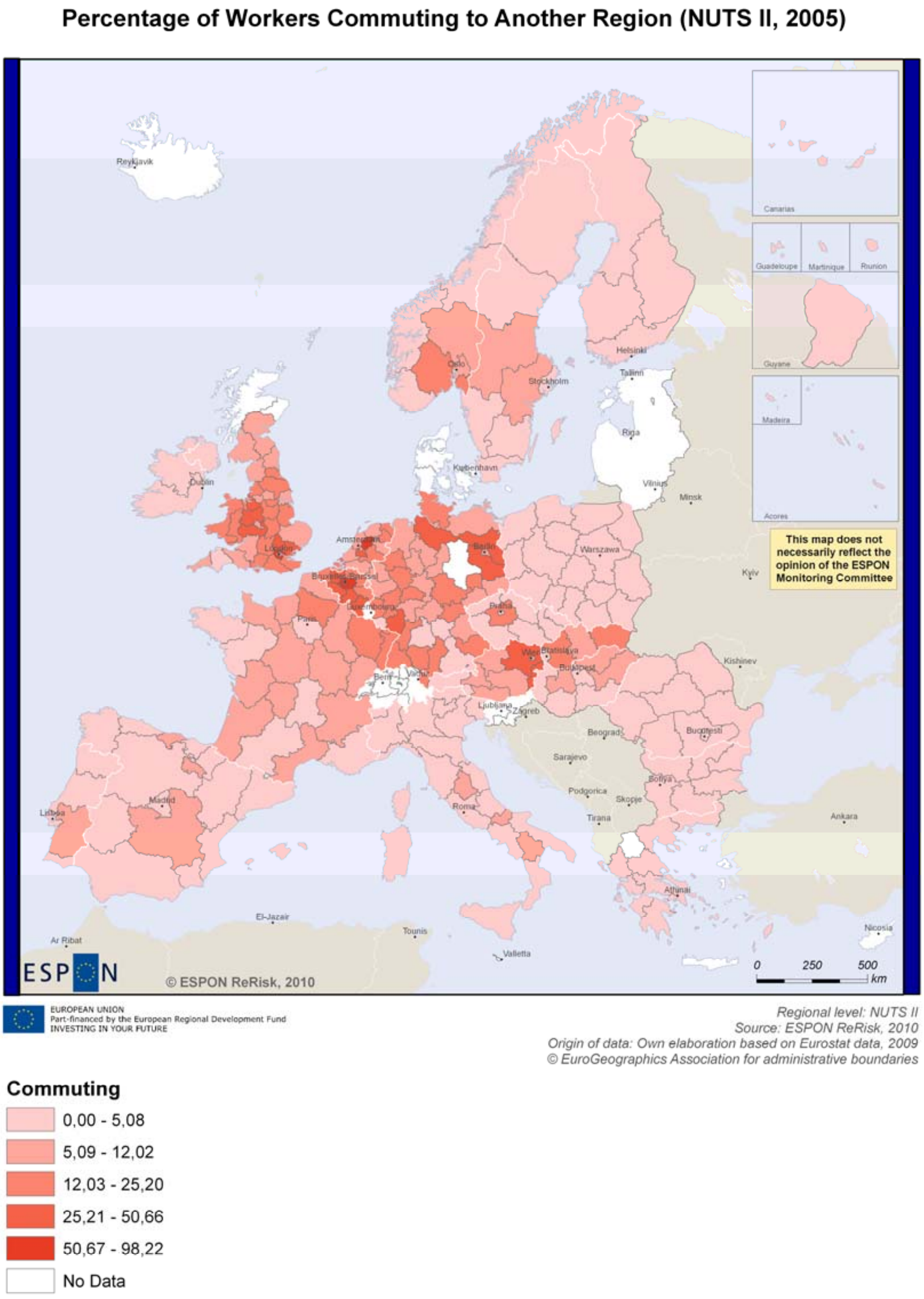
Source: Statistics Norway



Map 19 Commuting in Norwegian Municipalities (In-Commuting 2001)

Source: Statistics Norway

AN.1.5.5. Map



Source: Own elaboration based on Eurostat data

Map 20 Percentage of Workers Commuting to Another Region (NUTS II, 2005)

AN.1.6. Regional Air Travel

AN.1.6.1. Relevance

The total number of passengers embarked and disembarked in a given region makes it possible to identify the main hubs of air travel in Europe, as well as those island and peripheral regions, which depend heavily on air transport. Switching to alternative fuels is one of the prime challenges for the industry in view of rising oil prices, but progress in this field is going slowly, so that travelling by air is likely to become much more expensive in the near future.

AN.1.6.2. Data Source

Eurostat collects this indicator in the section on regional transport data. The ratio of passengers to total regional population has been calculated by the project team.

AN.1.6.3. Data Quality and Gaps

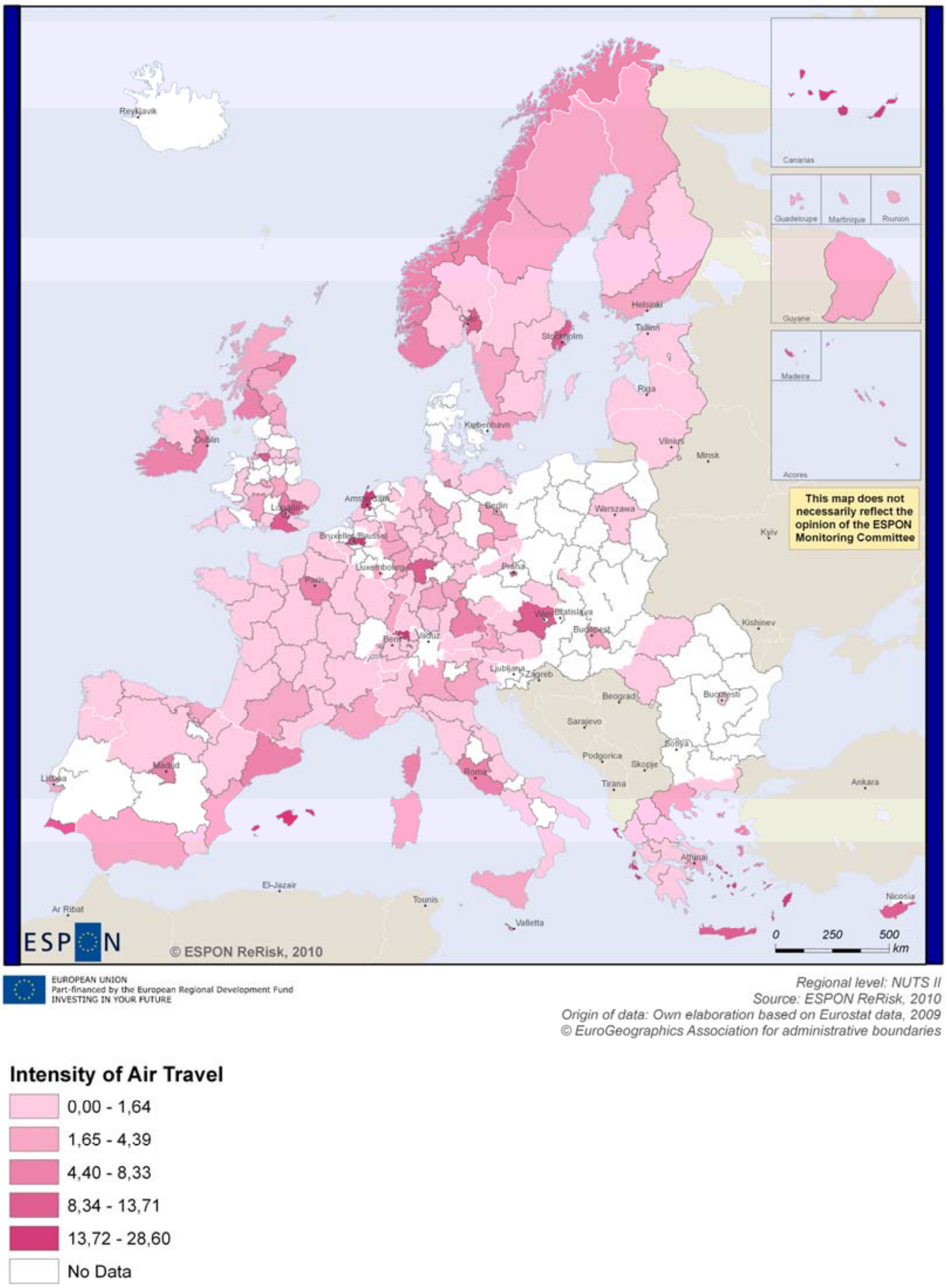
Data is lacking for a considerable number of regions for the reference year 2005, but has been slightly updated and completed for later years. However, all major air transport hubs were already identified in 2005, except for Hovedstaden in Denmark.

AN.1.6.4. Information from National Sources

Data from Eurostat offers a clear picture of dependence on air travel in the regions, so it has not been necessary to check for national data in this case.

AN.1.6.5. Map

Intensity of Air Travel in the EU Regions
(passengers embarged / total population, NUTS II, 2005)



Map 21 Intensity of Air Travel in the EU Regions (NUTS II, 2005)

AN.1.7. Long-term Unemployment

AN.1.7.1. Relevance

The share of long-term unemployment is the share of unemployed persons who have been in this situation for 12 months or more, expressed as a percentage of the total number of unemployed. Long-term or structural unemployment is one of the main reasons for people being driven permanently out of the labour market, thus loosing the income and social benefits associated to paid labour.

AN.1.7.2. Data Source

This indicator is calculated directly by Eurostat on a yearly basis and can be accessed online under “Regional labour market statistics”.

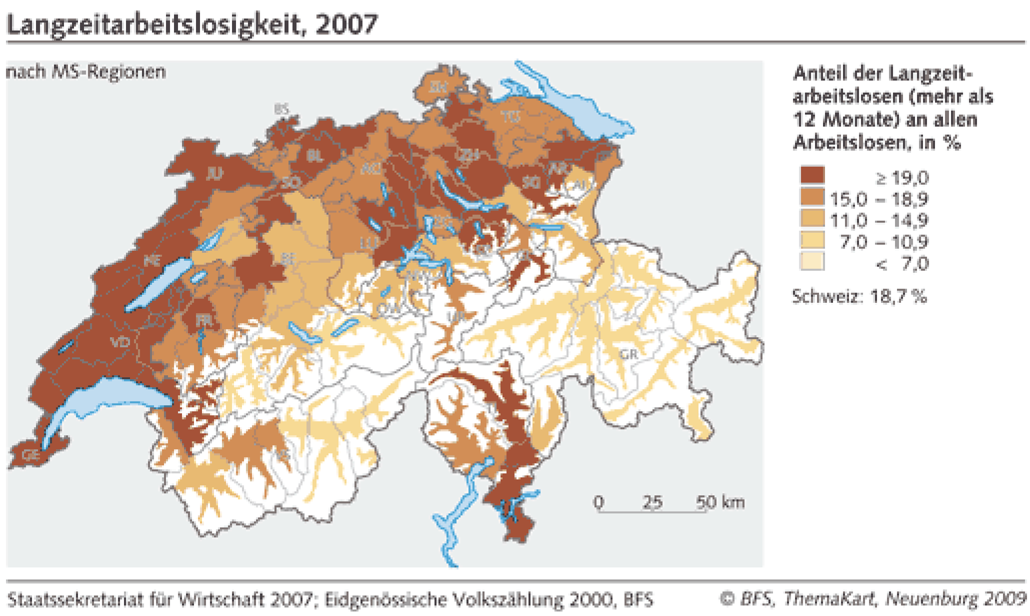
AN.1.7.3. Data Quality and Gaps

Data coverage is almost complete for EU 27 and Norway, but Eurostat does not calculate this indicator for Switzerland.

AN.1.7.4. Information from National Sources

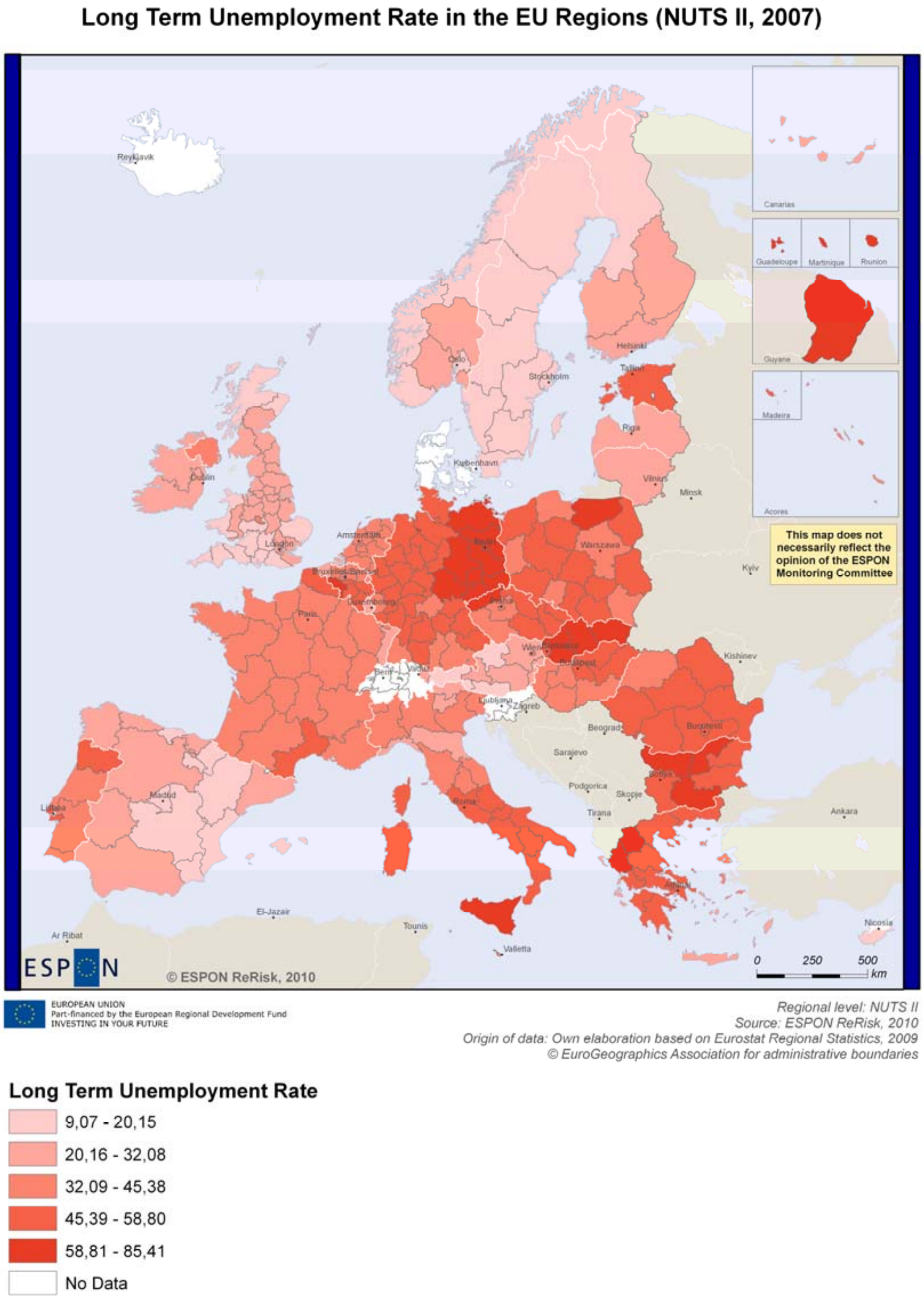
Regional data on long-term unemployment can be obtained from the Swiss Statistical Office as raw data or in the form of maps for the 106 Swiss “MS = Mobilité spatiale” regions.

Map 22 Long term Unemployment Rate in the Swiss MS Regions, 2007



Source: Swiss Statistical Office

AN.1.7.5. Map



Source: Own elaboration based on Eurostat data

Map 23 Long term Unemployment Rate in the EU Regions (NUTS II, 2007)

AN.1.8. Activity Rate

AN.1.8.1. Relevance

Activity rates represent the labour force as a percentage of the population of working age (15-64 years). In statistical terms, all persons who are not classified as employed or unemployed are defined as inactive. Inactivity or lack of access to the labour market is one of the main reasons for poverty, although in some Eastern countries, there is also a considerable percentage of “working poor”. The different forms of “inactivity” (unemployed, retired and other inactivity) have a strong influence on the risk of poverty, as 73% of the poor population in Europe is affected by this situation.

AN.1.8.2. Data Source

The economic activity rates by sex and age, at NUTS levels 1 and 2 are derived from the yearly labour force survey and calculated by Eurostat. The data is available in the section on “Regional labour market statistics” at the Eurostat web site.

AN.1.8.3. Data Quality and Gaps

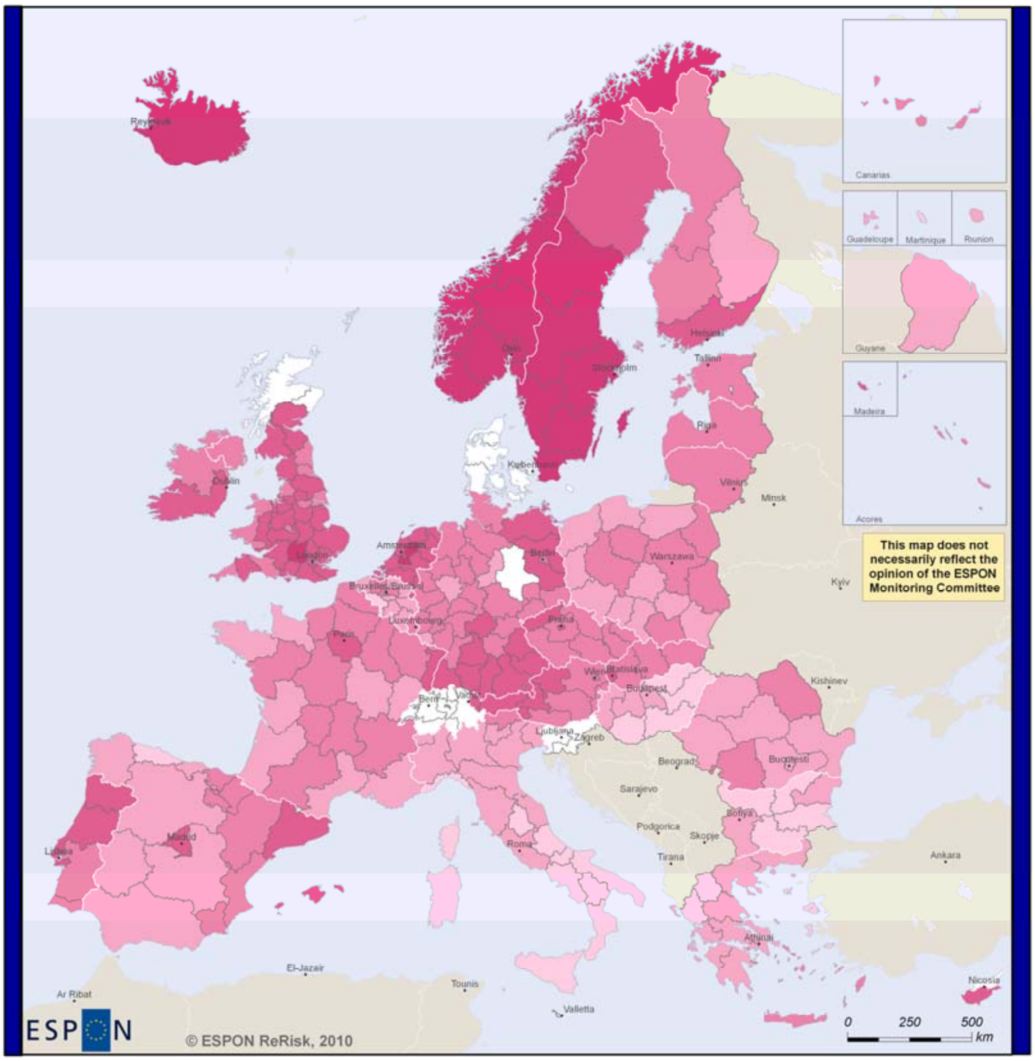
Data coverage for the EU 27 is almost complete, except for Denmark and Slovenia.

AN.1.8.4. Information from National Sources

Activity rates by sex for the Slovenian statistical regions (but not NUTS II level) can be found for the years 2000 – 2004 at the National Statistical Office’s database, organized by type of region (thinly or densely populated).

AN.1.8.5. Map

Activity Rate in the EU Regions (NUTS II, 2005)



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Regional level: NUTS II
Source: ESPON ReRisk, 2010
Origin of data: Own elaboration based on Eurostat data, 2009
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Activity Rate

- 41,70 - 49,50
- 49,51 - 55,30
- 55,31 - 60,20
- 60,21 - 66,80
- 66,81 - 81,40
- No Data

Map 24 Activity Rate in the EU Regions (NUTS II, 2005)

AN.1.9. Age Dependency Ratio

AN.1.9.1 Relevance

This indicator is the ratio between the total number of elderly persons of an age when they are generally economically inactive (aged 65 and over) and the number of persons of working age (from 15 to 64). The risk of elderly people sliding into poverty depends on the level of social protection and solidarity among family members. According to analysis carried out on the base of national data, "social benefits (pensions and other transfers) reduce the proportion of people at risk of poverty in all countries but to very differing degrees: the reduction ranging from 50% or less in Greece, Ireland, Portugal, Cyprus and Malta to more than 70% in Denmark, Luxembourg, Finland, Sweden, the Czech Republic and Slovakia." [EC/Eurostat 2006].

AN.1.9.2. Data Source

Data on the regional population by age classes can be accessed at the Eurostat webpage, in the section "Regional demographic statistics". The ratio has been calculated by the project team.

AN.1.9.3. Data Quality and Gaps

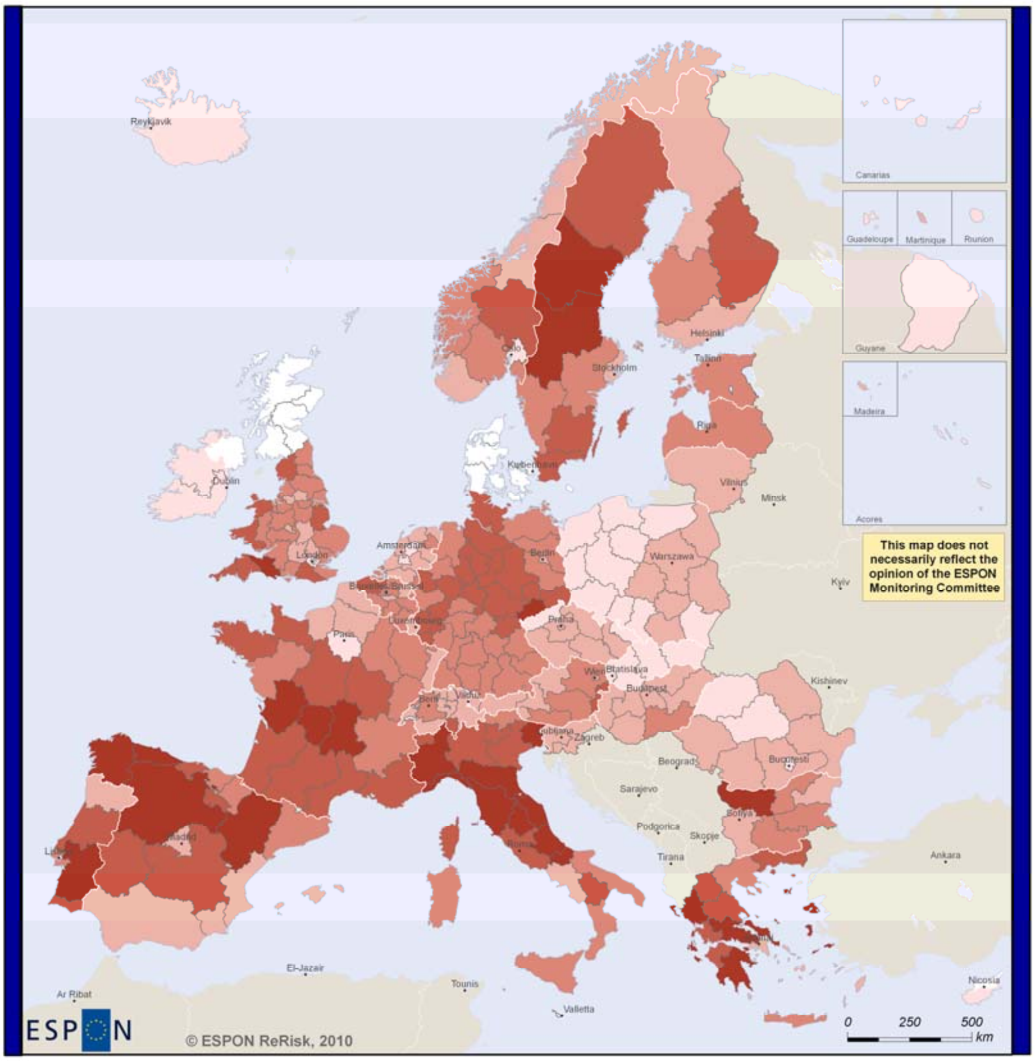
Data coverage is again very complete for this demographic indicator, with the exception of Denmark and three UK regions.

AN.1.9.4. Information from National Sources

It has not been necessary to consult national information sources.

AN.1.9.5. Map

Age Dependency Ratio in the EU Regions (NUTS II, 2005)



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Regional level: NUTS II
Source: ESPON ReRisk, 2010
Origin of data: Own elaboration based on Eurostat data, 2009
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Age Dependency Ratio

- 6,16 - 19,03
- 19,04 - 23,33
- 23,34 - 26,93
- 26,94 - 30,96
- 30,97 - 42,38
- No Data

Map 25 Age Dependency Ratio in the EU Regions (NUTS II, 2005)

AN.1.10. Disposable Income of Households

AN.1.10.1. Relevance

Disposable income, measured in power purchase standards (pps), explains the income differences in the European regions and is relevant for the risk of poverty in two aspects: on one hand, it explains the strain that rising energy prices can put on household budgets and, on the other, it is an indicator for the possibilities of private investment in energy savings measures and renewable energy technologies.

AN.1.10.2. Data Source

This indicator is entirely calculated by Eurostat on a yearly basis and has recently been updated.

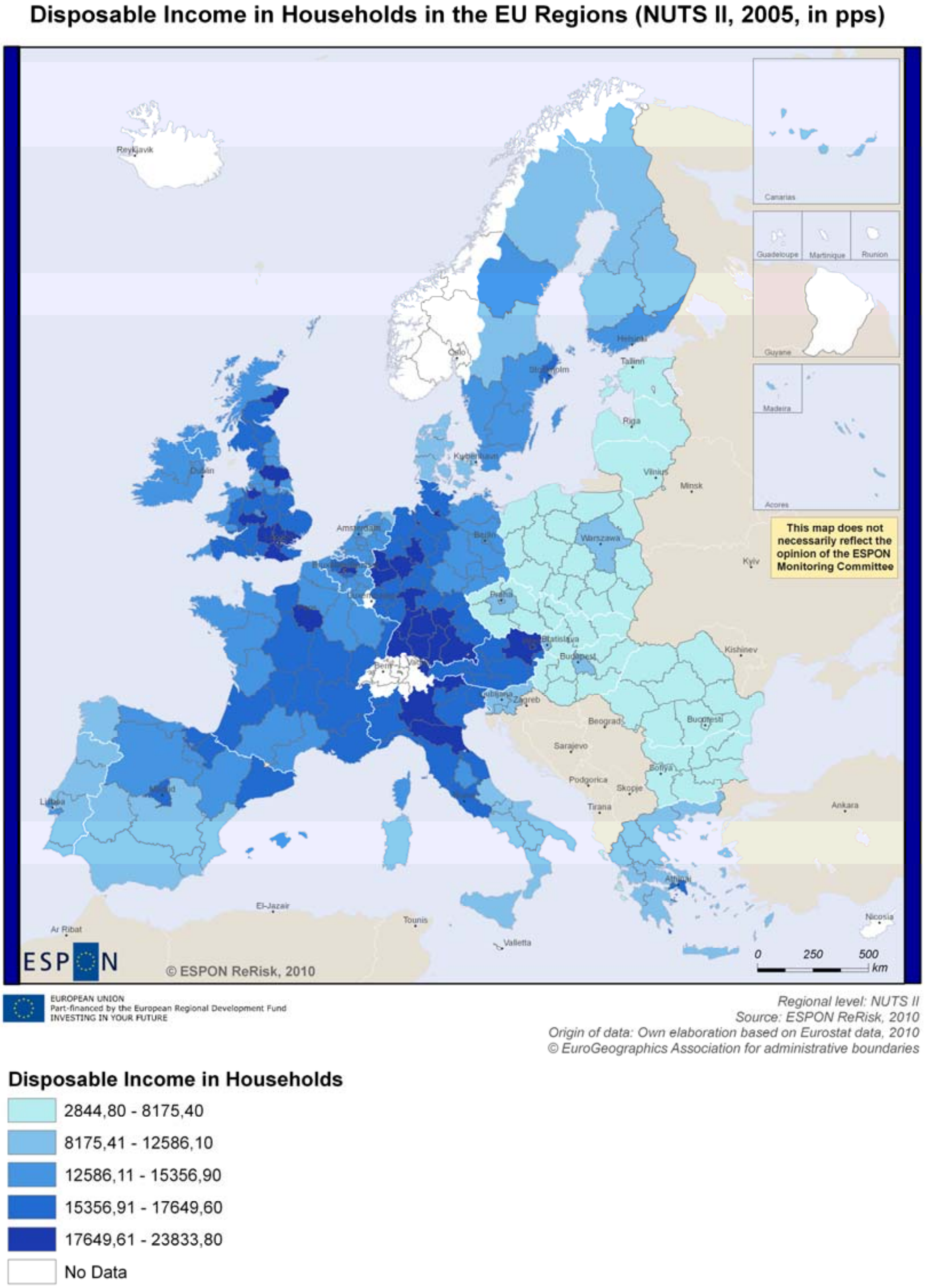
AN.1.10.3. Data Quality and Gaps

The only EU regions not covered in the Eurostat database are the French Overseas Territories. Norway is also not included in the Eurostat statistics, although this data has very recently been updated.

AN.1.10.4. Information from National Sources

Data on household income and debt from Statistics Norway indicates that there are important inequality within the regions and cities, especially in Oslo. Norwegian households are also highly indebted. However, in 2008, household incomes in the highest wage groups have grown slower than those of poorer households. Statistics Norway gives the following explanation: "The financial situation of households at the top of the income distribution is strongly influenced by changes in the financial markets. In the wake of the finance crisis, many shareholders sold off shares that had fallen in value. These capital losses led to a weaker growth in household income for those at the top of the income distribution compared to people in the middle of the distribution. The share of total household income received by the top decile was reduced from 21.4 per cent in 2007 to 20.8 per cent in 2008."

AN.1.10.5. Map



Map 26 Disposable Income in Households in the EU Regions (NUTS II, 2005)

AN.1.11. Onshore Wind Power Potential

AN.1.11.1. Relevance

This indicator identifies those regions in Europe, which have the highest potential for producing electricity from on-shore wind power. However, the European Environmental Agency [EEA 2009] has introduced some restrictions when calculating the maximum potential, mainly due to environmental reasons. ReRisk has followed these recommendations, using the "restrained" wind potential for the regional analysis. The EEA explains that the report provides an "analysis of local wind resources across Europe, primarily based on wind speed data. Those findings are then used along with projections of wind turbine technology development to calculate the maximum amount of wind energy that could be generated (the technical potential) in 2020 and 2030.

Evidently, raw potential is only part of the story. Policymakers need to know how much wind energy is feasible in practical terms and that calls for the integration of other factors into the analysis. For that reason, the subsequent analysis uses various proxies to convey both the (socially and environmentally) 'constrained potential' for wind energy development and the 'economically competitive potential'.

To calculate 'constrained potential', Natura 2000 and other protected areas are excluded from the calculations of wind energy potential. Although it is not illegal to site wind farms on Natura 2000 sites, they provide a useful proxy for the restrictions implied by biodiversity protection".

Wind power potential is measured in m/s, but the ReRisk indicator also accounts for the area size of the regions (km^2).

AN.1.11.2. Data Source

This data on wind intensity in the regions was prepared in GIS format by the European Topic Centre on Air and Climate change (ETC/ACC), led by PBL the Netherlands, on request of the European Environmental Agency [EEA 2009]. The data was converted to NUTS II level by the NTUA researchers, with help from the ESPON database project.

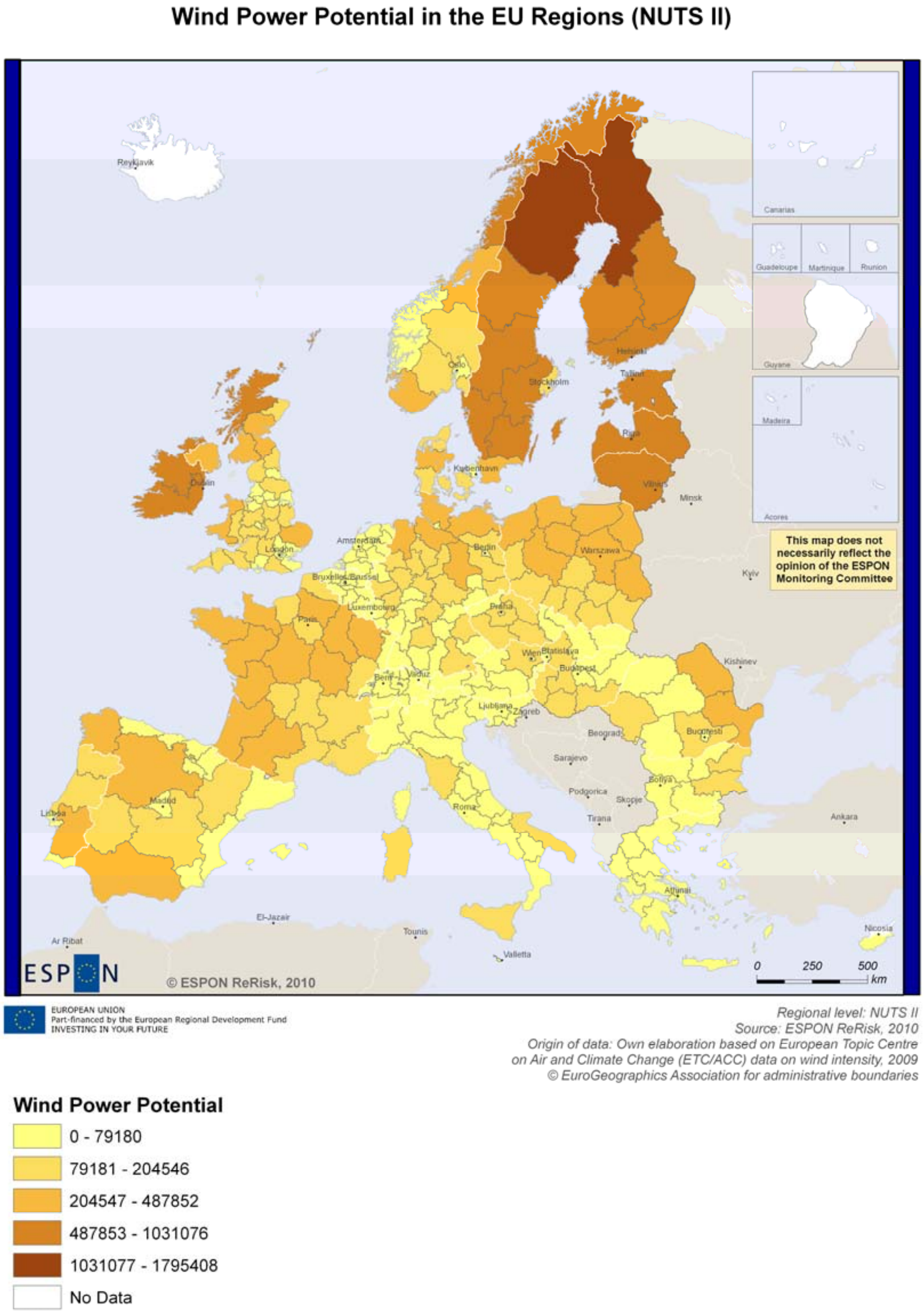
AN.1.11.3. Data Quality and Gaps

The data set obtained from EEA covers the whole of continental Europe, but not the Overseas Territories and islands.

AN.1.11.4. Information from National Sources

The Danish pioneering experience in the use of spatial planning for the development of wind energy has been well documented and constitutes an interesting reference document [Miles et al 2004].

AN.1.11.5. Map



Map 27 Wind Power Potential in the EU Regions (NUTS II)

Source: Own elaboration based on European Topic Centre on Air and Climate change (ETC/ACC) data on wind intensity

AN.1.12. PV Potential

AN.1.12.1. Relevance

The data refers to the yearly total yield of estimated solar electricity generation (for horizontal, vertical, optimally-inclined planes) [kWh] within the built environment. These types of installations will be the first to become competitive at end-use level with electricity obtained from the central grid, with estimates from the International Energy Agency [IEA 2010] pointing to 2020 as break-even point in the regions with the highest PV potential.

AN.1.12.2. Data Source

Data on PV potential in the regions was provided Joint Research Centre's Sunbird data base, which forms part of the SOLAREC action at the JRC Renewable Energies Unit.

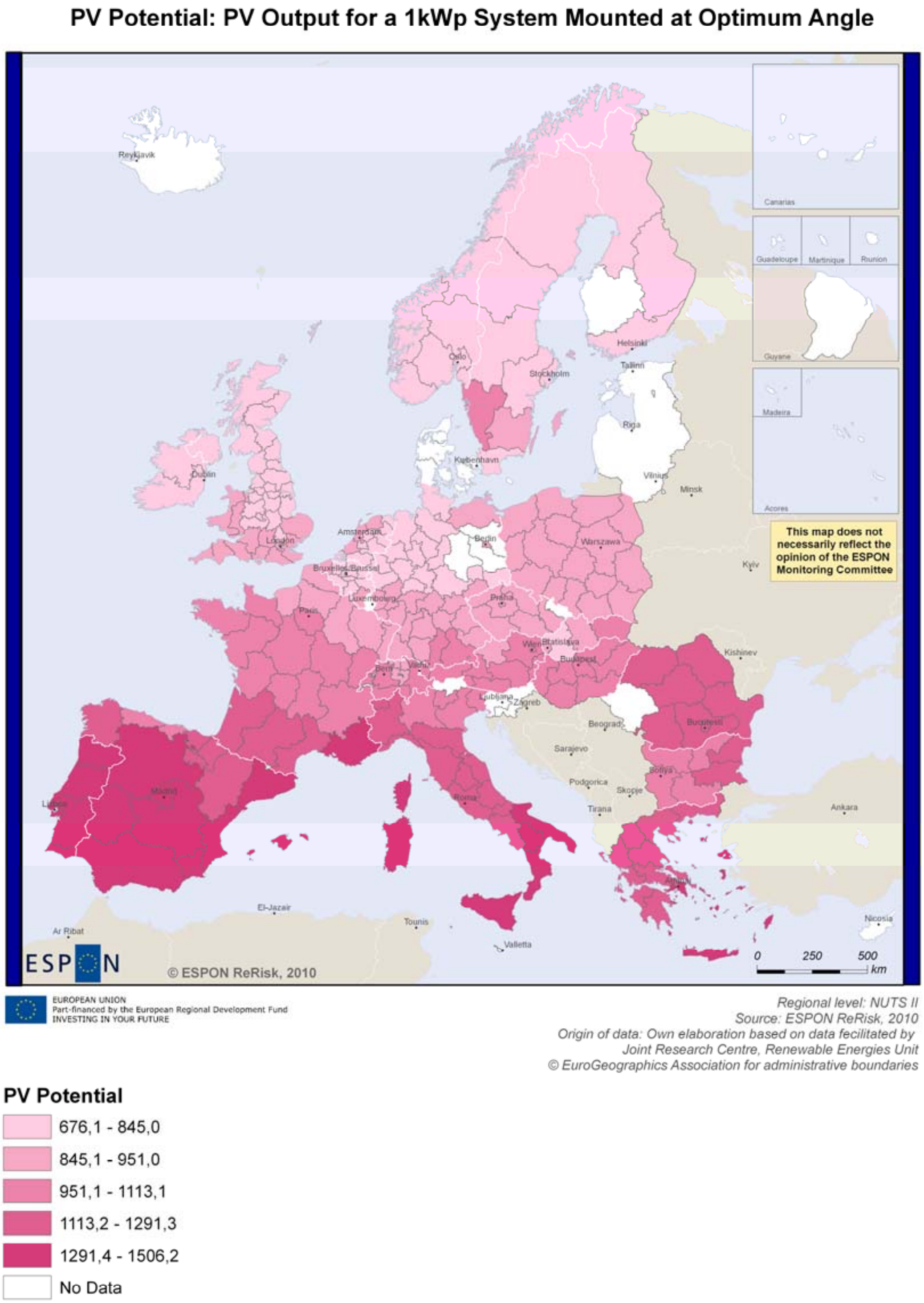
AN.1.12.3. Data Quality and Gaps

The JRC data set excludes most island regions, Denmark and Switzerland, but contains data for Norway.

AN.1.12.4. Information from National Sources

Some information on the Swiss PV potential and on the methodology employed for calculating the PV potential can be obtained from the International Energy Agency [IEA 2002].

AN.1.12.5. Map



Source: Own elaboration based on data facilitated by the Joint Research Centre, Renewable Energies Unit

Map 28 PV Potential in the EU Regions (NUTS II)

AN.1.13. PUSH Factor: Potential Urban Strategic Horizon

AN.1.13.1. Relevance

PUSH (Potential Urban Strategic Horizon) areas are well-connected local hubs that can be reached in 60 – 90 minutes travel by car from the surrounding areas and are therefore considered to offer opportunities for polycentric development. The PUSH factor is related to the so-called Functional Urban Areas (FUA), a term that was chosen in ESPON Project 1.1.1 to compensate the lack of a universal definition of what is a city or what is urban, as the political and even more administrative perception of both concepts vary widely across the study area (which comprise the old and new EU Member States plus Norway and Switzerland). This term expresses also the strong believe that a discussion of polycentricity, restricted to the analysis of nodes (in a network), is too narrow in the sense that this only reflects the European or even national approach, but is neglecting the fact that polycentricity also has a strong regional (or even local) dimension when analyzing functional linkages between core cities and their surroundings. This idea is interesting also in relation to energy consumption, since more compact and, at the same time, more decentralized spatial development concepts could contribute to creating less energy-intensive economies and societies in the longer run.

AN.1.13.2. Data Source

This indicator was originally calculated on NUTS 5 level by ESPON project 1.1.1 and has been converted to NUTS II by the ReRisk team.

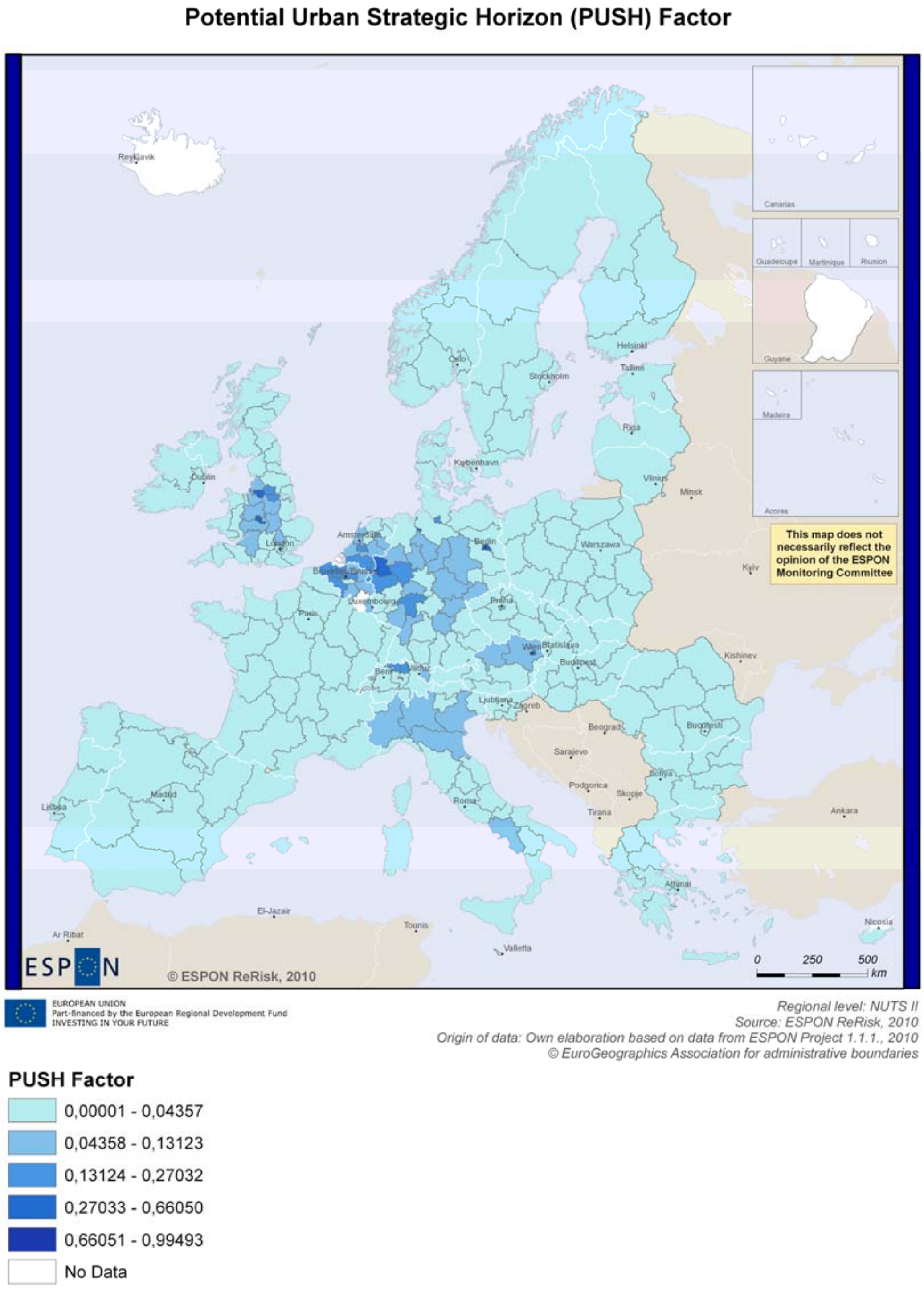
AN.1.13.3. Data Quality and Gaps

These areas have not been defined for the French Overseas Territories, the Spanish enclaves in Ceuta and Melilla, the Portuguese and one Finnish island region.

AN.1.13.4. Information from National Sources

This work had already been carried out by ESPON project 1.1.1.

AN.1.13.5. Map



Map 29 Potential for Polycentric Development in the EU Regions (NUTS II)

Annex 2: Statistical Data for Regions

Table 40 Statistical Data for Regions

NUTS2_2006	Regions' name	Typology	Mean minimum January temperature (degree Celsius, last 15 years)	Mean maximum July temperature (degree Celsius, last 15 years)	GVA in industries with high energy purchases (% of total regional GVA), 2005	Employment in industries with high energy purchases (% of total regional employment), 2005	Employment in transport sector (% of total regional employment) 2005	Commuting (persons working in another region / persons working in the same region), 2005	Fuel costs in freight transport (% of regional GdP), 2005	Air travel (passengers embarked and disembarked / total regional population)
AT11	Burgenland (A)	3	-10,67	33,43	3,78%	1,526	7,89%	50,659	1,714	
AT12	Niederösterreich	3	-12,05	32,89	8,09%	3,504	10,87%	36,293	2,238	10,03
AT13	Wien	1b	-10,54	34,01	3,37%	2,254	16,69%	9,323	0,393	
AT21	Kärnten	1b	-14,63	31,59	9,78%	4,752	10,23%	7,180	1,868	0,93
AT22	Steiermark	1a	-13,67	32,15	7,44%	4,135	10,10%	5,789	1,845	0,72
AT31	Oberösterreich	1b	-13,21	32,59	8,40%	4,889	10,63%	6,423	2,312	0,49
AT32	Salzburg	1b	-15,25	32,06	8,41%	4,812	14,61%	8,375	1,742	3,14
AT33	Tirol	1a	-13,92	28,15	9,43%	5,433	13,02%	3,619	1,424	1,04
AT34	Vorarlberg	1b	-12,01	31,37	8,84%	5,279	10,46%	12,444	1,569	
BE10	Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest	1b	-6,12	31,03	2,67%	3,122	26,07%	19,066	0,180	
BE21	Prov. Antwerpen	1b	-6,72	31,17	12,51%	7,869	16,20%	13,794	2,561	
BE22	Prov. Limburg (B)	1b	-7,82	32,35	13,13%	7,267	9,57%	23,333	3,005	
BE23	Prov. Oost-Vlaanderen	3	-5,13	30,73	8,75%	4,728	9,07%	31,929	2,855	
BE24	Prov. Vlaams Brabant	3	-6,51	31,25	3,79%	2,104	14,71%	72,922	1,238	15,32
BE25	Prov. West-Vlaanderen	1b	-4,65	29,63	11,02%	7,508	10,08%	12,509	3,058	
BE31	Prov. Brabant Wallon	3	-6,71	31,09	16,44%	7,715	9,25%	98,219	0,829	
BE32	Prov. Hainaut	1b	-6,27	30,58	8,82%	4,591	9,90%	29,065	2,543	1,45
BE33	Prov. Liège	1b	-8,13	31,36	6,89%	3,558	11,60%	13,968	1,990	

NUTS2_2006	Regions' name	Typology	Mean minimum January temperature (degree Celsius, last 15 years)	Mean maximum July temperature (degree Celsius, last 15 years)	GVA in industries with high energy purchases (% of total regional GVA), 2005	Employment in industries with high energy purchases (% of total regional employment), 2005	Employment in transport sector (% of total regional employment) 2005	Commuting (persons working in another region / persons working in the same region), 2005	Fuel costs in freight transport (% of regional GdP), 2005	Air travel (passengers embarked and disembarked / total regional population)
BE34	Prov. Luxembourg (B)	3	-8,87	30,43	1,15%	0,414	9,04%	45,143	1,838	
BE35	Prov. Namur	3	-8,09	30,73	7,38%	3,003	10,05%	45,164	1,699	
BG31	Severozapaden	2	-10,72	36,81	3,56%	1,408	4,31%	1,289	6,387	
BG32	Severen tsentralen	2	-11,41	37,17	3,44%	4,458	19,18%	1,027	14,221	
BG33	Severoiztochen	2	-11,05	33,57	8,65%	7,799	17,53%	0,648	7,162	
BG34	Yugoiztochen	2	-9,71	36,95	3,51%	1,111	9,31%	0,969	8,183	
BG41	Yugozapaden	1a	-12,41	34,57	3,69%	2,984	14,64%	1,881	2,267	
BG42	Yuzhen tsentralen	2	-10,73	37,82	7,35%	8,164	14,90%	2,602	6,722	
CH01	Région lémanique									0,06
CH02	Espace Mittelland									1,20
CH03	Nordwestschweiz									17,54
CH04	Zürich									0,07
CH05	Ostschweiz									
CH06	Zentralschweiz									0,26
CH07	Ticino									0,00
CY00	Cyprus		2,11	38,04	11,70%	6,659	13,60%		1,081	8,95
CZ01	Praha	1a	-12,47	33,08	4,86%	4,442	23,64%	3,744	1,152	9,12
CZ02	Stredni Cechy	2	-13,19	32,11	14,09%	9,186	11,40%	21,653	6,267	
CZ03	Jihozápad	2	-13,79	31,54	13,03%	9,706	13,15%	3,389	4,793	
CZ04	Severozápad	2	-12,67	32,13	20,37%	11,488	12,43%	3,504	5,547	0,03
CZ05	Severovýchod	2	-14,96	31,28	15,64%	12,524	10,75%	2,876	3,831	
CZ06	Jihovýchod	2	-13,83	31,68	14,43%	11,326	11,09%	3,688	3,742	0,17
CZ07	Stredni Morava	2	-14,57	31,69	16,04%	12,754	10,10%	3,965	5,307	
CZ08	Moravskoslezsko		-15,70	31,21	25,13%	14,225	12,14%	2,743	4,805	0,19
DE11	Stuttgart	1a	-11,33	32,27	3,44%	2,891	6,40%	2,617	1,209	2,31

NUTS2_2006	Regions' name	Typology	Mean minimum January temperature (degree Celsius, last 15 years)	Mean maximum July temperature (degree Celsius, last 15 years)	GVA in industries with high energy purchases (% of total regional GVA), 2005	Employment in industries with high energy purchases (% of total regional employment), 2005	Employment in transport sector (% of total regional employment) 2005	Commuting (persons working in another region / persons working in the same region), 2005	Fuel costs in freight transport (% of regional GdP), 2005	Air travel (passengers embarked and disembarked / total regional population)
DE12	Karlsruhe	1b	-10,41	32,79	9,19%	2,988	5,77%	14,401	1,490	0,28
DE13	Freiburg	1b	-9,45	31,58	5,00%	3,330	7,66%	14,953	1,602	0,00
DE14	Tübingen	1b	-11,21	30,67	10,33%	3,478	6,20%	14,678	1,597	0,32
DE21	Oberbayern	1a	-12,70	31,84	11,51%	3,617	6,28%	2,558	1,060	6,73
DE22	Niederbayern	1b	-13,47	31,85	16,84%	3,552	4,10%	12,545	2,269	0,00
DE23	Oberpfalz	1b	-13,41	31,75	11,87%	4,763	7,93%	9,903	2,271	
DE24	Oberfranken	1b	-12,54	31,25	10,04%	4,972	5,07%	12,373	1,790	0,02
DE25	Mittelfranken	1a	-12,95	32,54	8,00%	4,418	4,97%	4,223	1,448	2,27
DE26	Unterfranken	1b	-11,17	32,33	10,45%	4,137	6,99%	12,015	1,964	
DE27	Schwaben	1b	-13,60	31,81	10,49%	5,030	8,24%	13,095	2,036	0,01
DE30	Berlin	1a	-11,18	32,58	0,00%	1,811	7,88%	5,682	0,544	3,54
DE41			-11,56	31,77	8,63%	2,572	4,89%	34,583	3,711	
DE42			-12,27	32,67	10,03%	2,525	7,21%	31,596	3,430	3,57
DE50	Bremen	1a	-8,67	30,89	0,00%	0,674	25,25%	8,683	2,458	2,58
DE60	Hamburg	1a	-10,11	31,29	0,00%	1,026	17,03%	6,633	1,435	6,08
DE71	Darmstadt	1b	-10,61	32,74	9,72%	4,591	24,20%	9,858	0,817	13,71
DE72	Gießen	1b	-10,66	31,64	9,17%	5,264	4,66%	16,675	1,708	0,00
DE73	Kassel	1a	-10,80	30,96	4,75%	3,292	6,76%	7,493	2,184	0,00
DE80	Mecklenburg-Vorpommern	1a	-9,64	30,32	0,00%	0,635	6,48%	8,898	2,747	0,03
DE91	Braunschweig	1a	-10,43	31,27	3,36%	2,490	6,48%	8,944	1,831	0,00
DE92	Hannover	1a	-9,67	31,39	4,22%	2,624	7,55%	7,636	1,870	2,55
DE93	Lüneburg	3	-9,79	31,33	7,13%	2,862	6,21%	48,338	2,093	0,00
DE94	Weser-Ems	1b	-8,39	30,79	13,33%	5,096	8,44%	10,345	2,676	0,00
DEA1	Düsseldorf	1a	-7,88	32,35	11,38%	5,777	12,90%	5,386	1,497	3,05
DEA2	Köln	1b	-9,09	32,31	10,99%	4,611	45,78%	9,070	1,429	2,15

NUTS2_2006	Regions' name	Typology	Mean minimum January temperature (degree Celsius, last 15 years)	Mean maximum July temperature (degree Celsius, last 15 years)	GVA in industries with high energy purchases (% of total regional GVA), 2005	Employment in industries with high energy purchases (% of total regional employment), 2005	Employment in transport sector (% of total regional employment) 2005	Commuting (persons working in another region / persons working in the same region), 2005	Fuel costs in freight transport (% of regional GdP), 2005	Air travel (passengers embarked and disembarked / total regional population)
DEA3	Münster	1b	-8,77	31,74	10,49%	4,567	7,79%	21,423	2,182	0,56
DEA4	Detmold	1a	-9,43	31,07	4,19%	2,269	7,52%	6,829	1,905	0,62
DEA5	Arnsberg	1b	-9,49	31,17	8,51%	4,112	7,10%	16,033	2,156	0,45
DEB1	Koblenz	1b	-10,57	31,70	10,07%	4,705	5,18%	19,089	2,527	1,97
DEB2	Trier	1b	-9,59	30,97	2,35%	1,529	4,32%	16,233	2,967	0,00
DEB3	Rheinhessen-Pfalz	3	-10,32	32,61	13,85%	6,815	9,75%	29,753	1,996	0,00
DEC0	Saarland	1a	-9,59	31,20	0,00%	6,567	6,24%	4,940	1,638	0,42
DED1	Chemnitz	1b	-12,69	30,89	10,50%	3,132	6,62%	10,373	2,028	
DED2	Dresden	1a	-12,73	31,91	5,13%	2,055	8,68%	6,348	2,022	1,04
DED3	Leipzig	1b	-11,75	32,65	10,40%	3,290	5,07%	12,749	2,405	1,89
DEE0	Sachsen-Anhalt		-10,94	32,08	12,73%	4,833	6,07%		3,672	
DEF0	Schleswig-Holstein	1b	-8,14	29,66	3,94%	1,867	7,50%	16,204	1,975	0,27
DEG0	Thüringen	1b	-11,67	31,08	9,60%	3,931	5,40%	12,676	2,718	0,18
DK01	Hovedstaden		-10,30	27,65						
DK02	Sjælland		-7,83	26,36						
DK03	Syddanmark		-7,95	27,75						
DK04	Midtjylland		-9,98	27,89						
DK05	Nordjylland		-9,63	27,58						
EE00	Estonia		-18,47	28,44	11,68%	9,238	14,54%		4,256	1,03
ES11	Galicia	2	-2,15	32,21	13,70%	4,529	7,95%	2,522	3,910	1,46
ES12	Principado de Asturias	1a	-0,83	28,10	21,02%	6,323	8,16%	2,973	3,535	1,21
ES13	Cantabria	1a	-3,26	31,68	12,23%	3,426	7,74%	5,423	4,146	1,16
ES21	Pais Vasco	1a	-4,69	34,80	18,40%	6,007	8,86%	2,197	3,136	2,14
ES22	Comunidad Foral de Navarra	1b	-3,71	37,29	17,82%	9,051	8,48%	4,851	4,451	0,57

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ES23	La Rioja	1a	-5,45	35,49	8,60%	2,576	4,86%	6,991	3,625	
ES24	Aragón	2	-7,65	36,84	12,05%	4,892	8,47%	1,845	4,928	0,34
ES30	Comunidad de Madrid	1a	-3,97	37,91	4,87%	1,978	25,45%	1,679	1,372	7,10
ES41	Castilla y León	2	-5,37	35,45	7,76%	3,545	5,92%	2,846	4,554	0,18
ES42	Castilla-la Mancha	2	-4,57	38,98	16,76%	7,303	6,31%	9,475	5,693	
ES43	Extremadura	1a	-0,91	40,16	7,19%	2,285	5,09%	2,825	3,513	
ES51	Cataluña	1a	-7,38	36,71	7,08%	4,096	9,52%	0,467	2,878	4,65
ES52	Comunidad Valenciana	2	-4,43	35,87	9,01%	4,722	8,07%	1,528	4,363	3,00
ES53	Illes Balears	1a	0,33	34,85	4,03%	1,394	14,79%	0,623	0,481	28,60
ES61	Andalucia	1a	-1,01	40,56	7,53%	2,456	7,11%	1,426	3,494	2,53
ES62	Región de Murcia	2	-2,96	37,09	14,93%	6,765	7,61%	2,760	6,129	1,08
ES63	Ciudad Autónoma de Ceuta (ES)		3,98	34,60	9,03%	0,843	7,49%	4,400	0,188	
ES64	Ciudad Autónoma de Melilla (ES)		4,49	34,69	3,75%	0,432	6,51%	2,804	0,041	3,87
ES70	Canarias (ES)		9,29	33,36	10,18%	2,703	9,84%	0,505	0,522	15,78
FI13	Itä-Suomi	4	-25,77	27,44	5,40%	2,925	10,04%	3,007	3,480	0,90
FI18	Etelä-Suomi	4	-19,16	27,63	9,41%	5,114	13,70%	1,311	1,587	4,38
FI19	Länsi-Suomi		-21,75	28,37	10,74%	6,415	10,13%	3,582	2,326	0,93
FI1A	Pohjois-Suomi	4	-28,65	26,91	13,58%	6,443	10,72%	3,271	3,029	2,81
FI20	Åland	1a	-10,83	25,55	2,78%	1,743	60,26%	3,846	1,600	1,78
FR10	Île de France	1a	-6,03	32,55	2,39%	2,570	27,69%	2,396	0,505	6,84
FR21	Champagne-Ardenne	1a	-8,52	32,10	5,47%	3,943	8,60%	5,965	3,177	0,02
FR22	Picardie	1b	-6,41	31,09	8,48%	5,789	8,38%	24,541	3,145	0,98
FR23	Haute-Normandie	1b	-5,27	29,86	9,90%	5,415	10,46%	10,730	3,019	0,04

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FR24	Centre	1a	-6,30	33,23	6,97%	4,507	7,51%	9,805	2,432	0,04
FR25	Basse-Normandie	1a	-4,35	29,45	3,12%	1,967	6,88%	6,407	2,168	0,10
FR26	Bourgogne	1a	-7,98	33,02	6,32%	4,542	8,63%	9,218	2,610	0,01
FR30	Nord - Pas-de-Calais	1a	-5,44	29,89	6,91%	4,397	8,85%	5,283	2,783	0,21
FR41	Lorraine	1b	-8,87	31,51	6,90%	4,289	8,26%	15,349	2,693	0,14
FR42	Alsace	1b	-9,31	32,85	5,86%	3,682	8,12%	12,817	2,569	1,76
FR43	Franche-Comté	1a	-8,45	32,21	5,61%	3,729	6,61%	7,138	2,124	
FR51	Pays de la Loire	1a	-4,62	31,93	3,89%	2,901	7,87%	4,446	2,347	0,61
FR52	Bretagne	1a	-3,31	28,93	3,50%	2,413	8,86%	3,786	2,062	0,57
FR53	Poitou-Charentes	1a	-4,87	33,31	3,71%	2,479	6,52%	6,892	2,458	0,16
FR61	Aquitaine	1a	-4,54	34,34	3,67%	2,295	8,19%	5,563	2,347	1,57
FR62	Midi-Pyrénées	1a	-5,78	33,83	2,68%	1,741	7,09%	4,151	1,602	2,33
FR63	Limousin	1a	-6,13	32,71	3,91%	2,485	7,21%	6,263	1,776	0,43
FR71	Rhône-Alpes	1a	-7,91	32,77	5,62%	4,057	9,93%	5,487	1,807	1,18
FR72	Auvergne	1a	-9,07	32,89	9,54%	6,280	6,51%	4,780	2,089	0,44
FR81	Languedoc-Roussillon	1a	-7,11	34,67	4,22%	1,965	7,32%	8,379	2,095	0,93
FR82	Provence-Alpes-Côte d'Azur	1a	-8,35	34,37	3,53%	1,932	10,50%	3,596	1,379	3,37
FR83	Corse	1a	0,83	32,07	2,57%	1,253	21,24%	2,849	0,325	8,33
FR91	Guadeloupe (FR)				2,20%	0,810	6,44%	0,131		4,22
FR92	Martinique (FR)				1,93%	0,745	5,09%	0,094		3,81
FR93	Guyane (FR)				3,27%	0,700	5,93%	0,796		1,85
FR94	Reunion (FR)				1,76%	0,916	7,82%	0,000		2,10
GR11	Anatoliki Makedonia, Thraki	1a	-6,72	36,39	3,37%	1,134	6,58%	0,176	3,558	0,92

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GR12	Kentriki Makedonia	1a	-6,07	37,77	3,71%	1,356	8,03%	0,164	3,552	1,92
GR13	Dytiki Makedonia		-10,65	36,35	6,01%	1,588	7,04%		3,387	0,03
GR14	Thessalia	1a	-6,41	38,80	12,99%	3,675	5,31%	0,482	2,881	0,37
GR21	Ipeiros	1a	-4,49	36,15	10,73%	3,804	7,79%	0,410	2,731	0,38
GR22	Ionia Nisia	1a	-0,59	35,37	5,33%	1,596	8,83%	0,221	1,020	14,86
GR23	Dytiki Ellada	1a	-5,36	36,13	9,21%	2,731	6,89%	0,262	3,270	0,53
GR24	Sterea Ellada	1a	-5,30	37,75	15,79%	4,131	6,94%	0,556	3,445	0,02
GR25	Peloponnisos	1a	-4,61	37,11	7,05%	1,069	8,75%	0,164	2,417	0,18
GR30	Attiki	1a	-0,51	37,77	4,49%	2,926	16,62%	0,074	1,102	3,58
GR41	Voreio Aigaio		-1,61	35,35	7,75%	2,267	9,19%		0,526	6,14
GR42	Notio Aigaio	1a	4,53	35,33	5,65%	1,861	14,55%	0,000	0,433	19,44
GR43	Kriti		3,50	36,53	6,06%	2,418	8,85%		1,004	10,74
HU10	Közép-Magyarország	1a	-11,97	35,03	7,60%	5,606	23,60%	1,616	1,168	2,78
HU21	Közép-Dunántúl	1b	-11,27	33,89	11,16%	6,933	9,06%	10,404	2,959	
HU22	Nyugat-Dunántúl	1a	-10,95	33,47	4,76%	3,148	10,86%	4,009	1,959	
HU23	Dél-Dunántúl	1a	-11,05	34,08	7,83%	5,966	8,63%	4,001	2,445	
HU31	Észak-Magyarország	1b	-12,19	34,25	14,81%	8,761	9,03%	10,679	2,995	
HU32	Észak-Alföld	1a	-13,14	35,33	9,08%	6,208	8,20%	5,398	2,621	
HU33	Dél-Alföld	2	-13,53	35,59	10,35%	8,070	9,03%	2,955	2,543	
IE01	Border, Midlands and Western	4	-2,85	22,51	0,00%	1,581	2,18%	1,348	1,788	0,69
IE02	Southern and Eastern	4	-2,08	23,21	7,48%	2,602	5,41%	0,272	1,126	7,74
IS00	Iceland						0,00%			7,12
ITC1	Piemonte	1b	-7,30	33,39	12,55%	10,946	9,61%	3,133	0,445	0,72
ITC2	Valle d'Aosta/Vallée d'Aoste	1a	-13,06	23,91	10,58%	5,272	9,24%	2,621	0,287	0,06

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ITC3	Liguria	1a	-3,77	30,88	6,49%	4,708	14,07%	3,350	0,748	0,62
ITC4	Lombardia	1b	-8,31	34,42	14,28%	12,366	10,70%	2,302	0,380	3,53
ITD1	Provincia Autonoma Bolzano-Bozen		-15,05	26,25	8,50%	6,368	9,01%	2,104	0,271	0,13
ITD2	Provincia Autonoma Trento	1a	-12,16	29,46	10,82%	7,306	10,39%	2,587	0,225	0,00
ITD3	Veneto	1b	-9,26	34,36	14,04%	12,088	9,33%	2,461	0,257	2,04
ITD4	Friuli-Venezia Giulia	1b	-10,75	33,99	12,23%	12,504	9,21%	3,015	0,374	0,50
ITD5	Emilia-Romagna	1b	-5,57	34,35	16,25%	13,907	10,30%	1,914	0,400	1,09
ITE1	Toscana	1a	-4,48	35,09	6,95%	5,806	9,57%	2,053	2,887	1,08
ITE2	Umbria	1b	-5,61	35,23	11,22%	8,717	7,75%	6,071	2,616	
ITE3	Marche	1b	-4,56	34,16	10,46%	10,406	7,07%	3,944	2,307	0,30
ITE4	Lazio	1a	-1,92	33,70	3,42%	2,779	21,22%	1,450	0,612	6,05
ITF1	Abruzzo	2	-4,29	33,47	10,17%	7,412	8,65%	3,933	5,623	0,26
ITF2	Molise	1a	-3,13	34,57	7,97%	3,938	7,69%	7,278	4,316	0,00
ITF3	Campania	1a	-0,39	33,81	5,80%	3,814	10,68%	4,275	0,969	0,79
ITF4	Puglia	1a	-1,21	36,45	8,43%	5,371	7,63%	4,109	2,084	0,60
ITF5	Basilicata	2	-1,57	34,99	7,63%	4,423	6,47%	7,742	4,740	0,00
ITF6	Calabria	1a	0,61	33,91	5,82%	2,515	7,13%	3,544	1,627	0,58
ITG1	Sicilia	1a	2,81	35,30	6,06%	3,027	7,83%	2,243	1,754	1,87
ITG2	Sardegna	1a	0,60	35,72	7,50%	3,385	8,98%	1,277	1,345	2,99
LI00	Liechtenstein									0,00
LT00	Lithuania		-18,35	30,14	12,20%	7,404	13,05%		4,432	0,42
LU00	Luxembourg (Grand-Duché)		-8,80	31,15		6,138	0,00%		1,352	3,31
LV00	Latvia		-18,89	29,11	10,92%	8,946	15,52%		2,671	0,81

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MT00	Malta		5,88	37,10			0,00%		1,000	6,83
NL11	Groningen	1b	-7,59	29,97	22,36%	4,252	9,02%	13,083	1,326	
NL12	Friesland (NL)	1a	-7,23	29,14	4,43%	1,745	6,89%	8,766	1,533	
NL13	Drenthe	1b	-8,03	30,35	11,93%	3,684	5,81%	25,196	2,094	0,26
NL21	Overijssel	1b	-8,33	30,77	8,12%	3,568	8,83%	11,485	1,829	
NL22	Gelderland	1b	-7,55	31,39	5,50%	2,574	8,28%	19,028	1,998	
NL23	Flevoland	3	-6,38	30,21	4,65%	2,061	6,85%	60,618	1,911	
NL31	Utrecht	1b	-6,95	30,73	4,15%	2,081	10,73%	26,382	0,737	
NL32	Noord-Holland	1a	-5,39	28,79	7,33%	3,881	12,29%	8,395	0,792	16,93
NL33	Zuid-Holland	1a	-5,57	30,08	8,82%	3,000	10,70%	9,187	1,848	0,30
NL34	Zeeland	1b	-3,89	29,67	15,71%	5,346	8,10%	12,594	3,272	
NL41	Noord-Brabant	1a	-7,19	31,24	6,44%	3,155	9,24%	8,822	2,009	0,41
NL42	Limburg (NL)	1b	-7,40	32,32	8,65%	3,956	10,12%	10,152	2,601	0,27
NO01	Oslo og Akershus					3,269	20,66%	5,467		12,21
NO02	Hedmark og Oppland					4,050	9,69%	8,191		0,01
NO03	Sør-Østlandet					5,287	9,62%	12,964		1,07
NO04	Agder og Rogaland					4,137	13,17%	3,772		4,95
NO05	Vestlandet					3,033	14,65%	3,488		5,40
NO06	Trøndelag					3,130	12,30%	3,167		6,48
NO07	Nord-Norge					2,420	15,69%	1,860		7,40
PL11	Lódzkie	2	-15,25	32,05	3,32%	2,025	6,30%	2,126	4,477	
PL12	Mazowieckie	2	-15,75	31,59	3,03%	2,194	24,09%	0,666	2,788	1,37
PL21	Malopolskie	2	-16,37	31,35	5,13%	2,728	7,25%	2,656	3,645	
PL22	Slaskie	2	-15,01	31,48	5,51%	2,957	9,10%	1,573	4,406	
PL31	Lubelskie	2	-16,41	31,71	9,56%	4,437	5,89%	2,534	5,079	
PL32	Podkarpackie	2	-15,72	31,59	5,05%	2,992	5,64%	1,068	4,997	

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PL33	Swietokrzyskie	2	-16,09	31,64	6,21%	3,153	6,08%	1,742	7,992	
PL34	Podlaskie	2	-17,21	31,25	1,43%	0,838	5,47%	0,397	6,587	
PL41	Wielkopolskie	2	-13,87	32,08	2,96%	2,138	8,18%	1,135	5,013	
PL42	Zachodniopomorskie	2	-12,59	30,64	2,33%	1,792	10,61%	1,454	4,964	
PL43	Lubuskie	2	-12,99	32,30	8,34%	4,878	7,08%	2,210	6,670	
PL51	Dolnoslaskie	2	-15,05	31,69	5,58%	3,322	8,70%	2,733	4,589	
PL52	Opolskie	2	-14,83	32,23	10,89%	6,251	6,37%	5,084	5,626	
PL61	Kujawsko-Pomorskie	2	-15,19	31,71	4,17%	2,877	6,18%	1,368	5,331	
PL62	Warminsko-Mazurskie	2	-16,62	30,53	1,70%	1,188	5,96%	2,547	5,911	
PL63	Pomorskie	2	-13,71	29,57	2,38%	1,886	11,78%	1,895	4,956	
PT11	Norte	1a	-3,56	35,02	7,56%	5,698	3,09%	1,595	2,519	0,83
PT15	Algarve	1a	2,81	35,01	6,85%	3,124	6,82%	0,940	1,402	11,48
PT16	Centro (PT)	2	-0,03	37,79	12,87%	7,323	2,96%	3,513	5,105	0,00
PT17	Lisboa	1a	3,69	36,94	7,35%	4,487	13,04%	1,834	1,543	4,06
PT18	Alentejo	2	1,81	38,43	5,98%	2,779	4,93%	7,210	4,806	0,00
PT20	Região Autónoma dos Açores (PT)				0,00%	1,938	7,04%	0,095	0,500	5,55
PT30	Região Autónoma da Madeira (PT)				0,00%	1,769	7,60%	0,086	0,500	9,67
RO11	Nord-Vest	2	-14,49	35,17	8,65%	5,644	7,68%	0,613	5,252	0,07
RO12	Centru	2	-17,37	33,01	12,00%	8,139	8,12%	0,225	3,380	
RO21	Nord-Est	2	-15,44	33,72	9,49%	3,794	4,04%	0,651	3,397	
RO22	Sud-Est	2	-12,73	36,07	10,84%	5,373	9,90%	0,715	4,275	
RO31	Sud - Muntenia	2	-12,53	37,83	12,29%	5,391	4,44%	3,388	4,588	0,00
RO32	Bucuresti - Ilfov	1a	-12,75	36,67	8,45%	6,784	20,05%	0,293	1,985	1,35

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RO41	Sud-Vest Oltenia	2	-11,74	35,99	12,15%	4,249	5,29%	0,571	2,914	
RO42	Vest				7,55%	5,757	9,09%	0,243	4,652	0,25
SE11	Stockholm	1a	-14,22	27,71	3,44%	2,182	19,91%	2,374	0,568	10,01
SE12	Östra Mellansverige	4	-16,02	27,66	8,25%	6,072	10,50%	10,572	1,329	0,06
SE21	Småland med öarna	4	-13,97	27,37	6,11%	8,442	12,63%	3,560	3,157	0,72
SE22	Sydsverige	1a	-11,17	27,10	4,90%	5,934	13,33%	4,711	2,100	1,91
SE23	Västsverige	4	-13,83	27,31	6,51%	8,882	14,68%	3,544	1,727	2,30
SE31	Norra Mellansverige	4	-19,64	26,79	12,29%	12,135	11,43%	6,109	2,978	0,18
SE32	Mellersta Norrland	4	-23,24	25,61	7,83%	6,253	14,62%	4,243	3,094	2,52
SE33	Övre Norrland	4	-28,34	25,37	5,91%	7,130	13,22%	3,152	2,786	4,23
SI01	Vzhodna Slovenija		-12,53	32,56					3,171	
SI02	Zahodna Slovenija		-11,51	32,39					2,419	
SK01	Bratislavský kraj	1a	-11,33	33,89	3,03%	5,643	38,22%	2,927	1,878	
SK02	Západné Slovensko	2	-14,23	33,86	4,37%	4,248	2,38%	13,066	4,951	
SK03	Stredné Slovensko	2	-16,19	32,60	10,84%	7,242	6,11%	11,565	4,971	
SK04	Východné Slovensko	2	-15,58	32,67	14,87%	6,941	2,56%	12,596	4,640	
UKC1	Tees Valley and Durham	1b	-3,99	24,95		4,853	8,56%	16,755	1,813	0,78
UKC2	Northumberland, Tyne and Wear	1a	-3,30	23,73		4,332	9,44%	6,805	0,971	3,72
UKD1	Cumbria	1a	-3,50	24,33		3,199	9,52%	6,217	3,054	
UKD2	Cheshire	3	-3,78	27,37		6,470	14,50%	31,798	2,272	
UKD3	Greater Manchester	1b	-3,34	27,27		3,882	13,20%	10,353	1,047	8,68
UKD4	Lancashire	1b	-2,75	26,06		5,022	7,20%	13,470	1,445	0,26
UKD5	Merseyside	1b	-3,03	26,81		3,368	8,50%	18,641	1,790	3,25

NUTS2_2006	Regions' name	Typology	Mean minimum January temperature (degree Celsius, last 15 years)	Mean maximum July temperature (degree Celsius, last 15 years)	GVA in industries with high energy purchases (% of total regional GVA), 2005	Employment in industries with high energy purchases (% of total regional employment), 2005	Employment in transport sector (% of total regional employment) 2005	Commuting (persons working in another region / persons working in the same region), 2005	Fuel costs in freight transport (% of regional GdP), 2005	Air travel (passengers embarked and disembarked / total regional population)
UKE1	East Yorkshire and Northern Lincolnshire	1b	-2,28	26,19		7,249	10,04%	9,432	4,428	0,51
UKE2	North Yorkshire	1b	-3,53	26,27		3,522	12,31%	19,673	1,862	0,00
UKE3	South Yorkshire	1b	-2,92	27,56		6,020	10,89%	13,742	1,536	0,47
UKE4	West Yorkshire	1b	-3,08	27,43		5,420	11,08%	7,953	1,211	1,22
UKF1	Derbyshire and Nottinghamshire	1b	-3,25	27,91		5,258	8,21%	14,661	1,527	
UKF2	Leicestershire, Rutland and Northants	1b	-3,95	29,25		5,010	13,35%	17,013	2,504	2,59
UKF3	Lincolnshire	1b	-3,11	27,68		2,886	8,36%	18,785	2,911	
UKG1	Herefordshire, Worcestershire and Warks	3	-3,99	28,27	0,00%	4,289	10,78%	33,792	2,073	0,58
UKG2	Shropshire and Staffordshire	1b	-4,83	27,55	0,00%	5,452	11,53%	26,644	2,199	
UKG3	West Midlands	1b	-4,65	28,45	0,00%	6,597	11,63%	10,881	1,067	3,59
UKH1	East Anglia	1a	-3,29	28,07	0,00%	3,760	11,69%	7,566	2,299	0,24
UKH2	Bedfordshire, Hertfordshire	3	-3,64	29,11	0,00%	3,437	12,78%	37,175	0,832	5,58
UKH3	Essex	3	-3,13	28,11	0,00%	3,147	11,04%	31,338	1,935	13,27
UKI1	Inner London	1b	-2,61	29,99	0,00%	5,784	23,88%	17,934	0,104	0,68
UKI2	Outer London	3	-3,07	29,41	0,00%	1,926	15,06%	77,293	0,437	15,00
UKJ1	Berkshire, Bucks and Oxfordshire	1b	-4,43	29,31	0,00%	3,545	12,32%	20,062	0,638	
UKJ2	Surrey, East and West Sussex	1b	-3,65	27,92	0,00%	2,717	11,73%	23,608	0,322	12,59

NUTS2_2006	Regions' name	Typology	Mean minimum January temperature (degree Celsius, last 15 years)	Mean maximum July temperature (degree Celsius, last 15 years)	GVA in industries with high energy purchases (% of total regional GVA), 2005	Employment in industries with high energy purchases (% of total regional employment), 2005	Employment in transport sector (% of total regional employment) 2005	Commuting (persons working in another region / persons working in the same region), 2005	Fuel costs in freight transport (% of regional GdP), 2005	Air travel (passengers embarked and disembarked / total regional population)
UKJ3	Hampshire and Isle of Wight	1b	-3,72	27,91	0,00%	2,971	10,12%	15,709	1,120	1,47
UKJ4	Kent	1b	-2,88	27,52	0,00%	4,134	11,36%	17,951	1,717	0,13
UKK1	Gloucestershire, Wiltshire and Bristol/Bath area	1a	-3,71	27,83	0,00%	3,484	10,83%	7,125	1,197	2,33
UKK2	Dorset and Somerset	1b	-3,87	26,45	0,00%	3,290	5,79%	11,751	1,298	0,00
UKK3	Cornwall and Isles of Scilly	1a	-0,99	24,11	0,00%	2,093	4,31%	7,739	1,192	0,64
UKK4	Devon	1a	-2,38	25,15	0,00%	2,381	8,89%	4,337	1,015	0,76
UKL1	West Wales and The Valleys	1b	-1,83	24,58	0,00%	3,846	5,33%	15,099	1,251	
UKL2	East Wales	1b	-3,33	26,38	0,00%	5,384	8,21%	20,499	1,697	1,64
UKM2	Eastern Scotland	1a	-4,87	23,59	0,00%	0,841	3,24%	5,666	1,224	4,39
UKM3	South Western Scotland	1a	-4,27	23,49	0,00%	2,834	8,72%	6,946	1,350	4,90
UKM5	North Eastern Scotland		-5,05	23,58	0,00%				1,149	5,65
UKM6	Highlands and Islands		-4,69	23,79	0,00%				1,396	3,14
UKN0	Northern Ireland	1a	-2,89	24,01	0,00%	3,472	8,05%	1,705	1,377	4,21

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
AT11	Burgenland (A)	26,06	56.9	28,33	16840,4	32.383,72	1.001,036	0,0016120944
AT12	Niederösterreich	29,46	58.9	25,15	17831,3	157.900,40	971,181	0,0481641473
AT13	Wien	34,37	58.1	22,00	18279,5	5.397,04	969,618	0,6604950204
AT21	Kärnten	16,93	56.2	25,55	16523	6.103,52	995,716	0,0221839191
AT22	Steiermark	21,10	57.9	25,35	16638,9	44.274,00	988,695	0,0098382728
AT31	Oberösterreich	18,47	60.6	23,06	17261,5	53.312,80	931,984	0,0523904175
AT32	Salzburg	25,21	63.2	20,53	17563,2	8.236,32	985,725	0,0153385758
AT33	Tirol	13,21	62.0	20,61	17043,9	13.791,68	1.045,263	0,0021533033
AT34	Vorarlberg	23,80	63.7	19,40	17793,2	1.343,85	1.001,500	0,0732297136
BE10	Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest	57,57	53.9	23,29	14377,9	2.932,48	814,839	0,9949275463
BE21	Prov. Antwerpen	40,21	53.5	26,87	15745,8	40.870,80	813,564	0,1182181976
BE22	Prov. Limburg (B)	32,73	53.2	22,77	14562,5	32.426,68	809,911	0,0843598565
BE23	Prov. Oost-Vlaanderen	41,69	55.5	27,32	15970,6	43.892,40	829,682	0,1547702774
BE24	Prov. Vlaams Brabant	35,03	56.7	26,58	18205,6	29.893,44	813,195	0,1824752858
BE25	Prov. West-Vlaanderen	31,51	53.3	30,43	15224	50.602,40	849,933	0,1683482763
BE31	Prov. Brabant Wallon	53,59	53.7	23,33	17215,1	15.145,56	819,693	0,0064076876
BE32	Prov. Hainaut	60,78	49.3	26,04	12939,6	51.419,60	838,364	0,1595259489
BE33	Prov. Liège	55,95	51.0	26,68	13466,2	54.728,80	822,660	0,0947197628
BE34	Prov. Luxembourg (B)	47,65	53.4	25,14	13170,2	63.888,00	853,459	
BE35	Prov. Namur	51,35	53.0	25,19	13622,1	49.963,20	831,668	0,0467447303
BG31	Severozapaden	65,34	42.9	32,75	2844,8	57.520,40	1.057,584	0,0071169330
BG32	Severen tsentralen	65,22	47.4	25,64	3357,3	77.092,80	1.089,911	0,0087522380

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
BG33	Severoiztochen	54,35	52.0	21,94	3177,7	145.277,60	1.155,245	0,0080964004
BG34	Yugoiztochen	52,46	48.3	24,63	3481,5	115.723,20	1.122,967	0,0061997897
BG41	Yugozapaden	51,08	54.1	23,06	4250,1	24.337,40	1.073,698	0,0036384386
BG42	Yuzhen tsentralen	65,39	48.8	24,22	3191,8	59.100,00	1.074,699	0,0075496787
CH01	Région lémanique			22,11		1.724,09	1.028,687	0,0118917912
CH02	Espace Mittelland			24,63		4.160,68	971,546	0,0335809433
CH03	Nordwestschweiz			23,26		2.210,30	925,344	0,2703185327
CH04	Zürich			22,35		2.703,40	928,918	0,1613758883
CH05	Ostschweiz			22,73		3.129,62	999,125	0,0340237063
CH06	Zentralschweiz			21,07		184,16	950,981	0,0307812110
CH07	Ticino			27,42		8,97	1.002,877	0,0353981689
CY00	Cyprus	18,59	63.2	17,31		39.050,24		0,0009504773
CZ01	Praha	36,10	62.0	21,85	11225	4.327,88	865,811	0,0757957484
CZ02	Strední Cechy	43,23	59.5	19,96	8823,4	84.332,00	876,780	0,0022074663
CZ03	Jihozápad	42,24	60.0	20,06	8175,4	139.331,20	851,415	0,0036553694
CZ04	Severozápad	61,06	61.1	17,29	7362,3	59.811,20	868,100	0,0171620742
CZ05	Severovýchod	46,70	58.6	20,01	7939,9	88.970,00	907,229	0,0041514123
CZ06	Jihovýchod	52,63	58.2	20,53	8012,2	128.057,20	893,206	0,0045243101
CZ07	Strední Morava	54,79	57.9	20,01	7641,1	61.706,40	868,146	0,0106108613
CZ08	Moravskoslezsko	57,49	58.5	18,04	7559,7	43.606,80		0,0179353158
DE11	Stuttgart	48,52	61.4	25,15	19403,3	90.122,80	908,080	0,0304244753
DE12	Karlsruhe	51,56	60.1	25,81	18392,6	50.195,60	892,656	0,1173494595
DE13	Freiburg	38,48	62.1	25,92	18266,3	23.948,00	910,769	0,0379401746
DE14	Tübingen	47,16	62.4	24,42	18363,8	41.359,60	925,365	0,0277250882
DE21	Oberbayern	44,02	62.2	24,17	20063,6	91.639,60	977,526	0,0214526614
DE22	Niederbayern	47,51	63.1	25,69	16403,5	66.640,00	912,478	0,0211040223
DE23	Oberpfalz	51,74	61.4	25,97	16413,3	89.144,00	892,531	0,0193970339
DE24	Oberfranken	56,49	60.2	28,93	17134,1	69.864,80	868,123	0,0572952415

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DE25	Mittelfranken	51,36	59.9	26,51	18069,7	69.640,80	900,935	0,0669964814
DE26	Unterfranken	43,81	60.5	26,73	17094,7	83.939,60	873,171	0,0375454042
DE27	Schwaben	45,38	60.7	26,10	17799,3	58.764,80	957,554	0,0435705307
DE30	Berlin	63,17	60.1	22,02	14446,6	13.646,36	863,700	0,4687579710
DE41		59,63	61.3	25,59	14250,5	197.381,20		0,0388110265
DE42		59,78	60.8	26,14	14654	171.486,00		0,0337268744
DE50	Bremen	61,99	54.9	28,41	19220,8	5.928,64	822,475	0,3567638703
DE60	Hamburg	54,88	59.9	24,66	22355,6	12.116,96	826,056	0,2327777933
DE71	Darmstadt	53,63	59.4	24,84	18411,5	66.801,60	862,771	0,2166502486
DE72	Gießen	50,44	59.3	26,41	16678,3	52.801,60	834,762	0,0780402016
DE73	Kassel	57,23	57.0	29,55	16536,4	98.900,40	827,828	0,0192265304
DE80	Mecklenburg-Vorpommern	60,75	61.4	25,87	13719,2	334.284,80	868,246	0,0146086676
DE91	Braunschweig	52,58	54.4	29,20	16331,4	106.761,20	818,461	0,0864991108
DE92	Hannover	56,77	57.0	28,83	17009,9	120.940,00	812,804	0,0492578564
DE93	Lüneburg	56,94	57.0	27,25	17318	226.282,80	823,394	0,0102806183
DE94	Weser-Ems	53,98	58.3	25,66	15739,1	215.954,00	823,380	0,0311418483
DEA1	Düsseldorf	55,99	55.6	28,59	18507,9	66.887,20	815,414	0,3528486569
DEA2	Köln	57,21	56.4	25,48	18203,3	89.118,80	818,303	0,1498561197
DEA3	Münster	55,12	55.8	26,24	17157,5	85.136,40	814,721	0,0939165089
DEA4	Detmold	56,14	58.4	27,78	18636	86.715,60	812,931	0,0935903875
DEA5	Arnsberg	57,82	55.2	28,36	18028,6	108.004,40	813,761	0,1695439514
DEB1	Koblenz	52,93	57.7	29,04	16602,9	86.606,80	845,643	0,0190776330
DEB2	Trier	41,72	57.9	28,74	16290,6	54.603,20	860,941	0,0235778745
DEB3	Rheinhessen-Pfalz	50,28	58.5	26,91	16847,3	60.763,60	884,129	0,1185448926
DEC0	Saarland	51,90	53.9	30,05	16841,9	26.584,88	890,082	0,0379402914
DED1	Chemnitz	64,55	58.4	32,30	14346,4	57.226,00	845,027	0,0680476334
DED2	Dresden	59,33	58.8	29,76	14428,4	82.100,40	842,515	0,0351652499

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DED3	Leipzig	65,37	59.6	28,38	14201,1	45.674,40	836,751	0,0396815081
DEE0	Sachsen-Anhalt	64,07		29,07	13740,1	232.786,80		0,0560031473
DEF0	Schleswig-Holstein	52,04	59.3	27,80	16533,3	252.764,80	839,030	0,0303865991
DEG0	Thüringen	63,92	59.2	27,52	13900,8	171.329,20	839,907	0,0633293720
DK01	Hovedstaden				12549,4	49.772,80		0,0027530935
DK02	Sjælland				11976,6	126.669,60		0,0155495795
DK03	Syddanmark				11723,3	204.545,60		0,0313363707
DK04	Midtjylland				11849,4	229.267,60		0,0351948991
DK05	Nordjylland				11707,4	154.593,60		0,0121719142
EE00	Estonia	49,47	58.5	24,25	6101,3	616.728,00		0,0080465308
ES11	Galicia	25,50	52.6	31,49	12307,9	342.181,20	1.189,056	0,0034468697
ES12	Principado de Asturias	30,54	47.7	32,03	13831,3	73.938,80	1.046,250	0,0023054639
ES13	Cantabria	20,15	54.1	27,22	14351,3	22.542,40	1.093,632	0,0016208897
ES21	Pais Vasco	24,85	56.4	26,51	17648,6	53.032,80	1.137,402	0,0067211024
ES22	Comunidad Foral de Navarra	14,44	58.9	26,03	17493,7	67.104,80	1.224,147	0,0021700631
ES23	La Rioja	15,52	58.7	27,54	14798,4	14.260,76	1.235,710	0,0015032541
ES24	Aragón	17,12	56.1	31,37	14983,1	177.241,20	1.277,569	0,0002639843
ES30	Comunidad de Madrid	17,36	61.6	20,59	16541,8	11.105,48	1.404,979	0,0082790160
ES41	Castilla y León	22,43	52.0	34,25	13751,2	274.301,60	1.319,172	0,0011702403
ES42	Castilla-la Mancha	19,25	53.3	28,93	11351,9	199.338,80	1.429,281	0,0011956654
ES43	Extremadura	25,10	50.8	28,83	10561	131.070,00	1.450,185	0,0008705285
ES51	Cataluña	20,54	60.6	24,57	15694	56.236,40	1.317,340	0,0037144122
ES52	Comunidad Valenciana	16,04	58.0	23,08	12571,4	31.758,56	1.377,895	0,0100509723
ES53	Illes Balears	9,26	61.8	19,76	15022,3	61.733,60	1.357,847	0,0056897745
ES61	Andalucia	21,61	53.5	21,27	10960,7	218.206,40	1.453,352	0,0018940278

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ES62	Región de Murcia	14,42	57.1	20,37	11176,3	15.278,92	1.464,838	0,0080161691
ES63	Ciudad Autónoma de Ceuta (ES)	46,32	57.5	17,36	13928,3	0,00		
ES64	Ciudad Autónoma de Melilla (ES)	40,14	50.3	16,82	13802,9	0,00		
ES70	Canarias (ES)	21,82	58.5	16,72	12119,9			
FI13	Itä-Suomi	22,77	54.5	28,80	10874,1	1.031.076,00	786,749	0,0005664983
FI18	Etelä-Suomi	24,95	63.8	21,54	12802,3	617.064,00	836,313	0,0023005168
FI19	Länsi-Suomi	23,35	58.8	26,45	11366,6	890.264,00		0,0013598518
FI1A	Pohjois-Suomi	16,40	59.4	22,42	10818,4	1.795.408,00	793,711	0,0001323173
FI20	Åland	0,00	56.1	25,31	14187,3	16.307,16	879,359	
FR10	Île de France	42,83	61.4	18,42	19545,1	151.173,20	957,854	0,0163629591
FR21	Champagne-Ardenne	35,40	56.8	25,15	14882,1	269.868,00	921,707	0,0099801515
FR22	Picardie	38,47	57.2	22,26	15301,2	238.716,80	893,775	0,0177120363
FR23	Haute-Normandie	42,99	58.2	23,09	15570,8	181.766,40	930,486	0,0112382452
FR24	Centre	37,94	57.4	28,61	15917,3	462.108,00	1.006,197	0,0091815145
FR25	Basse-Normandie	34,58	54.2	28,64	14974,4	279.004,40	978,022	0,0114968237
FR26	Bourgogne	37,83	54.8	30,66	15821,6	283.933,60	995,295	0,0083730425
FR30	Nord - Pas-de-Calais	49,74	55.9	21,73	13456,5	183.049,60	858,013	0,0421372538
FR41	Lorraine	40,19	56.7	24,66	15092,3	227.816,80	903,514	0,0217632671
FR42	Alsace	31,61	60.4	21,49	16261,8	33.208,80	907,954	0,0326733107
FR43	Franche-Comté	34,01	54.9	25,50	15628,6	97.856,80	969,108	0,0086707953
FR51	Pays de la Loire	38,32	57.3	26,52	15085,7	424.388,00	1.060,953	0,0081475136
FR52	Bretagne	35,32	53.6	29,21	15050,8	487.852,00	1.006,694	0,0068485562
FR53	Poitou-Charentes	39,02	55.0	32,23	15052,7	283.670,80	1.110,678	0,0043942137
FR61	Aquitaine	35,22	53.2	30,00	15535,4	348.758,40	1.122,423	0,0069594565
FR62	Midi-Pyrénées	36,31	56.1	29,89	15224,5	235.079,60	1.165,059	0,0032270255
FR63	Limousin	41,02	55.5	36,99	15829,8	168.034,80	1.093,600	0,0050762125

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
FR71	Rhône-Alpes	34,94	58.7	23,42	16212,2	115.610,80	1.104,103	0,0126542098
FR72	Auvergne	36,50	56.0	31,43	15828,9	122.008,80	1.094,756	0,0046638291
FR81	Languedoc-Roussillon	46,18	50.3	29,91	14292,6	194.478,80	1.265,843	0,0070904974
FR82	Provence-Alpes-Côte d'Azur	41,06	51.3	29,08	15784,7	132.322,00	1.344,786	0,0068615408
FR83	Corse	46,42	46.9	29,46	13730,6	24.319,48	1.291,322	0,0001587800
FR91	Guadeloupe (FR)	80,75	52.0	17,20				
FR92	Martinique (FR)	85,41	49.2	20,32				
FR93	Guyane (FR)	67,02	53.4	6,16				
FR94	Reunion (FR)	75,18	52.9	11,13				
GR11	Anatoliki Makedonia, Thraki	55,88	52.3	30,28	10956,7	56.124,40	1.126,759	0,0086262478
GR12	Kentriki Makedonia	54,51	51.9	26,47	11874	15.148,28	1.182,286	0,0177768050
GR13	Dytiki Makedonia	62,97	49.0	30,96	11804,4	5.704,96	1.259,387	0,0087033174
GR14	Thessalia	48,13	52.9	30,79	10923,4	2.753,22	1.205,066	0,0104303826
GR21	Ipeiros	59,78	48.2	33,45	10753	1.779,41	1.193,026	0,0056711901
GR22	Ionia Nisia	27,91	53.9	32,13	7495,6	10.411,00	1.180,945	0,0000118392
GR23	Dytiki Ellada	51,64	49.9	28,04	9878,7	2.711,04	1.197,450	0,0063240906
GR24	Sterea Ellada	49,78	51.8	31,72	12516,3	27.276,92	1.284,083	0,0040183270
GR25	Peloponnisos	54,05	52.8	35,13	9955,7	18.975,68	1.271,129	0,0062323294
GR30	Attiki	49,95	55.2	22,87	15673,4	28.988,88	1.338,304	0,0032999588
GR41	Voreio Aigaio	40,88	47.2	34,03	11117,4	42.065,60	1.339,197	0,0013206993
GR42	Notio Aigaio	21,86	55.8	21,62	12341,4	47.282,40	1.388,884	0,0005751961
GR43	Kriti	28,74	57.2	25,82	11317,1	61.745,60	1.346,387	0,0006828738
HU10	Közép-Magyarország	51,39	54.5	22,41	11078,9	43.536,40	1.050,079	0,0278397362
HU21	Közép-Dunántúl	41,19	53.3	20,53	7178,9	86.311,20	1.040,598	0,0078649147
HU22	Nyugat-Dunántúl	44,38	53.7	21,81	7236,9	93.140,80	1.016,166	0,0164973566

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
HU23	Dél-Dunántúl	43,76	47.7	22,55	6279,1	95.618,80	1.019,657	0,0051844635
HU31	Észak-Magyarország	47,76	45.0	23,04	5844,1	58.764,80	1.022,116	0,0081444289
HU32	Észak-Alföld	47,69	45.6	20,66	5495,1	73.933,20	1.043,314	0,0065570734
HU33	Dél-Alföld	44,77	47.3	23,36	5946,4	92.440,80	1.081,104	0,0074340408
IE01	Border, Midlands and Western	30,21	60.0	17,73	13056,6	704.832,00	796,647	0,0011697276
IE02	Southern and Eastern	29,94	62.7	15,15	15145,5	698.516,00	833,354	0,0044892117
IS00	Iceland		81.4	17,86				
ITC1	Piemonte	43,44	51.2	33,76	17249,8	1.306,95	1.165,327	0,0771777666
ITC2	Valle d'Aosta/Vallée d'Aoste	34,20	53.7	29,89	17440,9	18,50	1.123,822	0,0030430752
ITC3	Liguria	31,64	46.7	42,38	16687,1	15.185,36	1.209,446	0,0185039209
ITC4	Lombardia	34,40	54.2	28,41	18140	1.756,52	1.085,533	0,1189557971
ITD1	Provincia Autonoma Bolzano-Bozen	23,00	58.8	24,58	18225	5.673,60		0,0080658579
ITD2	Provincia Autonoma Trento	23,49	53.9	27,95	15800,9	5.323,40	1.038,720	0,0089014806
ITD3	Veneto	34,57	53.7	28,15	16573,1	35.414,20	1.083,906	0,0666034085
ITD4	Friuli-Venezia Giulia	33,91	50.1	33,69	16781,8	10.489,24	1.066,320	0,0238650658
ITD5	Emilia-Romagna	28,48	53.9	34,94	18452	32.481,68	1.113,112	0,0471019478
ITE1	Toscana	38,62	50.7	35,69	16735,2	88.449,20	1.171,457	0,0266048589
ITE2	Umbria	40,47	49.2	36,15	15278,7	27.775,80	1.230,451	0,0083316532
ITE3	Marche	35,61	50.7	34,65	15680,5	17.963,04	1.241,164	0,0112489803
ITE4	Lazio	51,07	50.4	27,99	16515,4	49.698,80	1.256,899	0,0160105123
ITF1	Abruzzo	46,66	47.8	32,19	12499,6	10.030,08	1.247,805	0,0141399454
ITF2	Molise	49,29	43.0	33,63	11403,9	10.454,44	1.279,107	0,0124645764
ITF3	Campania	54,16	42.9	22,40	10643,8	25.596,72	1.282,123	0,0452011495
ITF4	Puglia	52,98	42.1	25,26	10829,9	156.014,80	1.368,917	0,0143193294
ITF5	Basilicata	54,54	43.8	29,93	11422,2	28.170,24	1.333,175	0,0082830001

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
ITF6	Calabria	55,50	41.7	26,93	10585,3	43.950,80	1.356,257	0,0061759247
ITG1	Sicilia	60,87	42.1	26,86	10702,1	109.274,80	1.448,346	0,0121215165
ITG2	Sardegna	46,41	48.1	24,57	11962,4	93.829,60	1.374,903	0,0041326759
LI00	Liechtenstein			15,61		2,92		0,0756676834
LT00	Lithuania	32,04	56.6	22,24	6839,1	756.792,00		0,0029028328
LU00	Luxembourg (Grand-Duché)	28,66	55.6	20,82		30.017,52		0,0731486343
LV00	Latvia	26,43	57.8	24,05	5801,3	855.688,00		0,0063556254
MT00	Malta	41,05	49.5	18,71		3.305,96		0,0000904243
NL11	Groningen	39,27	62.8	21,21	12153,3	39.192,60	842,594	0,0176635673
NL12	Friesland (NL)	39,36	63.1	22,45	12875	59.227,20	857,250	0,0026443363
NL13	Drenthe	38,89	62.8	24,65	13317,4	39.843,80	835,786	0,0183523255
NL21	Overijssel	44,17	64.3	21,20	13016,9	46.793,20	822,760	0,0494714428
NL22	Gelderland	37,85	64.9	21,19	13878,2	69.812,40	825,093	0,0809740412
NL23	Flevoland	43,11	70.5	12,73	12504,8	19.864,04	839,686	0,0292644059
NL31	Utrecht	35,97	67.8	18,42	15356,9	21.593,08	834,275	0,1417884069
NL32	Noord-Holland	41,18	66.2	19,88	14831,6	56.062,80	850,501	0,0776610540
NL33	Zuid-Holland	39,42	65.0	20,55	14041,5	53.229,60	845,826	0,1013892408
NL34	Zeeland	32,08	61.3	25,96	13957,1	22.788,96	837,022	
NL41	Noord-Brabant	40,33	65.2	20,54	13960,3	69.479,60	820,275	0,1358163662
NL42	Limburg (NL)	35,28	61.3	23,62	13749,5	29.045,28	811,875	0,2107058250
NO01	Oslo og Akershus	15,37	74.6	19,03		41.981,60	750,461	0,0038959425
NO02	Hedmark og Oppland	29,80	69.5	28,22		135.394,00	734,945	0,0006982454
NO03	Sør-Østlandet	26,01	71.1	24,33		162.239,60	744,325	0,0015712931
NO04	Agder og Rogaland	17,01	72.5	20,33		299.493,60	741,688	0,0002747926
NO05	Vestlandet	14,34	72.7	23,50		61.240,40	676,146	0,0000922292
NO06	Trøndelag	16,12	70.8	22,78		273.966,40	743,359	0,0001646417
NO07	Nord-Norge	14,09	70.9	22,91		648.096,00	683,162	0,0002160467

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
PL11	Lódzkie	54,46	55.3	21,19	6919,5	201.259,60	875,828	0,0060881695
PL12	Mazowieckie	43,73	56.1	20,82	8721,5	395.949,20	865,768	0,0054857457
PL21	Malopolskie	56,81	55.9	19,15	6131,9	116.584,80	865,031	0,0062233016
PL22	Slaskie	58,80	52.2	17,88	7711	124.596,00	856,208	0,0095720084
PL31	Lubelskie	49,89	56.7	20,72	5522,1	266.131,60	874,706	0,0055295714
PL32	Podkarpackie	37,63	54.3	18,57	5213,5	181.968,40	861,128	0,0048254614
PL33	Swietokrzyskie	58,53	54.3	21,47	5906,4	123.425,20	866,576	0,0044908211
PL34	Podlaskie	58,07	56.1	21,00	5783,3	230.127,20	853,990	0,0040094084
PL41	Wielkopolskie	55,21	57.0	16,72	7184,8	343.226,40	876,487	0,0050616503
PL42	Zachodniopomorskie	55,58	54.1	16,68	6952,6	323.118,80	883,897	0,0033907948
PL43	Lubuskie	34,10	55.0	16,19	6306,1	181.275,60	875,128	0,0085571656
PL51	Dolnoslaskie	51,98	54.5	18,67	7027,6	186.056,80	861,783	0,0045631862
PL52	Opolskie	41,38	53.8	18,73	5753,6	84.745,60	854,130	0,0045379948
PL61	Kujawsko-Pomorskie	56,75	55.7	17,32	6449,8	210.023,20	869,594	0,0092489205
PL62	Warminsko-Mazurskie	59,32	52.3	16,23	5845,4	298.685,20	859,430	0,0033159131
PL63	Pomorskie	42,35	53.6	16,65	6490,2	286.288,40	877,532	0,0028231885
PT11	Norte	52,61	63.1	21,43	8939,8	95.854,00	1.322,745	0,0109189634
PT15	Algarve	38,44	58.7	28,03	11518,2	46.532,00	1.506,236	0,0051967247
PT16	Centro (PT)	42,80	66.0	30,41	9775	172.934,00	1.354,397	0,0103971070
PT17	Lisboa	45,93	60.3	23,78	13732,9	34.146,80	1.394,874	0,0025629469
PT18	Alentejo	35,78	56.9	35,78	9964,4	253.304,80	1.484,336	0,0027453860
PT20	Região Autónoma dos Açores (PT)	38,41	56.7	18,37	10218,5			
PT30	Região Autónoma da Madeira (PT)	46,36	61.5	19,16	11171,4			
RO11	Nord-Vest	42,72	51.9	18,41	3949,2	76.352,00	1.129,820	0,0009974212
RO12	Centru	46,36	50.4	18,34	3909,9	35.292,44	1.183,215	0,0014200459

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
RO21	Nord-Est	51,51	58.6	20,18	3219,6	224.228,80	1.158,200	0,0008364379
RO22	Sud-Est	51,75	51.6	19,52	3777,3	282.158,00	1.237,719	0,0008512046
RO31	Sud - Muntenia	50,98	54.9	23,04	3601,2	134.724,00	1.156,470	0,0019458648
RO32	Bucuresti - Ilfov	49,30	53.3	18,60	6890,5	9.298,24	1.163,713	0,0111078629
RO41	Sud-Vest Oltenia	51,89	57.1	22,70	3669	75.199,20	1.138,342	0,0011705651
RO42	Vest	53,30	51.4	19,42	4551,6	95.270,00		0,0009482615
SE11	Stockholm	15,56	74.4	20,82	15517,2	91.826,00	839,828	0,0012943158
SE12	Östra Mellansverige	18,77	69.1	26,70	13064,3	557.860,00	800,003	0,0016178529
SE21	Småland med öarna	13,00	71.3	29,96	12586,1	631.400,00	853,439	0,0011866635
SE22	Sydsverige	9,07	68.6	27,44	13164,9	251.961,60	799,896	0,0025965141
SE23	Västsverige	13,45	71.4	26,33	13200,3	533.628,00	994,423	0,0022125217
SE31	Norra Mellansverige	11,60	67.4	31,32	12357,4	792.620,00	838,614	0,0002722872
SE32	Mellersta Norrland	10,92	67.2	31,81	12972,7	667.076,00	823,835	0,0001896978
SE33	Övre Norrland	14,26	66.2	28,07	12068,3	1.245.316,00	815,031	0,0001423541
SI01	Vzhodna Slovenija			21,39	10530,4	55.265,60		0,0048995816
SI02	Zahodna Slovenija			22,31	12016,3	20.832,56		0,0055268931
SK01	Bratislavský kraj	53,62	63.9	16,32	11867,3	20.227,12	939,031	0,0322317688
SK02	Západné Slovensko	69,75	59.3	17,10	7000,6	94.630,80	839,508	0,0137493807
SK03	Stredné Slovensko	74,84	59.2	16,35	6790	64.782,00	932,263	0,0044544667
SK04	Východné Slovensko	79,47	58.1	15,23	6201,9	76.645,60	983,285	0,0038478793
UKC1	Tees Valley and Durham	22,64	57.7	24,42	14427,1	58.956,80	811,555	0,0099815212
UKC2	Northumberland, Tyne and Wear	26,04	57.7	25,13	14733,6	115.654,80	809,076	0,0052854570
UKD1	Cumbria	28,06	64.1	28,14	16514	127.378,40	795,511	0,0090682820
UKD2	Cheshire	21,28	63.2	24,02	18100,1	41.204,40	820,794	0,1312296955
UKD3	Greater Manchester	23,81	61.7	21,33	15190,3	25.927,88	816,327	0,3734869222
UKD4	Lancashire	23,61	59.3	24,57	15050,5	56.951,60	812,140	0,0831014334

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UKD5	Merseyside	26,68	56.7	24,92	15056,2	13.152,80	819,108	0,0987813573
UKE1	East Yorkshire and Northern Lincolnshire	25,55	58.1	25,21	15202,7	68.910,80	828,571	0,0155080155
UKE2	North Yorkshire	20,63	62.5	26,54	18099,6	159.568,00	815,269	0,0197327647
UKE3	South Yorkshire	24,31	59.8	23,69	14885,2	28.955,20	813,525	0,1917022716
UKE4	West Yorkshire	23,99	62.1	21,47	15272,8	38.997,44	810,069	0,2535345588
UKF1	Derbyshire and Nottinghamshire	21,71	61.4	23,54	15570,3	86.316,80	818,891	0,0821963984
UKF2	Leicestershire, Rutland and Northants	20,79	65.4	21,41	16643,7	86.881,60	824,563	0,0871304752
UKF3	Lincolnshire	22,89	61.0	29,14	15991,5	103.046,40	831,089	0,0392121698
UKG1	Herefordshire, Worcestershire and Warks	14,80	64.0	25,62	18017,4	103.329,20	834,588	0,0836803964
UKG2	Shropshire and Staffordshire	22,23	62.0	24,16	15812,8	109.478,80	827,020	0,1250380096
UKG3	West Midlands	32,32	59.1	23,00	14177,7	21.079,88	829,857	0,4675550033
UKH1	East Anglia	19,51	62.9	26,58	16974,4	221.187,20	851,021	0,0190525665
UKH2	Bedfordshire, Hertfordshire	22,94	65.9	21,41	19840,1	50.133,60	839,508	0,0489464491
UKH3	Essex	26,47	63.9	24,95	18558,1	62.347,20	846,786	0,0173374637
UKI1	Inner London	33,04	60.7	12,70	23833,8	6.016,40	848,520	0,2255653405
UKI2	Outer London	26,95	64.5	18,90	19716,2	26.540,76	849,122	0,0026139910
UKJ1	Berkshire, Bucks and Oxfordshire	20,01	68.9	19,37	20278,2	99.063,60	848,855	0,0346436720
UKJ2	Surrey, East and West Sussex	17,30	62.9	27,53	20886,3	101.469,20	867,312	0,0237998554
UKJ3	Hampshire and Isle of Wight	19,08	64.5	24,03	17552,7	78.774,80	887,156	0,0253357010
UKJ4	Kent	25,03	64.0	24,52	17455,4	69.722,00	851,815	0,0223889658

NUTS2_2006	Regions' name	Long term unemployment rate (% of total unemployment), 2007	Economic activity rate (labour force / population 15-64 years), 2005	Age dependency ratio (Population > 65 years / population 15-64), 2005	Household disposable income (in pps), 2005	Wind energy potential (m/s/km2)	PV output (kWh)	PUSH factor Potential Urban Strategic Horizon (intensity of PUSH areas within the NUTS II region)
UKK1	Gloucestershire, Wiltshire and Bristol/Bath area	13,71	66.8	23,72	17649,6	128.569,60	868,341	0,0529487374
UKK2	Dorset and Somerset	15,52	58.6	32,43	17637,6	102.325,20	907,600	0,0180141572
UKK3	Cornwall and Isles of Scilly	12,09	58.1	30,40	15241,4	79.180,40	929,970	0,0038724728
UKK4	Devon	14,93	60.4	29,85	16034,9	133.178,40	928,819	0,0041299595
UKL1	West Wales and The Valleys	19,40	55.6	27,50	14777,4	245.417,60	868,826	0,0011331824
UKL2	East Wales	21,32	61.5	23,92	15894,1	128.016,00	859,826	0,0005909444
UKM2	Eastern Scotland	22,38	63.8		17004,7	333.804,80	769,709	0,0092516507
UKM3	South Western Scotland	21,90	60.9		15604,9	265.640,80	764,846	0,0141638351
UKM5	North Eastern Scotland	15,17			18434,9	152.903,20	771,666	0,0001256222
UKM6	Highlands and Islands	15,17			14942	712.224,00	741,592	0,0002900369
UKN0	Northern Ireland	36,60	58.8		15025,9	305.517,60	791,567	0,0070699115

Indicators marked in yellow were used for the clustering exercise

**The value -9 means no data available for that region

Annex 3: Discussion Paper "Impacts of Climate Change on Regional Energy Systems"

Title: Impacts of Climate Change on Regional Energy Systems

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Abstract

Little scientific evidence is presently available on the actual impacts of climate change effects on the energy system. The possible affections have mainly been identified as a result of modelling exercises, which implies a high level of uncertainty with regard to the actual speed and extent of climate variations. The severest impacts are expected to occur in the longer-term horizon (between 2070 and 2100), but many experts, including the IPPC, warn of the risk of non-linear climate change and that changes may be quicker than expected. The regional dimension is highlighted in this context because most renewable energy projects are carried out on local scale, based on the regional resource potential. Furthermore, vulnerability to climate change is very much determined by regional land use and the location of energy infrastructure. It is therefore necessary that planners, law makers and companies design robust strategies for the sustainable development of local energy resources and the protection of the critical infrastructure.

Keywords:

1. Introduction

Certain regions in Europe are clearly more vulnerable to environmental risks derived from climate change than others [Schmidt-Thomé, 2003]. This vulnerability has been documented with regard to the possible impacts of storms, draughts, floods and forest fires. It is assumed that climate change will in general lead to more extreme weather conditions, putting additional pressure on the energy infrastructure in terms of production, transport and distribution.

However, little scientific evidence is presently available on the actual impacts of climate change effects on the energy system and even less information exists on impacts on regional scale. The possible affections have mainly been identified as a result of modelling exercises, which implies a high level of uncertainty with regard to the actual speed and extent of climate variations. The severest impacts are expected to occur in the longer-term horizon (between 2070 and 2100), but many experts, including the IPPC, warn of the "risk of non-linear climate change" [EEA 2008] and that changes may be quicker than expected. It is therefore necessary that regional planners design "robust strategies" [Dessai and Hulme, M. 2007] to their local resources and infrastructure. And even if the greatest effects of climate change may only occur in the medium term, it should be kept in mind that energy infrastructure tends to have a long lifespan of 50 to 100 years [Paskal 2009], considering that sites are often reused when renewing energy production and transmission facilities.

This paper reviews systematically the possible climate change impacts on existing and emerging energy technologies and proposes policy options to minimize the possible risks, especially in the most vulnerable regions. Section I contains a short summary of expected climate change impacts, which are then analyzed with regard to their possible effects on energy production (section II), transmission and distribution networks (section III), as well as energy usage (section IV), ending with conclusions and recommendations for regional policy makers.

2. Expected Climate Change Impacts on Europe's Regions

According to the latest analysis of climate change impacts in Europe [EEA 2008], regions will be affected in different ways by the following trends:

- Global mean temperature has increased by presently 0.8 °C compared with pre-industrial times for land and oceans, and by 1.0 °C for land alone. Projections suggest further temperature increases in Europe between 1.0–5.5 °C by the end of the century. These temperature increases will intensify the danger of forest fires and lead to more area being burned, more ignitions and longer fire seasons, especially in southern and central Europe.

- Changes in precipitation show diverse spatial trends between a wet northern part (an increase of 10 to 40 % during the 20th century) and a dry southern part (a decrease of up to 20 % in some parts of southern Europe). This adds to changes to the hydrological cycle, due to the loss of snow cover and permafrost areas. European glaciers are melting rapidly: those in the Alps have lost two thirds of their volume since 1850, with loss accelerating since the 1980s, and they are projected to continue their decline. Snow cover has decreased by 1.3 % per decade during the past 40 years, with the greatest losses in spring and summer, and decreases are projected to continue. Precipitation extremes, causing the risk of flooding and draughts, are also expected to become more frequent.

- For the moment, there is no clear trend in the frequency and intensity of storms, but increased intensity of storms is considered likely. Sea-level rise has already been documented and will cause flooding, coastal erosion and the loss of flat and low-lying coastal regions. It increases the likelihood of storm surges, enforces landward intrusion of salt water and endangers coastal ecosystems and wetlands.

- Biodiversity is already being affected by northward and uphill distribution shifts of many European plant species.

2.1. Impacts on Energy Production

2.1.1. Hydropower

Energy production is closely related to the availability of water resources, since they constitute the “fuel” for large and small hydropower stations, but are also needed to cool nuclear plants or for biocrop production. The consequences of climate change on the water flows of mountain watersheds have been analysed for the Upper-Danube watershed in Central Europe [Mauser and Bach 2009]. Supplies from this area are intensively used in the German, Austrian, Swiss and Italian border regions for hydropower production and the cooling of power plants. Expectations are that the annual low-flows, i.e. times of minimum availability of water in the river, will continually decrease from an average value of 650 m^3/s today to 350 m^3/s in the middle of the century. This will be the effect of complex changes in the Alpine environment, as described in the IPCC-A1B climate scenario. In the Pyrenees, dramatic effects are expected as a result of the alteration of snowpack, both with regard to thickness and duration. Depending on the altitude, the maximum accumulated snow water equivalent may decrease by up to 78% and the period of snow cover will shorten considerably in those altitudes that can typically be found in the Pyrenees. In this case, the most affected area are the central and southern (Spanish) side of the Pyrenees, where snow plays an important role in releasing high and regular spring river flows to the main tributaries of the Ebro River, which, in turn will affect some important power stations in the region [Lopez Moreno et al. 2009].

Diminishing inflows of water from the mountains will add to a pronounced decrease in precipitation, especially in the warm season in the Southern Mediterranean area [Giorgio and Lionello 2008]. Precipitations will not only be less frequent, but also more variable, making water management extremely difficult. The phenomenon will intensify over time, from about -7% in 2001 – 2020 to ~-28% in 2081 – 2100. The increase in variability, along with the large mean warming, is expected to produce a much more frequent occurrence of extremely high temperature events and heat waves, the consequences of which on the energy system will be discussed later in this paper.

2.1.2. Biocrops

Tuck et al [2006] have modelled the possible impact of higher mean temperatures on the availability of biocrops in Europe, concluding that "Mediterranean oil and solid biofuel crops, currently restricted to southern Europe, are predicted to extend further north due to higher summer temperature".

Graph: Northward Migration of "Biocrops"

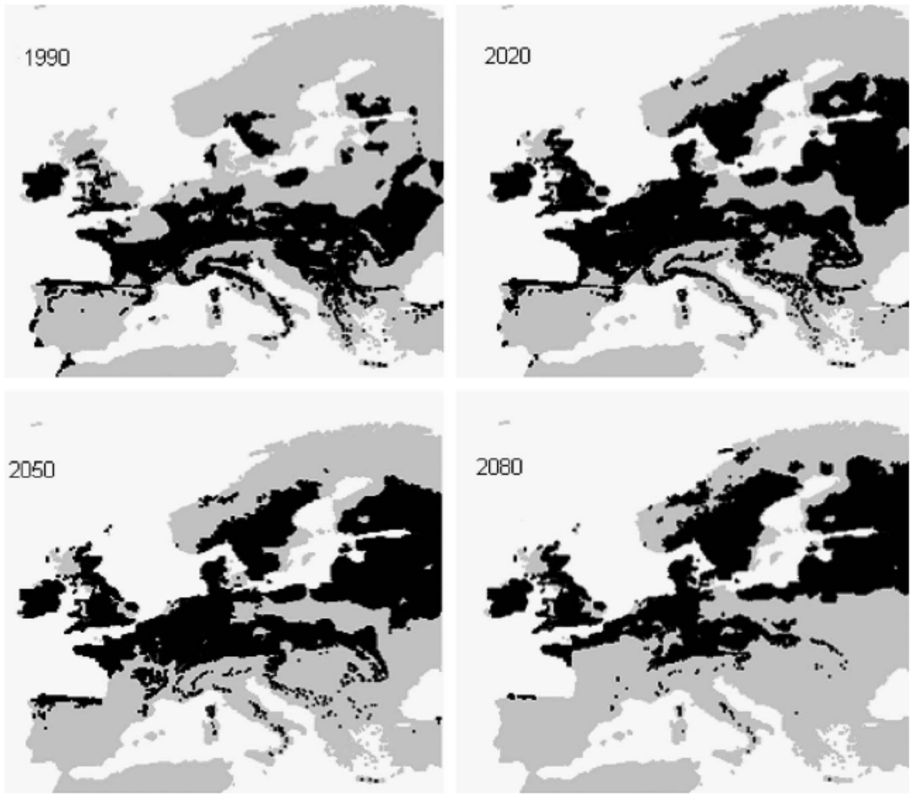

Fig. 3. Climate suitability maps for hemp, as predicted by the HadCM3 model and the A2 scenario, showing the baseline distribution (1990), and the change with time, for the time slices 2020s, 2050s and 2080s.

Source: Tuck et al [2006]

While for the major part of Europe, the effects of climate change on biocrop production are expected to be positive, the Southern region, comprising parts of France, Portugal, Greece and, especially, Spain, will see their potential for biocrop production "severely impaired": "If bioenergy crops are to be viable in these vulnerable regions in the future, efforts such as breeding for temperature/drought tolerance or alternative management strategies (e.g. earlier sowing) will be required to allow bioenergy crop production to adapt to the challenges presented by climate change." [Tuck et al 2006].

2.1.3. Near-shore and off-shore energy facilities

Facilities located near shore or off-shore may be affected by the rise of the sea level, as documented by Estonian researchers [Kont et al. 2003]. The worrying example has been the former uranium enrichment plan in Sillamäe, from which radioactive substances leak into the soil and sea. The facility is protected by a dam, which, in case of destruction, could cause catastrophic pollution in the Gulf of Finland.

Sea level rise could also affect the foundation loading of off-shore wind facilities, which tend to be built in shallow waters [Pryor and Barthelmie 2009]. Further climate change impacts on the wind energy sector are presently little explored and wind resource magnitudes are not expected to become severely affected in the short and medium term, since wind speeds are generally variable, with annual variation of 10 - 15%. However, small changes in a given location could have an important – positive or negative – impact on the production of wind parks, since a change in wind speed at turbine hub-height of 0.5 m s leads to an increase in energy density by over 30%. In general, with regard to wind energy, experts expect to see “winners” and “losers” – regions where wind energy development may benefit from climate change and regions, where the wind energy industry may be negatively impacted.

Some efforts are under way to measure and predict wind speeds more precisely and thus support siting decisions for new wind farms[21]. According to the new measurements available, wind speeds in the Southern half of the North Sea are rapidly increasing during summer time, so that energy outputs are up 50% compared to 1990 levels [Atmos Consulting 2009]. However, wind speeds are also becoming lower in other regions and this data needs to be taken into account for sites with a wind potential that is close to the lower threshold of 5 m/s, which large wind turbines need to operate.

Further uncertainties are related to the possible need of design changes in the turbines to withstand extreme weather events or the possible, positive effect of declines in sea ice and icing frequencies in Northern locations, which are presently not appropriate for installing wind parks. Finally, the expected pole-ward displacement of storm tracks and fewer, but more intense mid-latitude cyclones may have to be considered in the planning phase of wind parks.

Storms pose a dangerous threat to off-shore and near-shore facilities, as hurricane Katrina and other recent events have demonstrated. This includes gas and oil production platforms, but may extend in the future to off-shore wind parks and, especially, ocean power projects. The resistance of off-shore wind parks to hurricanes is already being considered in the authorization

[21] See The Guardian, 26/04/09, “*Winds of change blow for offshore power operators*”

procedure and planning phase of projects in the US[22]. Models are available to take the likelihood of hurricanes into account when analysing the financial viability of off-shore wind parks [Stratford 2007], but it is not clear if the reference values for decision-making consider the likelihood of more extreme conditions or are based on historical data.

Ocean power technologies have not yet reached the same stage of large-scale deployment, but may offer interesting opportunities for coastal regions in the medium future. Companies are presently testing the resistance of different pilot technologies to storms and wave heights, and it is clear that robustness will be one of decisive elements for the competiveness of the winning technologies.

2.2. Impacts on Transmission and Distribution of Energy

Storms are also one of the main threats to the energy sector's transport and distribution system. For example, the storms of December 1999 in France destroyed significant parts of the French electricity system causing wide-spread blackouts. As a result, the French authorities decided to follow a new policy of undergrounding significant parts of their electricity system in order to secure supply availability under adverse weather conditions [European Commission 2003]. "Undergrounding" transport and distribution lines requires additional investment by the energy companies, but may be the more cost-effective solution in the longer term, preventing economic losses in the future. This will be especially important with the growing interconnection of the European electricity market, which implies the transport of larger quantities of electricity over longer distances. But it could also be important to better protect regions, which rely increasingly on autonomous energy production facilities and local networks.

The increasing risk of forest fires is another element to take into account, as recent events in Greece, Northern Portugal, Spain and other locations have shown. Grid failures can, for one hand, be the cause of these fires, but, on the other hand, the transport infrastructure can also be used for early fire detection with the help of advanced sensors.

The expected changes in energy demand patterns, which are explained below, will provoke problems in the form of peak loads in regions with increasing need for air-conditioning, especially in grids that are operating close to their maximum capacity.

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[22] See, for example, the EPA environmental impact analysis of the Long Island Offshore Wind Park or the Bluewater project in Delaware.

2.3. Impacts on Energy Demand

There is a general agreement among researchers that increased mean temperatures will lead to a higher demand for cooling purposes and a lower demand for heating our buildings. Climate change will therefore have the greatest effects on the energy used for space heating and cooling, especially in the commercial sector. In industry, heating and cooling demands are often considered to be independent of outdoors temperatures [Ruth and Lin 2006], but this may not be true for specific industrial activities, for example cooling processes related to food production and storage [Hekkenberg et al 2009]. Also, not all cooling and heating processes will be affected, since some of these are continuous (for example, the freezer at home) and may only require a slight increase of energy input. Much more important for future demand increases are the temperature-related processes in a building.

Heating and cooling demand of buildings is generally expressed in the shape of a U-curve, indicating that there is a range of outside temperature, generally set at 15.5 to 18-18.5º C, when a building does not need any type of energy input to be comfortable. Although 18.0º C may appear a low threshold, it must be kept in mind that buildings, and especially office buildings, receive residual heat from inside, for example from ICT applications. According to Swiss researchers [Frank 2005], temperatures up to 29º C can be coped with by natural night ventilation, but only for a short-term period with an outdoor air temperature maximum of 36.7º C. The need for mechanical cooling sets in during prolonged periods of heat, as experienced in large parts of Europe in 2003 and, in a more general form, in the Southern European regions. The most important effect of heat waves on the demand side will be the "Heat Island Effect" in certain urban areas, where heat is much more intense than in other environments.

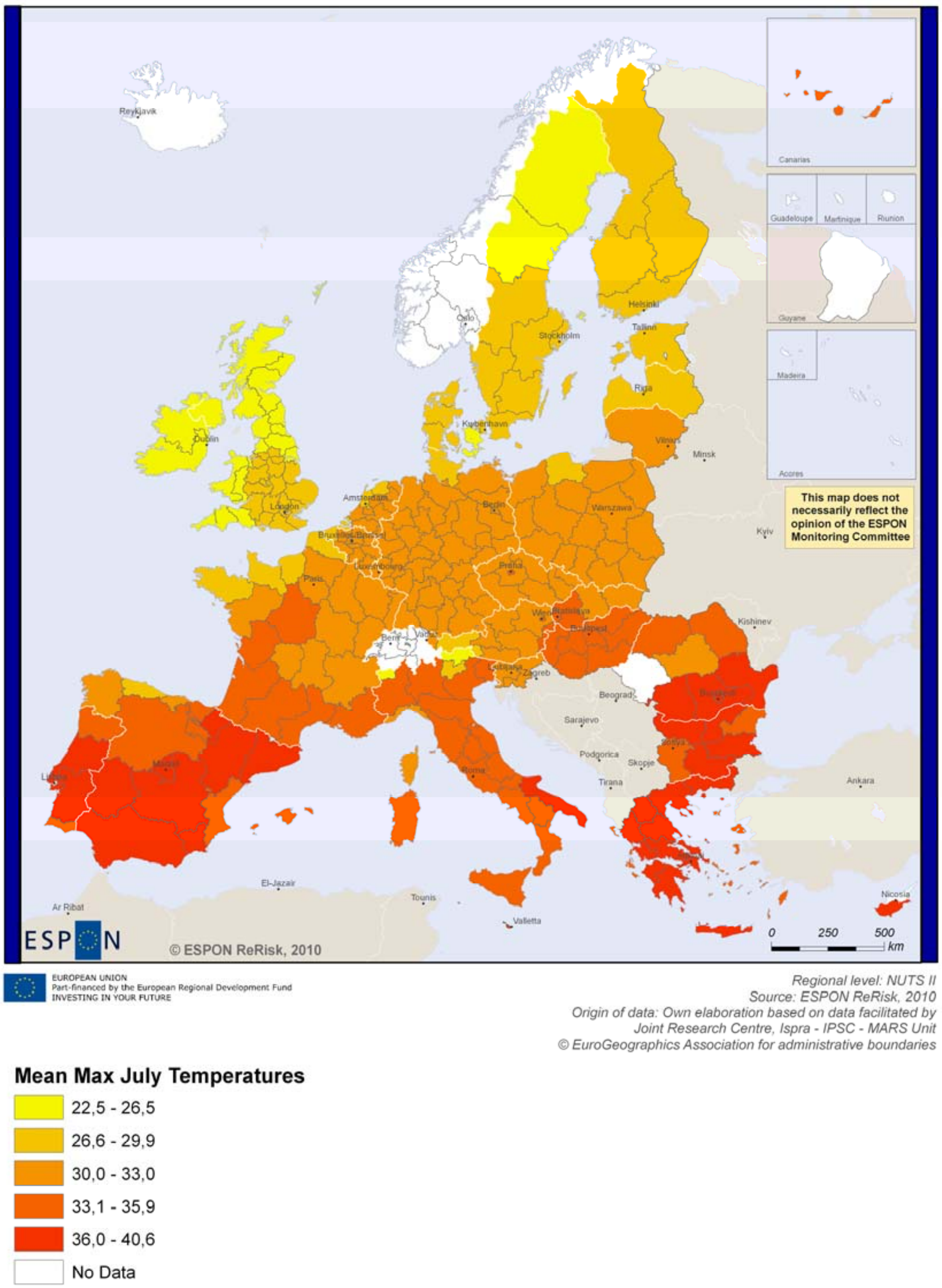
Impacts on energy demand for heating and cooling are expected to be considerable, even in central Europe: in Switzerland, a 33-44% decrease in the annual heating energy demand is foreseen for the period 2050-2100 for residential buildings, but the cooling demand for office buildings will increase by 223 - 1050%. There are, however, important regional differences [Christenson et al. 2006] depending on the climate zone and the building quality, as well as cultural and sociological factors, which will be discussed later.

From the energy sector's point of view, the shift from heating to cooling demand implies, in most countries, a switch to greater electricity use and lower demand for gas, oil or other fuels used for heating. This means, that the strain on the electricity grid will increase during the summer months, but little benefits can be expected for other energy networks. The increase of annual electricity demand attributable solely to climate change is expected to be in the range of 3.6 – 5.5% in Greece [Mirasdegis et al 2007]. Again, we find important differences within the country, being the most affected regions Attika and the central Macedonia regions, the Aegean Islands, Crete and the Thessalia prefecture [Cartalis et al. 2001].

When looking at the maximum mean July temperatures in the European regions over the last 15 years, as shown in the map below, the borderline between the most vulnerable regions in the South and the rest of continent becomes perfectly visible. Depending on the speed and intensity of climate change, this borderline is expected to move upward. The greatest increase in additional electricity demand for cooling is not likely to occur in the hottest regions, where air-conditioning is already quite common, but in regions with moderately hot summers (up to now).

Map: Regions with Highest Summer Temperatures in Europe

Mean Maximum July Temperature in the EU Regions (NUTS II, 1994 - 2009)



Source: ESPON ReRisk Project. Elaboration: NTUA, based on JRC data

The critical question for the future energy demand for cooling consists in the number of persons who will make increased use of air-conditioning, as temperatures climb beyond the “range of comfort”. This range is not precisely defined and is obviously related to personal preferences and cultural settings. Comparative research on the saturation of air conditioning markets in 39 US cities [Sailor and Pavlova 2003] shows that there are several determinants for air-conditioning use, others than temperature:

- household income
- household size
- electricity price

According to Heckenberg et al [2009], Frank [2005] and Cadot [2007], other aspects influencing consumer behaviour and, therewith, future energy demand are

- the quality of the building stock and the design of the specific building
- the ICT equipment used in building and the amount of residual energy emitted
- deployment of energy-efficient appliances
- the percentage of elderly population in a region, which is more affected by heat waves
- legislation, such as the Swiss National Standard SIA 382, which defines a minimum threshold for the installation of air-conditioning appliances in office buildings

These non-climate factors combined and the socio-economic dynamics behind them are likely to have a greater effect on the development of energy demand for cooling than the impacts of climate change. They also set the frame for policy interventions on regional level.

3. Conclusions and Recommendations for Regional Policy Makers

Although the extent and the speed of climate change impacts on the energy sector are not known at the moment and all data presented here relies in the interpretation of the rather conservative IPCC scenarios, a quite coherent picture arises, when analysing the modelling results.

Impacts are likely to be severe in the Southern regions belonging to Spain, Greece, Portugal and France, both in terms of energy production and demand. In these regions, summers are going to be complicated for energy companies, due to diminishing water reserves, higher mean temperatures and heat waves, and consequently, forest fires. The supply problems will coincide in time with higher peaks of electricity demand, derived from a more extended use of air-conditioning.

Existing energy infrastructure is under risk in most parts of Europe and needs additional protection through monitoring or undergrounding. New capacity to be installed, including projects for the use of wind or bio- or ocean energy, also has to be scrutinized for possible vulnerabilities to climate change impacts. The need for new, expensive and under-used peak load capacities for electricity production will be greatest in regions, which have not yet reached full market saturation of air-conditioning appliances. However, much of this may be avoided by promoting passive cooling techniques or solar-based appliances in buildings and cities or by defining a minimum threshold for their installation in offices and public buildings.

One recommendation is that environmental risk assessment must be extended: “It is not enough just to assess an installation’s impact on the environment; one must also assess the impact of a changing environment on the installation. Then, as much as possible, the impact of that change must be integrated into planning and countered” [Paskal 2009]. The necessity to consider climate change impacts on the regional and local energy systems has also been recognized in the context of the AMICA project[23], which recommends that the vulnerable aspects of each system (e.g., problems with grid connection because of fallen trees, oil pollution during flood events, lack of water in rivers for hydro-power stations and cooling in thermal power stations, etc.) must be identified in order to develop more secure energy sources and infrastructure.

This is especially important for coastal zones, according to the Portuguese agency CCDRN Comissão de Coordenação e Desenvolvimento Regional do Norte. Regions near the shore could make use of the tools related to the Integrated Coastal Zones Management (ICZM) to reduce their vulnerability to climate change effects, paying special attention to energy infrastructure and hazard risks.

However, all European regions need more accurate and “down-scaled” scenarios to make the right long-term planning decisions. First regional

[23] www.amica-climate.net

estimates available for the German Länder indicate that there will be a considerable regional differentiation with regard to temperature rises between the Southwest and the Northeast, and also with regard to rainfall increases during the summer (Bundesamt für Bauwesen und Raumordnung 2007].

Furthermore, attention should be paid to protecting the most vulnerable part of the population, i.e. elderly people in urban areas, during heat waves. This can be done by changing the design of cities, for example opening corridors for better ventilation, amplifying green spaces and shadow areas. However, it will still be necessary to prepare short-term emergency responses with the help of "heat wave plans" on local and regional level. The framework for this has been set recently by several EU countries and some regions (England, France, Spain, Portugal, Italy, Belgium, the Netherlands, Denmark and Luxemburg[24]) with the objective of reducing the number of 55.000 premature deaths registered in Europe in 2003.

[24] The plans can be accessed at http://ec.europa.eu/health/ph_information/dissemination/unexpected/unexpected_3_en.htm

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Annex 4 List of Abbreviations

AEBR Association of European Border Regions
BAT Best Available Technologies
CCA Cross Consistency Assessment
CENIGER Centre for Training in Renewable Energy
CHP Co-generated Heat and Power
EEA European Environmental Agency
EERE Energy Efficiency and Renewable Energy
EESC European Economic and Social Comittee
EESC European Economic and Social Committee
EIA Environmental Impact Assessment
ESCO Energy Service Companies
ETC/ACC European Topic Centre on Air and Climate change
ETS Emissions Trading Scheme
FUA Functional Urban Areas (FUA)
GdP Gross Domestic Product
GHG Greenhouse Gases
GIS Geographical Information System
GVA Gross Value Added
ICLEI International Council for Local Environmental Initiatives
ICT Information and Communication Technologies
IEA International Energy Agency
IIIEE International Institute for Industrial Environmental Economics
IS Industrial Symbiosis
JRC Joint Research Centre
LISP Landskrona Industrial Symbiosis Programme
MA Morphological Analysis
MS Mobilité Spatiale
NACE Nomenclature générale des activités économiques dans le communautés européennes',
NEEAP National Energy Efficiency Action Plans
NGO Non-Governmental Organization
NUTEK Swedish Business Development Agency
NUTS Nomenclature of Units for Territorial Statistics
PPP Public-Private Partnerships
PPS Power Purchase Standards
PUSH Potential Urban Strategic Horizon
PV Photovoltaic
R&D Research and Development
RES Renewable Energy Systems
SET Strategic Energy Technology Plan
SMEs Small and Medium Enterprises
TMN Transnational Municipal Networks

Annex 5: Bibliography and Interview Partners

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