5. CLIMATE ACTION, RESOURCE EFFICIENCY AND RAW MATERIALS

5.1. Fighting and adapting to climate change

Current CO_2 concentrations in the atmosphere are close to 40 % higher than those at the start of the industrial revolution and at the highest levels experienced in the last 2 million years. Non-CO_2 greenhouse gases also contribute to climate change and are playing an increasingly significant role. Without decisive action, climate change could cost the world at least 5 % of GDP each year; and up to 20 % under some scenarios. In contrast, with early and effective action the net costs could be limited to around 1 % of GDP per year. Meeting the 2°C target and avoiding the worst impacts of climate change will require developed countries to cut greenhouse gas emissions by 80-95 % by 2050 compared to 1990 levels.

The aim of this activity is therefore to develop and assess innovative, cost-effective and sustainable adaptation and mitigation measures, targeting both CO_2 and non-CO_2 greenhouse gases, and underlining both technological and non-technological green solutions, through the generation of evidence for informed, early and effective action and the networking of the required competences.

To achieve this, research and innovation will focus on the following:

5.1.1. Improve the understanding of climate change and the provision of reliable climate projections

Better understanding of the causes and evolution of climate change and more accurate climate projections are crucial for society to protect lives, goods and infrastructures and ensure effective decision making and adequate mitigation and adaptation options. It is essential to further improve the scientific knowledge-base of climate drivers, processes, mechanisms, feedbacks and thresholds associated with the functioning of terrestrial, marine and polar ecosystems and the atmosphere. Improved understanding will also allow more accurate detection of climate change and attribution to natural and anthropogenic causal factors. Improved reliability of climate projections and predictions at pertinent temporal and spatial scales will be supported via the improvement of measurements and via the development of more accurate scenarios and models, including fully coupled Earth-system models taking into account paleoclimate history.

5.1.2. Assess impacts, vulnerabilities and develop innovative cost-effective adaptation and risk prevention and management measures

There is incomplete knowledge on the ability of society, the economy and ecosystems to adapt to climate change. Effective, equitable and socially acceptable measures towards a climate resilient environment, economy and society require the integrated analysis of current and future impacts, vulnerabilities, population exposure, risks and their management, second order effects such as migration and conflicts, costs and opportunities associated with climate change and variability, taking into account extreme events and related climate-induced hazards and their recurrence. This analysis will also be developed on the adverse impacts of climate change on biodiversity, ecosystems and ecosystem services, water resources, infrastructures and economic and natural assets. Emphasis will be placed on the most valuable natural ecosystems and built environments, as well as key societal, cultural and economic sectors across Europe. Actions will investigate the impacts and growing risks for human health stemming from climate change, climate induced hazards and increased greenhouse gases concentrations in the atmosphere. Research will evaluate innovative, equitably distributed and cost-effective adaptation responses to climate change, including the protection and adaptation of natural resources and ecosystems, and related effects, to inform and support their development and implementation at all levels and scales. This will also include the potential impacts, costs , risks and benefits, of geo-engineering options. The complex inter-linkages, conflicts and synergies of adaptation and risk-prevention policy choices with other climate and sectoral policies will be investigated, including impacts on employment and the living standards of vulnerable groups.

5.1.3. Support mitigation policies, including studies that focus on impact from other sectoral policies

The Union's transition to a competitive, resource efficient and climate change resilient economy and society by 2050 requires the design of effective, long-term, low-emission strategies and major advancements in our capacity to innovate. Research will assess the environmental and socio-economic risks, opportunities and impacts of climate change mitigation options. It will also assess impact from other sectoral policies. Research will support the development and validation of new climate-energy-economy models, taking into account economic instruments and relevant externalities, with the aim of testing mitigation policy options and low carbon technology pathways at different scales and for the key economic and societal sectors at Union and global level. Actions will facilitate technological, institutional and socio-economic innovation by improving the links between research and application and between entrepreneurs, end users, researchers, policy makers and knowledge institutions.

5.2. Protection of the environment, sustainable management of natural resources, water, biodiversity and ecosystems

Societies face a major challenge to establish a sustainable balance between human needs and the environment. Environmental resources, including water, air, biomass, fertile soils, biodiversity, ecosystems and the services they provide, underpin the

functioning of the European and global economy and quality of life. Global business opportunities related to natural resources are expected to amount to over EUR 2 trillion by 2050[1]. Despite this, ecosystems in Europe and globally are being degraded beyond nature's ability to regenerate them and environmental resources are being over-exploited and even destroyed. For example, 1000 km² of some of the most fertile soils and valuable ecosystems are lost every year in the Union, while a quarter of fresh water is wasted. Continuing these patterns is not an option. Research must contribute to reversing the trends that damage the environment and to ensuring that ecosystems continue to provide the resources, goods and services that are essential for well-being and economic prosperity and sustainable development.
The aim of this activity is therefore to provide knowledge, and tools for the management and protection of natural resources that achieves a sustainable balance between limited resources and the present and future needs of society and the economy.
To achieve this, research and innovation will focus on the following:

5.2.1. Further our understanding of biodiversity and the functioning of ecosystems, their interactions with social systems and their role in sustaining the economy and human well-being.

Society's actions risk triggering changes in the environment that are irreversible and which alter the character of ecosystems and their biodiversity. It is vital to anticipate these risks by assessing, monitoring and forecasting the impact of human activities on the environment, including land use change, and environmental changes on human well-being. Research on marine, (from coastal zones to the deep sea including the sustaibability of marine resources), polar, fresh-water, terrestrial and urban ecosystems, including groundwater dependent ecosystems, will improve our understanding of the complex interactions between natural resources and social, economic, and ecological systems, including natural tipping points, and the resilience, or fragility, of human and biological systems. It will examine how biodiversity and ecosystems function and react to anthropogenic impacts, how they can be restored, and how this will affect economies and human well-being. It will also investigate solutions for addressing resource challenges in the European and international context. It will contribute to policies and practices that ensure that social and economic activities operate within the limits of the sustainability and adaptability of ecosystems and biodiversity.

5.2.2. Developing integrated approaches for the sustainable management of water-related challenges

Freshwater availability and quality have become global issues with far-reaching economic and social implications. With ever-growing demand for different uses, increased resource vulnerability exacerbated by climate and global change, urbanisation, pollution and over exploitation of freshwater resources, maintaining and improving water quality and availability, and mitigating the impact of human activities on fresh water ecosystems is becoming a critical challenge for the users of water in various sectors as well as for aquatic ecosystems. Research and innovation will address these pressures and will provide integrated strategies, tools, technologies and innovative solutions to improve water quality, cope with imbalances between water demand and availability or supply at different levels and scale and address water related risks whilst sustaining the integrity, structure and functioning of the aquatic ecosystems in line with the prevailing EU policies.

5.2.3. Provide knowledge and tools for effective decision making and public engagement

Social, economic and governance systems still need to address both resource depletion and the damage to ecosystems. Research and innovation will underpin policy decisions needed to manage natural resources and ecosystems so as to avoid, or adapt to, disruptive climate and environmental change and to promote institutional, economic, behavioural and technological change that ensure sustainability. Research will thus underpin the development of systems to value biodiversity and ecosystem services, including understanding the stock of natural capital and the flow of ecosystems services. Emphasis will be put on critical policy relevant ecosystems and ecosystem services, such as fresh water, seas and oceans (including coastal areas), forests, polar regions, air quality, biodiversity, land use and soil. The resilience of societies and ecosystems to pollutants and pathogens and to catastrophic events, including natural hazards (such as seismic and volcanic, flooding and droughts), will be supported through improving capacities for forecasting, early warning, and assessing vulnerabilities and impacts, including the multi-risk dimension. Research and innovation will thus provide support for environmental and resource efficiency policies, and options for effective evidence-based governance within safe operating limits. Innovative ways will be developed to increase policy coherence, resolve trade-offs and manage conflicting interests, and improve public awareness of research results and the participation of citizens in decision-making.

5.3. Ensuring the sustainable supply of non-energy and non-agricultural raw materials

Sectors such as construction, chemicals, automotive, aerospace, machinery and equipment, which have a combined added value in excess of EUR 1,000 billion and provide employment for some 30 million people, all depend on access to raw materials. The Union is self-sufficient in construction minerals. Nonetheless, whilst the Union is one of the world's largest producers of certain industrial minerals, it remains a net importer of most of them. Furthermore, the Union is highly dependent on imports of metallic minerals and is totally import dependent for some critical raw materials.
Recent trends indicate that demand for raw materials will be driven by the development of emerging economies and by the rapid diffusion of key enabling technologies. Europe has to ensure a sustainable management and secure a sustainable supply of raw materials from inside and outside its borders for all sectors that depend on access to raw materials. Policy targets for critical raw

[1] Estimates developed by PricewaterhouseCoopers for "sustainability-related global business opportunities in natural resources (including energy, forestry, food and agriculture, water and metals)" and WBCSD (2010) Vision 2050: The New Agenda for Business, World Business Council for Sustainable Development: Geneva, URL: http://www.wbcsd.org/web/projects/BZrole/Vision2050-FullReport_Final.pdf

materials are outlined in the Commission's Raw Materials Initiative.[2]
The aim of this activity is therefore to improve the knowledge base on raw materials and develop innovative solutions for the cost-effective and environmentally friendly exploration, extraction, processing, re-use, recycling and recovery of raw materials and for their substitution by economically attractive and environmentally sustainable alternatives with a lower environmental impact.
To achieve this, research and innovation will focus on the following:

5.3.1. Improve the knowledge base on the availability of raw materials

The assessment of the long-term availability of global and Union resources, including access to urban mines (landfills and mining waste), coastal-sea and deep-sea resources (e.g., the sea-bed mining of rare earth minerals) and the associated uncertainties will be improved. This knowledge will help society reach a more efficient use, recycling and reuse of scarce or environmentally harmful raw materials. It will also develop global rules, practices and standards governing economically viable, environmentally sound and socially acceptable resource exploration, extraction and processing, including practices in land use and marine spatial planning on the basis of an ecosystems approach.

5.3.2. *Promote the sustainable supply and use of raw materials, including mineral resources, from land and sea, covering exploration, extraction, processing, re-use, recycling and recovery*

Research and innovation is needed over the entire life cycle of materials, in order to secure an affordable, reliable, and sustainable supply and management of raw materials essential for European industries. Developing and deploying economically viable, socially acceptable and environmentally friendly exploration, extraction and processing technologies will boost the efficient use of resources. This will include mineral resources, from land and sea, and will also exploit the potential of urban mines. New and economically viable and resource efficient recycling and materials recovery technologies, business models and processes will also contribute to reducing the Union's dependence on the supply of primary raw materials. This will include the need for longer use, high-quality recycling and recovery, and the need to drastically reduce resource wastage. A full life-cycle approach will be taken, from the supply of available raw materials to end of life, with minimum energy and resources requirements.

5.3.3. Find alternatives for critical raw materials

In anticipation of the possible reduced global availability of certain materials, due for example to trade restrictions, sustainable substitutes and alternatives for critical raw materials, with similar functional performance, will be investigated and developed. This will reduce the Union's dependence on primary raw materials and improve the impact on the environment.

5.3.4. Improve societal awareness and skills on raw materials

The necessary move to a more self-reliant and resource efficient economy will require cultural, behavioural, socio-economic, systemic and institutional change. In order to address the growing problem of skills shortage in the Union's raw materials sector, (including the European mining industry), more effective partnerships between universities, geological surveys, industry and other stakeholders will be encouraged. It will also be essential to support the development of innovative green skills. In addition there is still limited public awareness of the importance of domestic raw materials for the European economy. To facilitate the necessary structural changes, research and innovation will aim to empower citizens, policy-makers, practitioners and institutions.

5.4. Enabling the transition towards a green economy and society through eco-innovation

The Union cannot prosper in a world of ever increasing resource consumption, environmental degradation and biodiversity loss. Decoupling growth from the use of natural resources requires structural changes in how such resources are used, re-used and managed, while safeguarding our environment. Eco-innovations will enable us to reduce pressure on the environment, increase resource efficiency, and put the Union on the path to a resource and energy efficient economy. Eco-innovation also creates major opportunities for growth and jobs, and increases European competitiveness within the global market, which is estimated to grow to a trillion Euro market after 2015[3]. Already 45 % of companies have introduced some type of eco-innovation. It has been estimated that around 4 % of eco-innovations led to more than a 40 % reduction of material use per unit of output[4], highlighting the great future potential.
The aim of this activity is therefore to foster all forms of eco-innovation that enable the transition to a green economy.
To achieve this, research and innovation will focus on the following:

5.4.1. Strengthen eco-innovative technologies, processes, services and products including exploring ways to reduce the quantities of raw materials in production and consumption, and overcoming barriers in this context and boost their market uptake

All forms of eco-innovation, both incremental and radical, combining technological, organisational, societal, behavioural, business and policy innovation, and strengthening the participation of civil society, will be supported. This will underpin a more circular economy, while reducing environmental impacts, increasing environmental resilience and taking account of rebound effects on the environment and potentially on other sectors. This will include user-driven innovation, business models, industrial symbiosis,

2 COM (2008) 699

3 European Parliament "Policy Department Economic and Scientific Policy, Eco-innovation - putting the EU on the path to a resource and energy efficient economy, Study and briefing notes", March 2009

4 Eco-innovation Observatory "The Eco-Innovation Challenge - Pathways to a resource-efficient Europe - Annual Report 2010", May 2011

product service systems, product design, full life cycle and cradle-to-cradle approaches as well as exploring ways to reduce the quantities of raw materials in production and consumption, and overcoming barriers in this context. The potential to move to more sustainable patterns of consumption will be addressed. The aim will be to improve resource efficiency by reducing, in absolute terms, inputs, waste and the release of harmful substances along the value chain and foster re-use, recycling and resource substitution. Emphasis will be given to facilitate the transition from research to market, involving industry and notably SMEs, civil society organisations and end-users, from the development of prototypes and demonstration of technical, social and environmental performance, up to their introduction in the market and replication. Networking among eco-innovators will also seek to enhance the dissemination and exploitation of knowledge and better link supply with demand.

5.4.2. Support innovative policies and societal changes

Structural and institutional changes are needed to enable the transition towards a green economy and society. Research and innovation will address the main barriers to societal and market change and will aim to empower consumers, business leaders and policy makers to adopt innovative and sustainable behaviour, with contributions from Social Sciences and Humanities. Robust and transparent tools, methods and models to assess and enable the main economic, societal, cultural and institutional changes needed to achieve a paradigm shift towards a green economy and society will be developed. Research will explore how to promote sustainable consumption patterns, encompassing socio-economic research, behavioural science, user engagement and public acceptance of innovation, as well as activities to improve communication and public awareness. Full use will be made of demonstration actions.

5.4.3. Measure and assess progress towards a green economy

It is necessary to develop robust indicators at all appropriate spatial scales that are complementary to GDP, methods and systems to support and assess the transition towards a green economy and the effectiveness of relevant policy options. Driven by a life-cycle approach, research and innovation will improve the quality and availability of data, measurement methods and systems relevant to resource efficiency and eco-innovation and facilitate the development of innovative offset schemes. Socio economic research will provide a better understanding of the root causes of producer and consumer behaviour and thus contribute to the design of more effective policy instruments to facilitate the transition to a resource efficient and climate change resilient economy. Moreover, technology assessment methodologies and integrated modelling will be developed to support resource efficiency and eco-innovation policies at all levels, while increasing policy coherence and resolving trade-offs. The results will enable the monitoring, assessment and reduction in material and energy flows involved in production and consumption, and will enable policy-makers and businesses to integrate environmental costs and externalities into their actions and decisions.

5.4.4. Foster resource efficiency through digital systems

Innovations in information and communication technologies can constitute a key tool to support resource efficiency. To achieve this objective, modern and innovative ICT will contribute to significant efficiency gains in productivity, notably through automated processes, real time monitoring and decision support systems. The use of ICT will look to accelerate a progressive dematerialisation of the economy, by increasing the shift towards digital services, and to facilitate changes of consumption behaviours and business models through the use of the ICT of the future.

5.5. Developing comprehensive and sustained global environmental observation and information systems

Comprehensive environmental observation and information systems are essential to ensure the delivery of the long-term data and information required to address this challenge. These systems will be used to monitor, assess and predict the condition, status and trends of the climate, natural resources including raw materials, terrestrial and marine (from coastal zones to deep sea) ecosystems and ecosystem services, as well as to evaluate low-carbon and climate mitigation and adaptation policies and options across all sectors of the economy. Information and knowledge from these systems will be used to stimulate the smart use of strategic resources; to support the development of evidence-based policies; to foster new environmental and climate services; and to develop new opportunities in global markets.

Capabilities, technologies and data infrastructures for Earth observation and monitoring must build on advances in ICT, space technologies and enabled networks, remotely sensed observations, novel in situ sensors, mobile services, communication networks, participatory web-service tools and improved computing and modelling infrastructure, with the aim of continuously providing timely and accurate information, forecasts and projections. Free, open and unrestricted access to interoperable data and information will be encouraged, as well as the effective and - if required - secure storage, management and dissemination of research results. Activities shall help define future operational activities of the European Earth Monitoring programme (GMES) and enhance the use of GMES data for research activities.

5.6. Cultural heritage

Cultural heritage assets are unique and irreplaceable in their tangible form as well as in their intangible value, cultural significance and meaning. They are a major driver of societal cohesion, identity and well-being as well as contributing significantly to sustainable growth and job creation. However, Europe's cultural heritage is subject to deterioration and damage, further exacerbated by increasing exposure to human activities and extreme weather events resulting from climate change as well as due to other natural hazards and disasters.

The aim of this activity is to provide knowledge and innovative solutions, through adaptation and mitigation strategies,

methodologies, technologies, products and services for the preservation and management of tangible cultural heritage in Europe at risk from climate change**.**
To achieve this, multidisciplinary research and innovation will focus on the following:

5.6.1. Identifying resilience levels via observations, monitoring and modelling

New and improved damage assessment, monitoring and modelling techniques will be developed to improve the scientific knowledge-base of the impact on cultural heritage of climate change and other environmental and human risk factors. The knowledge and understanding generated with the help of scenarios, models and tools, including analysis of the perception of value, will help provide a sound scientific basis for the development of resilience strategies, policies and standards, within a coherent framework for risk assessment and management of cultural heritage assets.

5.6.2 Providing for a better understanding on how communities perceive and respond to climate change and seismic and volcanic hazards

Research and innovation will, through integrated approaches, develop resource efficient solutions for prevention, adaptation and mitigation, involving innovative methodologies, technologies, products and services for the preservation of cultural heritage assets, cultural landscapes and historic habitats.

5.7. Specific implementation aspects

Activities will enhance the Union's participation in and financial contribution to multilateral processes and initiatives, such as the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Group on Earth Observations (GEO). Cooperation with other major public and private research funders as well as with major research networks will improve global and European research efficiency and contribute to global research governance.

S&T cooperation will contribute to the UNFCCC global technology mechanism and facilitate technology development, innovation and transfer in support of climate adaptation and the mitigation of greenhouse gases.
Building on the outcomes of the UN Rio+20 Conference, a mechanism will be explored to systematically collect, collate and analyse scientific and technological knowledge on key sustainable development and green economy issues, which will include a framework for measuring progress. This will complement existing scientific panels and bodies and seek synergies with them.

Research actions under this challenge will contribute to European Earth Monitoring Programme (GMES) operational services by providing a developmental knowledge base for GMES.

Consideration may be given to support relevant Joint Programming Initiatives (JPIs) and relevant public-public and public-private partnerships.
Approriate links with the actions of relevant European Innovation Partnerships and the relevant aspects of the research and innovation agendas of European Technology Platforms will also be established.

Specific measures will ensure that results from Union research and innovation in the fields of climate, resource efficiency and raw materials are used downstream by other Union programmes, such as the LIFE + programme, regional and structural funds, and external cooperation programmes.

Actions will also provide: the continuous analysis of scientific and technological progress in the Union and its major partner countries and regions; an early investigation of market opportunities for new environmental technologies and practices; foresight for research & innovation and policy.