ANALYTICAL OVERVIEW

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1. INTRODUCTION

The focus of this handbook is to demonstrate how different policies are being implemented in the European countries participating in this Action, indicated in *Figure 1*, that are helping to progress the low-carbon agenda, and to illustrate how industry and broader stakeholder groups are involved in the process. The analysis of the regions included within this handbook together with the specific case studies will help to provide an understanding of how low carbon technologies can be made appropriate and transferable within and between regions.

Figure 1 – Map indicating the countries involved in COST Action TU1104, Smart Energy Regions

COST Action members were asked to provide case studies to illustrate low carbon initiatives taking place at a regional scale within this region. A template was provided to all participants to enable consistent information to be collected across the countries and regions and to enable a comparative study of the information provided. Data collected included:

- an overview of the region, including the general characteristics as well as information on the energy demand and supply of the region;
- the current situation, including the targets related to energy policy and other regional targets, barriers and drivers;
- a case study, including general information as well as specific information on the objectives and methods, the results and outcomes;
- conclusions including the transferability of the case study and general region approach to other regions.

The countries, the regions and the case studies are presented in *Table 1*.

The findings of the investigation are presented in the section below. Please note that the country code used in all figures refers to the region within the country and not to the country as a whole.

2. CHARACTERISTICS OF THE REGIONS

The European regions identified vary significantly with regards to culture, politics, history, economy and energy consumption together with their size, population, density, climate, topography and other aspects.
The individual characteristics of each region are presented below to help understand the strategies implemented within the wide range of European regions included within this investigation.

Population and economy
With regards to population density and geographical size there is a large variation between countries, with DK, MT, NL, NO, RS, SL, ES, SL, and CH investigating highly populated small regions mostly consisting of urban areas and their surroundings, which are heavily influenced by the nearby city.

Other countries have presented larger regions with medium population density, such as BE, CY, DE and the UK. Regions with a low population are located in largely rural areas, such as those identified by AT, BA, GR, LV, and MK.

Figure 2 illustrates the wide range of different population densities to be found within the various regions presented in this study. The lowest population density was found in the Kuldiga Municipality (LV), with approximately 14 persons per km^2. The highest density was found in the region of the Municipality of Copenhagen (DK) with approximately 6,230 persons per km^2.

Country	Country code	Region	Case study
Austria	AT	Styria	Okoregion Kaindorf
Belgium	BE	Wallonia	Energy efficiency incentives in Wallonia
Bosnia and Herzegovina	BA	Bosnia and Herzegovina	DELTER project
Bulgaria	BG	Gabrovo Municipality	Integrated Plan for Urban Regeneration and Development of Gabrovo
Cyprus	CY	Cyprus	Energy upgrading of the refugee settlement
Denmark	DK	Copenhagen region	Carlsberg development plan
Finland	FI	Tampere city region	Härmälänranta residential development
fYR Macedonia	MK	Macedonia	Karposh Municipality
Germany	DE	Bavaria	Urban Laboratory Nuremberg Western City
Greece	GR	Western Macedonia	Kozani's District Heating System
Hungary	HU	Vasvar region	Aspects of the regional building stock
Ireland	IE	Ireland	Better Energy Communities Programme
Italy	IT	Basilicata	TIMES-Basilicata model
Latvia	LV	Kuldiga region	A single computerised Kuldiga region utilities management and control system
Lithuania	LT	Kaunas region	Cogeneration power plant in village of Noreikiskes
Malta	MT	Malta	Gozo island
Netherlands	NL	Parkstad Limburg	Mine water for heating and cooling in the municipality Heerlen
Norway	NO	Trondheim municipality	The Brøset neighbourhood
Poland	PL	Podkarpackie Province	Bieszczady Mountains
Portugal	PT	North region of Portugal	The Great Metropolitan Area of Porto
Romania	RO	North-East region of Romania	County of Iasi
Serbia	RS	Belgrade region	Refurbishment of suburban apartment buildings, Karaburma
Slovenia	SI	Municipality of Maribor	EnergaP, demonstrating the impacts of the Local Energy Concept on the renovation of primary schools
Spain	ES	Autonomic Community of Madrid	Local strategies for improving the energy certification in Madrid region buildings
Switzerland	CH	Canton of Zurich	Smart City Winterthur
United Kingdom	UK	Wales	Arbed scheme

Table 1 – Regions included within the investigation together with the country, the country code and case study name

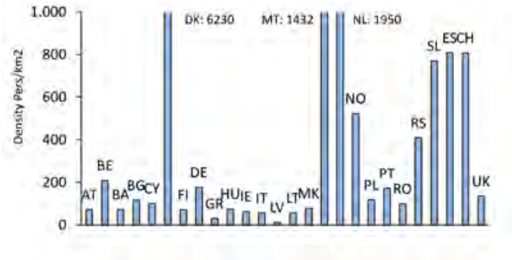

Figure 2 – Population density of the regions indicated by country code

The size of the regions also varied significantly. The smallest region was the Municipality of Copenhagen (DK) covering an area of 90 km². The largest area was IE totalling 70,280 km².

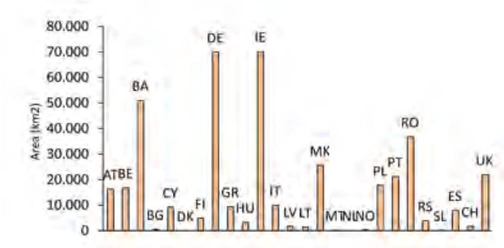

Figure 3 – Geographical size of the regions

The comparison of the area and the population density of the various regions can be seen as an indicator of the very heterogeneous structure of the various regions within Europe.

Economic situation
Independent of size and population density the ratio of the Gross Domestic Product (GDP) to employment rate can be used to indicate the economic situation of a region. This is illustrated in *Figure 4*. The employment rate is calculated by dividing the number of persons aged 20 to 64 in employment by the total population of the same age group.

It is illustrated in *Figure 4* that the most countries and their associated regions are characterised by the long-term development from an industrial society to a service-oriented society. In most European countries industrial production is increasingly shifting from highly developed countries to developing countries, such as countries in Asia. As a consequence of this transition from energy intensive industrial production economies to less energy intensive service economies the energy demand in these European countries is decreasing. This is illustrated in regions such as in the region of Wallonia (BE), where the shrinking steel industry has caused a significant reduction in CO_2 emissions enabling the region to comply with the Kyoto objectives.

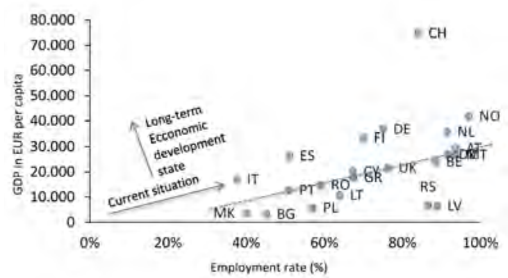

Figure 4 – Employment rate and GDP of the regions

Energy Consumption and CO_2 Emissions
Economic situation and its impact on total energy consumption of regions
As mentioned in the previous section, the economic situation seems to have a strong impact on total energy consumption.
Often, strong economic development results in a relatively high energy consumption. As shown in *Figure 5*, regions with the highest energy demand (kWh/person/year) are DE, AU, BE and IE, which also have higher GDP. Exceptions to this are NO and CH. In these countries, the regions selected show an above-average GDP, coupled with a below-average energy demand. This illustrates that care must be taken when interpreting the results, as the energy consumption cannot always be taken as an indicator for the economic productivity of a region. In some regions an economy based on industry and production results in high energy demand, while the economy of other regions, such as that selected by NO and CH, which is based on a successful service-oriented economy.

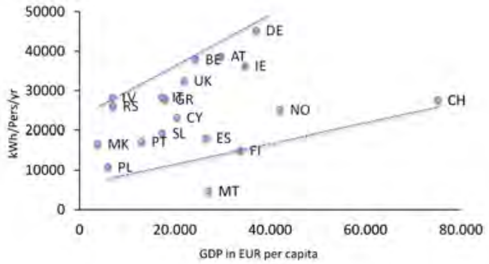

Figure 5 – Regional GDP and energy demand

The same situation can be found in regions with a lower GDP, such as the regions of LT, RS, MK and PL. These also demonstrate that total energy consumption varies despite the fact GDP being within a comparable range.

Economic situation and total amount of emissions.

When correlating GDP of a region with the total CO_2 emissions per person/year, a similar situation is experienced to the relationship of GDP and total energy consumption of a region, with the amount of emissions not being directly related to the economic situation of a region as illustrated in *Figure 6*.

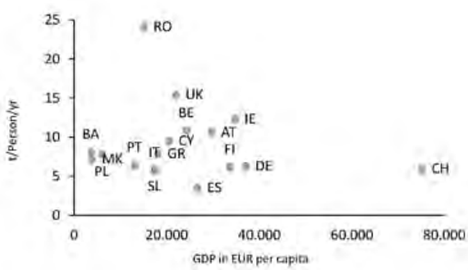

Figure 6 – GDP and emissions of the regions

The reason for this is that the total amount of emissions depends on the share of non-fossil energy sources providing the energy of a region and not on the overall energy consumption. As an example, the region of Bavaria (DE) was, until recently, heavily dependent on nuclear power, but, as a result of National policy, is now shifting to an increasing share of renewable energies. The regions GDP is high, but CO_2 emissions are relatively low. The County of Iasi (RO), is still dependent mainly on fossil fuels, while Brøset neighbourhood (NO) relies 100% on hydro power. The region of Winterthur (CH) has the highest GDP, but has low CO_2 emissions per person/year due to its large share of nuclear energy and renewable energies from hydro power (as illustrated in *Figure 6*).

Energy consumption also depends on the economic structure of a region, as heavy industries, such as steel and aluminium production consume much more energy than service-oriented economies, which are dominant in the region of CH.

Electricity

The share of renewable energy related as a proportion of energy produced within a region is a major factor determining the CO_2 emissions per kg per kWh. However, the overall share of fossil fuel as well as nuclear fuels used for the energy production has to be considered.

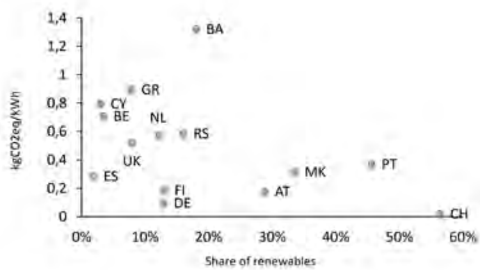

Figure 7 – Proportion of renewables and CO_2 emissions related to the total electricity supply of regions

As shown in *Figure 7*, the Winterthur region (CH) has a large proportion of renewable energy and produces a major proportion of electrical energy from nuclear power plants. This leads to a very low rate of CO_2 emissions as a result of electricity production. Different reasons are presented for other regions with low CO_2 emissions: the Municipality of Copenhagen (DK) covers a large share of its energy demand from wind power, that of DE still depends heavily on nuclear power, while that of NO depends on hydro-power. Other regions, such as that of MT, CY, BE, and CS are largely dependent on fossil fuels.

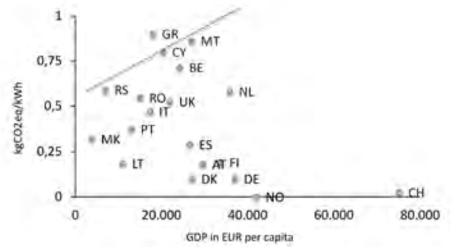

Figure 8 – GDP and CO_2 emissions related to the electricity supply of regions

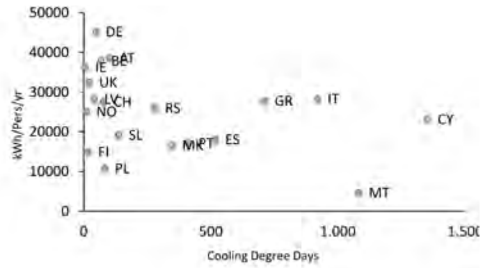

Figure 10 – Cooling degree days of a region related to the energy demand of a region

Figure 8 shows the relationship of the GDP of the regions versus the amount of CO_2 emissions per kWh in the area of the electricity consumption of a region. Similar to the relationship between the GDP and the overall CO_2 emissions in kg per kWh of a region, a clear difference between regions is illustrated. While regions like that of CH have a relatively low emission rate, due to their large share of renewable energies and nuclear power, other countries, depending mainly on fossil fuels, have a significantly higher amount of CO_2 emissions related to the GDP of their region.

Climate

The amount of heating degree days (HDD) are to be regarded as an indicator for the heating energy demand of a building. This is directly related to the outside air temperatures of a region. In a similar manner, the amount of cooling degree days (CDD) is an indicator for the amount of energy required to cool a building.

As shown in *Figure 9*, the various regions show very different conditions with regard of the heating and cooling degree days. However, it is not possible to draw direct conclusions on the energy demand of the regions.

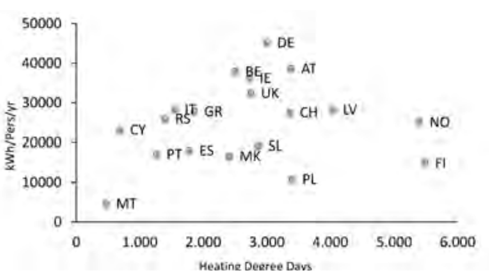

Figure 9 – Heating degree days of a region related to the energy demand of a region

GHG reduction targets (% and years, only most relevant)

Many regions have adopted the 20-20-20 objectives of the European Union and have developed strategies based on this. However, some regions are exceeding these objectives having set their own very ambitious targets. For example, the region of the 'Municipality of Copenhagen' (DK) aims to achieve zero emission region status by 2025. The region of Parkstad Limburg (NL) plans to be carbon neutral in 2040. The region of Winterthur (CH) aims to reduce the total emissions per capita from 6 tons to 2.2 tons by 2050.

Drivers and Barriers

One of the main drivers to aid the creation of Smart Energy Regions within Europe is the Energy Efficiency Directive (2012/27/EU), which entered into force on 4th December 2012. Most of its provisions will have to be implemented by the Member States by 5th June 2014. By 30th April 2014 and every three years thereafter Member States will have to submit their National Energy Efficiency Action Plans (NEEAPs) to the Commission.

Many factors are found throughout the regions analysed that influence the drive and magnitude for increasing energy efficiency and use of renewable energies. Some of the main factors are presented in the following paragraphs.

Local drivers for smarter energy regional policy

In ES, the 'Blue Plan for Air Quality and Climate Change' was in place between 2006 and 2012. The 'Air Quality Strategy and Climate Change' of the Community of Madrid is currently being developed to follow this (2013 – 2020).

In the region of Wales, UK, both the potential for offshore and onshore wind turbines as well as the potential for tidal energy harvesting are seen as positive elements for a sustainable energy supply in the future. Another major driver for this region is the legal commitment by the Welsh Government to include sustainable development in its constitution.

In DK, the limited capacities of the power plants is acting as a driver for investments in energy efficiency measures to avoid major investments in new power plants.

In DE and CH governments have created clear and binding strategies for phasing out nuclear power plants. This has led to enhanced strategies for reducing energy demand through improving the energy efficiency of the building stock, the infrastructure and the energy system as well as increasing the share of renewable energies.

In IE, the government follows the strategy to replace peat with biomass, thereby reducing GHG emissions. The economic recession in IE has led to a considerable drop of the energy-intensive cement production. Similarly, BE was facing serious challenges with its steel industry, which has led to a considerable drop of CO_2 emissions, which has supported the country's achievements in meeting its Kyoto commitments.

Other more generic drivers, which have been identified throughout the regions investigated have been the:

- increasing necessity to tackle fuel poverty;
- increasing innovative research on low-carbon technologies.

Challenges and barriers

As noted in the previous sections, there are still major challenges existing in member countries to meet the goals to reduce the GHG emissions by reducing energy demand and increasing the share of renewable energies throughout the EU. From the regional investigations some of the major challenges have been identified as:

- poor performance of the existing building stock;
- poor performance of the energy supply systems;
- the low refurbishment rate of buildings, especially those that constructed before the mid-80s;
- poorly performing economies, which offer few options for investment in to a future-oriented energy system.

Major barriers have been identified to be:

- no proper institutional structure;
- lack of competence and clear responsibilities;
- slow bureaucracy and administration;
- political instability;
- bureaucratic and administrative corruption as mentioned in some of the case study descriptions.

Across the regions, more specific obstacles were found, such as:

- fixed electricity energy prices, which have found to be counterproductive with regard to saving electrical energy, and are in part responsible for the high share of domestic heating using electricity;
- lack of public awareness of need for energy efficiency;
- lack of relevant building materials, components and systems for the improvement of the energy efficiency of buildings;
- lack of knowledge, human resources, and of sustainable and long term financial sources for energy efficiency projects;
- lack of information about government funding;
- unresolved situations with regard to tax rebates for energy efficiency measures;
- lack of integration of sustainable development in policy areas;
- an increased percentage of unemployment.

Socio-economic Transformation

The economic situation in the countries and their regions plays a decisive role with regard to energy consumption and the opportunities for moving towards reducing energy demand and increasing supply from renewable energy systems. It has been found that the economic situation of the regions is directly related to the social situation and access to education, information, training, materials and systems as well as other resources. It is becoming clear that the transformation from a carbon-based to a carbon-free economy/society can only be successful if economic and social development are regarded as integrated entities.

As previously illustrated, the economic situation is very different across European Countries. It therefore has to be expected that the means for supporting the socio-economic transformation are very different throughout the various members of this COST Action. While the individual contributions of each member country of the Action give a detailed account of the specific situation, some of the strategies and instruments for supporting the socio-economic transition are highlighted briefly in the following section.

Regional agencies and initiatives
In RO, the North-East Regional Development Agency has been created to stimulate economic and social development in the North-East Region of the country. This has been done by developing strategies, attracting resources, identifying and implementing financing programs and offering services for encouraging sustainable economic development, partnerships and entrepreneurial spirit.

In the UK region of Wales, the initiative "One Wales One Planet" adopts a holistic approach to sustainability and places much importance on public awareness, on the involvement of local communities and on the engagement and education of children and young people to sustainable practices. With this initiative, the Government acknowledges the need to further investigate social patterns of consumption and identify successful strategies for behavioural change.

Funding / Tax incentives for investments
Funding opportunities and related instruments, such as tax incentives and feed-in tariffs are important measures for the widespread and fast implementation of energy efficiency measures and the integration of renewable energy supply systems into the energy system. In addition to this, in most of the member countries, European Structural funds from EDRF and ESF programmes are an important driver for the progression of the low-carbon and climate change agenda.

Energy policies / Legal Framework
Energy policies and the related legal framework are important instruments to encourage rapid transformation of the energy structure of a region and its associated country. Examples of how such instruments can support the integration of energy efficiency measures and the integration of renewable energy supply can be found in CY, including:

- the installation of solar systems to satisfy the domestic hot water requirements on every new building used as a residence is mandatory. To ensure the proper implementation, a technical guide of solar systems is provided by the Building Authority;
- the Electricity Authority of Cyprus (EAC) is obliged to purchase renewably generated electricity;
- local authorities identify areas where the development of renewable energy systems is allowed. This includes the definition of clear terms for the connection of photovoltaic systems and electricity generation systems using biomass and other renewable energy systems within the grid;
- adoption of the Law on the Promotion of Combined Heat and Power and the prioritisation to energy produced with combined renewable energy power generation from the transmission system operator;
- simplification and acceleration of the renewable energy licensing procedures through the adoption of principles such as the "One Stop Shop";
- the facilitation of small- scale renewable energy developments through reduced application charges and faster, non-dissuasive procedures for licensing;
- reduced fees for connection of renewable energy plants with the grid.

Similar policies can be found in other countries such as DE, MT and others.

Information / Training / Knowledge
Strategies to encourage rapid and thorough exchange of information, including programmes for education and training are of utmost importance for the transformation of our society. In addition to traditional activities at the level of universities and other educational facilities, the UK offers some further activities, such as the delivery of specific training programmes to workers and professionals. Such specific programmes offer additional career development to the workforce and provide the industry with the skills needed to

progress the low-carbon transition.
Other examples for the support of the transition to a low-carbon society include the creation of planning tools, such as the 'Wind Atlas', which has been produced for the southern part of BA, which is recognised as a region suitable for large scale wind parks.

Innovation
A wide range of innovation technologies are demonstrated throughout the case studies presented for the regions. These include strategies for the implementation of low-carbon mobility and low-carbon energy systems on a regional and urban scale. A particularly interesting example of an innovation is the minewater concept in the NL, which was developed in 2012 with the following goals:

- maximised long term use of geothermal underground for sustainable heating and cooling of buildings;
- becoming an essential part of the Sustainable Energy Structure Plan 2040 of the municipality Heerlen (carbon neutral city);
- establishing a Minewater Corporation with a sound business case or in other words a lot of connections to the grid.

3. OVERVIEW OF THE CASE STUDIES

The representatives of each member country were asked to choose a case study to demonstrate how specific methods and concepts might have an impact on a regional scale to support the creation of a 'Smart Energy Region' in the region investigated.

In addition to key information on the case study chosen, such as area, population, initial conditions and local situation, authors were asked to describe the role of the stakeholders involved, the expected outcomes with regard to the social, economic, environmental, and the technical impact on the region, such as interventions and industry innovation as well as measures and methods.

Furthermore, the case studies are meant to support the identification of specific drivers and barriers for the creation of a 'Smart Energy Region' as well as the analysis of the various systematic interactions which are needed to support the energy shift throughout Europe.

Focus areas of the case studies
Although the various regions show very different characteristics with regard to their economic, climatic, social and cultural background, as described above, it was possible to identify four common approaches from the case studies with regard to supporting the creation of Smart Energy Regions.
These are presented below:

Eco Regions
A common approach to stimulate the smart energy region approach is to identify a local area to focus ideas on to demonstrate to other areas the possibilities available to reduce energy demand and to stimulate supply from renewable sources. Common characteristics of an 'Eco Region' are:

- clearly defined spatial area, creating a framework for the making and implementation of relevant policies;
- awareness with regard to the necessity to take an integrated approach with multiple indicators and disciplines to create a 'Eco Region';
- demonstrational character with regard to potential light-house projects

Case studies related to the creation of 'Eco Regions' are provided by:

- Austria
- Belgium
- Bulgaria
- Cyprus
- Denmark
- Finland
- Germany
- Malta
- Norway
- Poland
- Romania
- Switzerland

Energy Supply / Smart Grid
Some case studies concentrate on the supply side of energy and implement intelligent demand-supply-management.
Countries presenting case studies in this area are:

- Italy
- Lithuania

Transport
An interesting topic which has a considerable impact on reducing greenhouse gas emissions on a regional scale is transport. As the main focus of the action is on the building sector, only one case studies deals with mobility exclusively:
- Portugal.

Retrofit
The retrofitting of buildings and urban areas is one of the most effective measures for the reduction of GHG emissions. However, looking at the current refurbishment rates throughout Europe it seems to be very difficult to improve the building stock within the near future. Barriers include the lack of the necessary financial means and conflicting interests of the home-owner and the tenant.

Case studies dealing with the challenges and opportunities in the field of the retrofitting of the building stock can be found in the chapters provided by:
- Denmark
- Ireland
- Macedonia
- Serbia
- Slovenia
- Spain
- United Kingdom

Methods / Tools
Due to the complex subject, the development and implementation of Smart Energy Regions is best dealt with by taking a systems based approach to capture the wide range of related aspects and to show the relevant interdependencies in a tangible manner. With that regard novel methods are required to address the energy transition in an effective way. This includes the development of necessary tools for strategic planning and control.

Countries which have presented case studies in this field are:
- Germany
- Italy
- Latvia

CONCLUSIONS

This overview provides some examples of what the concept of a Smart Energy Region in the Action is understood to involve. A broad set of issues have been found to have a significant impact on the successful adoption of low carbon technologies and associated processes on a larger, regional scale implemented in the drive to create a low-carbon built environment. These include:
- the full implications of the role of regional governance and policy;
- a lack of flexibility and shortage of skills in associated supply chains;
- a misunderstanding of capital and operational costs;
- the potential for implementation of technologies geographically;
- the benefit and cost of installing and implementing information and communication technologies (ICT) in the built environment;
- the impact on quality of life and policy and planning for the future.

A major aspect of Smart Energy Regions has been highlighted as integrative management of the different aspects, which are required to consider for reducing energy consumption and emissions on a regional level. This includes technological and environmental issues as well as social, economic and political aspects that should be considered together with how they interact. Although conditions differ, the comparison of case studies show that there are a set of common approaches. For this purpose, the following chapters provided by the partner countries involved in this Action on exemplary regions and approaches enable an exchange of knowledge with the purpose to intensify the development of smart energy regions.

ACKNOWLEDGEMENTS

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The COST Action TU1104 Smart Energy Regions brings together over 70 researchers from European institutions to investigate the drivers and barriers that may impact on the large scale implementation of low carbon technologies in the built environment. The book "Smart Energy Regions" is the outcome of the Working Group 1 of the Action and collects analysis and case studies from 26 European countries. For more information about the Action and COST please visit www.smart-er.eu and www.cost.eu.

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COST DESCRIPTION

THE ORGANISATION OF COST

COST - European Cooperation in Science and Technology is an intergovernmental framework aimed at facilitating the collaboration and networking of scientists and researchers at European level. It was established in 1971 by 19 member countries and currently includes 35 member countries across Europe, and Israel as a cooperating state.

COST funds pan-European, bottom-up networks of scientists and researchers across all science and technology fields. These networks, called 'COST Actions', promote international coordination of nationally-funded research.

By fostering the networking of researchers at an international level, COST enables break-through scientific developments leading to new concepts and products, thereby contributing to strengthening Europe's research and innovation capacities.

COST's mission focuses in particular on:

- building capacity by connecting high quality scientific communities throughout Europe and worldwide;
- providing networking opportunities for early career investigators;
- increasing the impact of research on policy makers, regulatory bodies and national decision makers as well as the private sector.

Through its inclusiveness, COST supports the integration of research communities, leverages national research investments and addresses issues of global relevance.

Every year thousands of European scientists benefit from being involved in COST Actions, allowing the pooling of national research funding to achieve common goals.

As a precursor of advanced multidisciplinary research, COST anticipates and complements the activities of EU Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries. In particular, COST Actions are also open to participation by non-European scientists coming from neighbour countries (for example Albania, Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Jordan, Lebanon, Libya, Moldova, Montenegro, Morocco, the Palestinian Authority, Russia, Syria, Tunisia and Ukraine) and from a number of international partner countries.

COST's budget for networking activities has traditionally been provided by successive EU RTD Framework Programmes. COST is currently executed by the European Science Foundation (ESF) through the COST Office on a mandate by the European Commission, and the framework is governed by a Committee of Senior Officials (CSO) representing all its 35 member countries.

More information about COST is available at www.cost.eu.

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