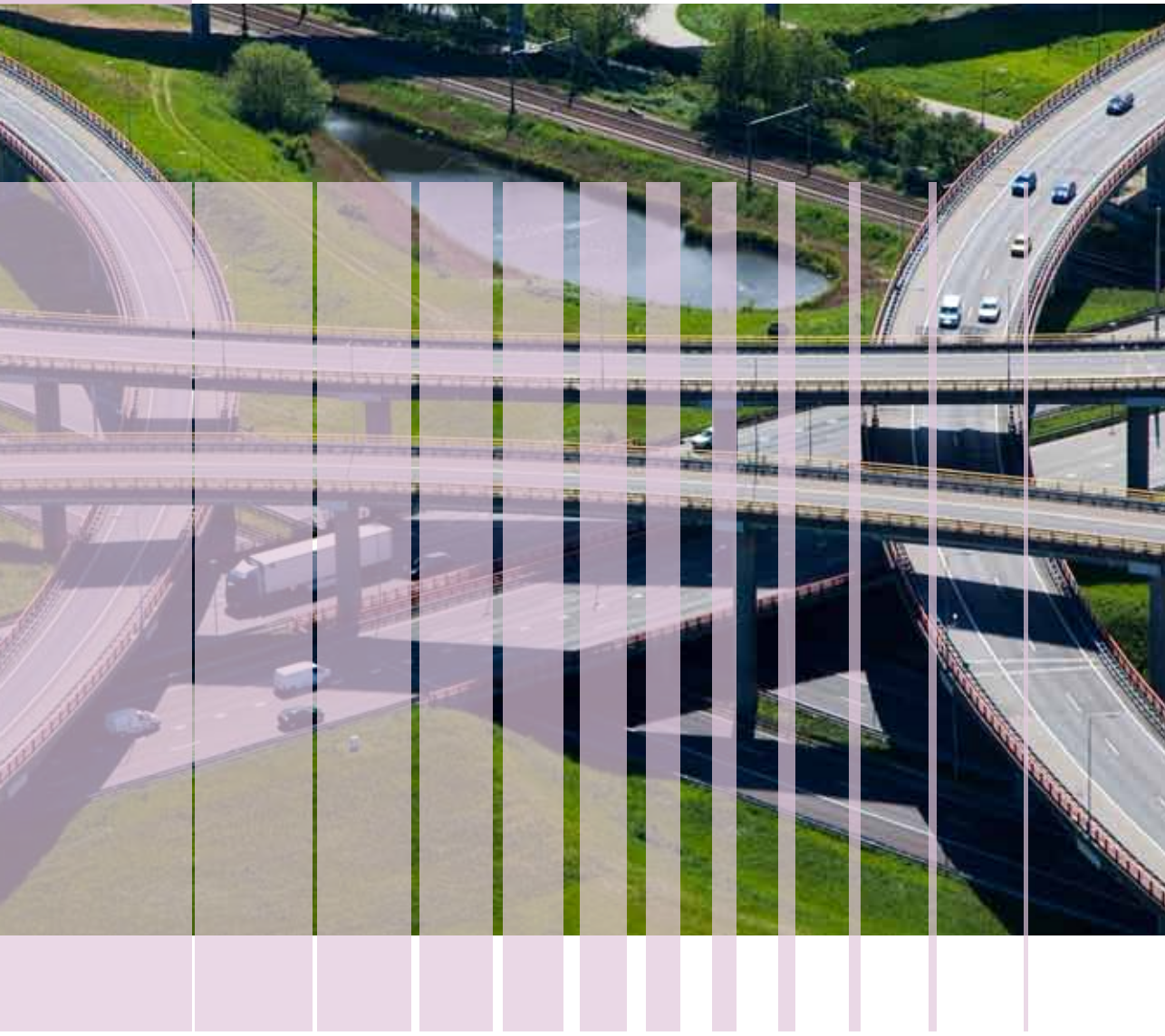
Getting into the Right Lane for 2050



Netherlands Environmental Assessment Agency

Stockholm Resilience Centre
Research for Governance of Social-Ecological Systems

Stockholm University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Getting into the Right Lane for 2050

A primer for EU debate

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Foreword

Global resource crises in energy and climate and in food and agriculture urgently call for attention. If we want to achieve an ambitious vision for 2050, strategic policy choices need to be made in the next few years. A question is whether sufficient attention can be given to these issues in a time of economic crisis. Fortunately, we see that the need to respond to the urgent but temporary economic crisis has not diminished attention to structural ecological problems.

Starting from a vision for Europe in 2050, this study identifies key policy junctions at which the EU will soon face strategic choices. This assessment highlights the substantial potential the EU has through its regulatory powers to establish a long-term investment framework for essential infrastructure and to act as a global player.

The vision for 2050 encompasses producing food for a global population of nine billion while minimising biodiversity loss; mitigating climate change while enhancing energy security for the EU; and practical and workable solutions for an EU transport system that is low carbon. Specifically, the vision includes a power grid that would allow citizens to become electricity producers and would help ensure a dependable supply of electricity. This study highlights examples of how policy actions in the next five to ten years have to be made in view of long-term goals. These examples are tabled as a primer for debate on the long-term agenda of the next European Commission and the coming presidencies.

The report has been prepared by the Netherlands Environmental Assessment Agency and the Stockholm Resilience Centre. It is one is a series of three reports from different perspectives – global, regional and national. Getting into the Right Lane for 2050 focuses on the EU and the report entitled Growing within Limits revisits the resources issues raised by the Club of Rome in a context of global governance. The third report will address the options to further the search for a sustainable development of the Netherlands.

Professor Maarten Hajer
Director of the Netherlands Environmental Assessment Agency

Contents

Summary: Getting into the Right Lane for 2050

The same visionary foresight that founded the European Union half a century ago is needed today to chart the course of the EU through the coming half century, in a world of changing global relations and growing scarcity of natural resources.

This study examines the EU of today, from a global perspective, and looks at long-term visions on the world of 2050. It identifies key decisions for today on global land and water resources, and low-carbon energy systems, including transport.

This analysis has revealed strategic junctions in the coming five to ten years at which EU decision-making is essential. The direction taken at these junctions will be decisive in determining whether the long-term vision postulated for wise natural resource use can be achieved. Specifically, the vision for 2050 encompasses producing food for a global population of nine billion while minimising biodiversity loss; mitigating climate change while enhancing energy security for the EU; and practical and workable solutions for an EU transport system that is low carbon. These three themes have been singled out on the basis of recent authoritative worldwide assessments. The analysis of the three themes builds on global modelling developed for these assessments.

Reasoning back from the 2050 vision for each theme, the study reveals strategic actions for the EU agenda for the coming five to ten years that will be decisive in achieving long-term visions. Strategic timing of the policy decisions for the issues in focus is critical, because the magnitude of change is large and the pace of change is limited. For instance, refocusing institutions and constructing large-scale infrastructure takes decades to achieve. Thus, the study's findings underline the significance of the end of the first decade of this century for the EU long-term agenda. Furthermore, the study reveals specific policy challenges for natural resource use on which the EU is well positioned to take a global leadership role. This brings another consideration in favour of action now, namely that EU leverage globally, for instance its influence on global product standards, will shrink as new players on the world stage become more prominent and powerful.

A vision to feed nine billion people worldwide by 2050 and halting biodiversity loss by 2030 is a compelling reason for EU leadership in global collaboration to prioritise, protect and pay for key ecosystems and biodiversity. The EU is also well positioned to take a lead in global collaboration to bridge diverging perspectives on land and

water resources, food and biodiversity in the context of globalisation – as has been done for climate change.

Even with the improved agricultural productivity projected by the FAO, a further 3 million km² of land would need to be converted in order to feed the world's population in 2050. In a context of global collaboration on agricultural methods, the Mediterranean basin could be seen as a logical pioneer area for renewed agricultural and ecosystems policy.

Nurturing the present diversity in agricultural practices within the EU would contribute to buffering inevitable shocks to the global food system in a very crowded world. Thus, diversity in land management needs to be made a strategic aim of the post-2013 Common Agricultural Policy.

The vision on a low-carbon energy system and increased security of energy supply involves the EU taking the lead in the global collaboration against climate change. It requires preparations to rapidly accelerate deployment of low-carbon technologies after 2020, to achieve an 80% reduction in emissions by 2050, relative to 1990 levels, within the EU. While the current Emission Trading Scheme provides incentives for gradual emission reductions, the EU needs to develop powerful additional incentives and new institutional arrangements to bring about more radical changes in the energy system. For instance, an investment framework for a continental-scale power grid of the future is critical to a low-carbon EU economy.

A low-carbon EU transport system that is economically viable depends on technology advances and equally on challenging reductions in transport growth. In fact, projected growth in EU transport as a whole implies emissions have to be reduced in 2050 from baseline projections, by a factor of 12. In particular, emissions from road passenger transport will have to be reduced by as much as a factor of 20 or 25. A sufficient supply of low-carbon electricity for urban and medium-range transport requires early action, irrespective of whether electricity or hydrogen will be the dominant energy carrier. Critical to achieving low-carbon transport in the EU is timely international action on greenhouse gas emissions from aviation and maritime transport. Above all, policy coherence on transport and climate is vital for all portfolios of the European Commission. Add-on policies cannot achieve the envisaged emission reduction in EU transport, with the implication that the energy sector would have to achieve even steeper emission reductions to compensate.

From a global perspective, the three themes are manifestations of the same challenge, namely to steer through the far-reaching changes in the coming decades, so that global use of natural resources remains within long-term constraints. Among trade-offs and potential synergies, an intellectual and policy challenge is to transcend partial analyses, for example, between policies on land and water resources, and on energy and climate resources.

In this vein, bio-energy policies are a tangible link between energy and climate change; land resources, food and biodiversity; and transport and mobility. This study makes a case for restricting bio-energy to applications for which no alternatives are currently available and where climate benefits most, namely

maritime transport, road freight transport, aviation, and electricity production coupled with carbon capture and storage. This strategy differs from current EU policy.

At a strategic level, there are more links and similarities between the themes. In backcasting from 2050 to the present, three similarities are revealed. The first is a strategic approach to interim solutions, for instance, not allowing energy supply constraints in 2020 to determine the EU energy system of 2050. The second is that diversity emerges as a strategic notion in all three themes – in sources and technology in the EU energy system; in transport solutions; and in the battle against uniformity of landscapes. The third, and perhaps most difficult, is the need for balanced consumption in achieving the visions for 2050 and the EU role, if any, in influencing consumer choices.

Getting in the Right Lane provides examples that connect coming EU policy decisions to an agenda for a visionary EU. It illustrates that enhancing policy coherence has three interrelated dimensions:

- Between policy portfolios, as promoted through the Commission's system of Impact Assessment of new policies;
- Between the EU and elsewhere, as expressed in the notion of incorporating an external dimension in EU policies;
- Between now and later, as provided in this study that connects the long-term vision to agenda items for the next European Commission.

1 Overview

The last past of the first decade of this century will be memorable for the future policy direction of the European Union, largely because of an extraordinary combination of policy openings - the election of a new Parliament and entry of a College of Commissioners, the entry into force of the Lisbon treaty; the current economic crisis and stimulus policies; and review of broad EU policies such as budget, Common Agricultural Plan, Lisbon Strategy and Sustainable Development Strategy. At this time, global resource crises of energy and climate and food and agriculture are becoming increasingly more evident and the policy response crafted now will determine the sustainability of solutions for 2050.

Basis of this study

This study is based on almost two decades of global outlooks. It examines EU policy challenges towards 2050 from a world perspective because global assessments have shown that significant changes will occur outside the EU as the centre of

Christo, Wrapped Walk Ways, Project for Loose Park, Kansas City, Missouri.
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gravity shifts towards Asia. The study starts with a vision for 2050 and looks back from the future to the present, identifying in all probability some of the rate-determining steps. Recent global assessments have shown that the slow evolving pace of change of natural systems, man-made infrastructure and social systems can result in decades of delay between problem recognition and the results of policy responses. Consequently, policy adjustments require the foresight of a supertanker pilot.

A source of inspiration for the study was the Beyond GDP conference, which returned to the historic reasons for the EU and Robert Schuman's call for inventive ways to address the challenges facing Europe. In this vein, this study identifies policy junctions in the near future, at which EU regulation and its global presence can play a leadership role in selecting the road forward. These policy junctions range from the EU power grid of the future; bridging differing views on global land resources, in a similar way to climate issues in the last 20 years; and a strategic priority for the post-2013 Common Agricultural Plan. This study highlights opportunities for connecting long-term ambitions to decision making in the next five to ten years.

Connecting long-term strategy and near-term decisions for the EU

A visionary agenda for the EU in relation to global natural resources requires the right choices to be made now in order to make the long-term goal attainable. In addition, a vision for 2050 can contribute to targeting economic stimulus plans.

Critical junctions to be encountered early on the route to 2050 are identified. The choices require EU leadership and relate to global collaboration and to EU internal infrastructure. Looking back from 2050, some junctions are clearly dead ends or may be a wrong turn that goes only part of the way to the vision. For example, EU climate objectives can only be met if, after 2025, all fossil-fuelled power plants that are built include carbon capture and storage.

Focus on three themes in a vision for 2050

New policies are required to ensure that global issues related to climate change and land resources do not mushroom. Yet, scope for global cooperation on these challenges may well shrink as the world moves towards 2050. Furthermore, inevitable mishaps along the way will have greater consequences as the world becomes more crowded and more interconnected.

From recent global outlooks, three themes emerge as significant and challenging. They are land resources, food and biodiversity; energy and climate change; and transport and mobility in relation to low-carbon energy. These themes are multi-facetted. For example, worldwide issues of land resources are linked with water availabilty and EU energy policies are not only related to climate change but also to security of supply. Their common denominator is global resource use and the common challenge is long-term management of global resources. Coordinated approaches to these themes have a much better chance of success, as for example in bio-energy.

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The analysis is largely based on modelling and other tools used in the recent global outlooks, including the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC); the fourth Global Environment Outlook (UNEP); the International Assessment of Agricultural Science and Technology for Development (IAAST); and the OECD Environmental Outlook to 2030 (MNP, 2008; PBL, 2009). In fact, the Netherlands Environmental Assessment Agency and the Stockholm Resilience Centre contributed to a great extent to these outlook studies and, from this global perspective, now focus on the EU and the strategic opportunities for the next European Commission.

For each theme, a vision for 2050 has been formulated based on current debate. The vision, however, is only one interpretation, that allows a backcast to identify critical items for the EU strategic agenda.

The year 2050 is of significance because it is close to the centenary year of the European Union, and because it is also the time horizon at which the increase in

global population is expected to level off – a major milestone. In 2050, an aging population is likely to have become a problem for many developing countries and a major distraction in global collaboration. But as the global population plateaus, one root cause of the steep rise in pressure on global resources is finally under control, at least in terms of global average. With this prospect, and if enough progress can be made in balancing per-capita resource use, the challenge becomes smart management of key global resources while on the way to this population plateau in 2050.

The EU role extends to the global stage

The EU is a key actor in all three themes globally, as well as in its own domain. The most global of the themes is land resources, food and biodiversity, with dynamic changes in the coming decades occurring mostly outside the EU. The energy theme in relation to climate change and security of supply has strong global connections and is the most advanced in terms of recognition as a global system requiring joint action. At the other end of the spectrum, transport and mobility is 'closest to home'.

The EU has greater global leverage than its size suggests, and this may still be so, to some extent, in 2050. But, by that time, the relative EU influence will have shrunk as new economic players with larger populations become dominant on the world stage. Thus, now rather than later is the time for the EU to take the lead on key global issues and to influence outcomes by 2050. The EU's considerable leverage in global natural resources is largely because of its active role in finding multilateral solutions; its size as an importer which is relevant for promoting product standards; its reputation for regional integration and global interest; and joint size when the EU neighbourhood is weighed in. While these advantages are not unique, they are time-bound.

Land resources, food and biodiversity

A vision of the world in 2050 is that of feeding nine billion people while minimising impact on ecosystems and climate and halting biodiversity loss before 2030. The vision for the EU is to nurture diversity in agricultural practices including creating a buffer against 'shocks' in a very crowded world.

The following actions are on the critical path for the EU.

- Put worldwide research investments in agricultural systems back on track, and improve implementation of existing technologies in developing countries. Specifically for the EU, diversity needs to become a strategic objective of the Common Agricultural Policy and subsequent policies, and related regional policies. This is essential in maintaining and increasing current agricultural productivity in the EU, as well as providing a buffer against shocks in a very crowded and interconnected world, and in helping to maintain biodiversity and cultural landscapes that define Europe.
- Initiate and develop arrangements in a global collaborative setting to prioritise, protect and pay for ecosystems and related ecosystem services. This comes early on the critical path, because increasing agricultural productivity worldwide and changing the trend in diets will take time, and most losses of ecosystems are irreversible.

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- Contribute to structuring worldwide debate to bridge the diverging perspectives on land, food and biodiversity in the context of globalisation, as has been done on climate change. The key challenge is to gain recognition of the existence of one global food system, linking national and local food systems and ecosystems. A 'hot potato' to be addressed in this arena is meat consumption.

The EU has a role to play on the global stage, contributing to investment in research programmes, helping to resolve issues in the current debate on intellectual property rights, setting product standards that take biodiversity into account, and supporting multilateral organisations towards coherent policies that go beyond individual policies on land, food, development and biodiversity.

In the EU, strategic priorities are identified for the post-2013 Common Agricultural Policy and subsequent policies to nurture diversity in EU land management. These will play out differently in the Member States and in the neighbouring countries.

One implication is that a distinction is to be made between highly productive agricultural areas and areas with other priorities.

In view of the projected scale of increasing pressure on the rural environment in the coming decades, including climate change, the Mediterranean basin is a strong case for pioneering a renewed agricultural and ecosystems policy in and possibly around the EU. Moreover, if dryland agricultural and related territorial management here were made an EU focus, a new connection between the external dimension and internal policies would be created.

Climate change mitigation and energy security

The vision is that of a low-carbon energy system in the EU by 2050. To limit the increase in mean global temperature to 2 °C, greenhouse gas emissions in high-income countries need to be 80 to 95% less in 2050 than in 1990. The vision for 2050 is to achieve at least 80% emission reduction within the EU. Such a development towards a low-carbon energy system in the EU would send a clear message to other global players, and would allow the EU to take full advantage of the development and application of low-carbon technologies. An essential element in this vision is that global collaboration is forged and includes currently emerging new players, such as India and China.

A low-carbon energy system can be achieved in the EU by 2050 using currently identified technologies. The initial steps have been taken in the EU energy package to increase energy savings, increase production of renewable energy, and decrease carbon dioxide emissions. However, in the long term, the energy system in the EU will need to undergo radical restructuring to make energy end-use carbon-free, and to develop a Europe-wide power system that is low-carbon. Such a transition would not necessarily be financed via the EU budget, but does require EU organisation and regulation. The following actions are on the critical path for the EU.

- EU leadership towards and during worldwide climate agreements is of global importance. This requires a contribution to global financing, acknowledging the needs of developing countries, and sending consistent messages to other global players by implementing a European low-carbon economy to set an example.
- In the EU, investing in the power grid of 2050 is essential for the transition to a low-carbon economy and requires EU leadership. Likewise, preparations need to be made for rapid acceleration in the deployment of low-carbon energy technologies in the 2020-2030 period. One of the steps on the critical path is that of coordinated stimulation of currently available no-regret technologies, such as heat pumps, solar PV and wind power. Emission standards need to be set for newly constructed power plants, a clear target for phasing out fossil power plants without carbon capture and storage, and long-term targets for decreasing emissions of greenhouse gases. Substantial funding for energy research needs to be raised and international R&D cooperation strengthened in a broad range of technologies that need further development.
- Commitment to both medium-term and long-term goals for the EU energy system is essential to increase long-term policy coherence and to direct technology development and application. It needs to include a strategy for efficient application of bio-energy, the availability of which is limited, in part because production places additional claims on the world's land resources.

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Enhanced security of supply for the EU comes as a bonus of ambitious climate policy, but only if ambitious and only in that order. This is because of a considerable decrease in the use of fossil energy in the EU, more diverse origins of imported energy, and increased production of renewables.

Market incentives alone are not sufficient to make the transition to a low-carbon-energy system by 2050. Instruments such as cap-and-trade schemes are effective in achieving gradual emission reduction. However, development and application of breakthrough technologies needed in a low-carbon energy system depend on reliable long-term policy and command-and-control policies. In the short term, a massive investment in R&D and targets for technology deployment is essential to start the transition process.

The EU cannot afford to become locked into expedient short-term decisions that hamper achieving a long-term strategy for a low-carbon energy system in 2050.

Choices of today will ultimately determine the energy system of 2050. In the coming decades, security of energy supply remains a major concern with the risk of coal being selected to alleviate dependency on oil and natural gas. Such a move can be prevented with early implementation of policy measures that channel the energy system towards a low-carbon future. Such measures would include scaling up renewable energy production, mandatory carbon capture and storage, biofuel strategies, and ambitious emission standards.

Transport and mobility

A vision for 2050 is a *low-carbon EU transport system* achieved by decreasing carbon dioxide emissions from all transport modes. Low carbon in this vision means 80% less carbon dioxide emissions (well-to-wheel) by 2050, compared to 1990 levels.

This target equals the EU average decrease in greenhouse gas emissions as envisaged in this study. But it is harder to achieve than the EU average decrease, because of the steep growth projected for EU transport without new policies. In fact, achieving the target of 80% emission reduction relative to 1990 levels, amounts to reducing emissions by almost a factor of 12 by 2050.

In achieving the 80% reduction target by 2050, carbon dioxide emission reductions are not the same in all transport modes. Road passenger transport contributes most to the overall target. Road freight, aviation, inland shipping and maritime transport contribute less to the overall reduction target because fewer cost-effective technologies are available.

The following actions are on the critical path for achieving the 2050 vision of a low-carbon EU transport system that is also economically viable.

- Deployment of a full range of low-carbon technologies, as well as a challenging reduction in transport growth. For the technologies for urban transport and distances of up to 150 kilometres, timely action to ensure a sufficient supply of low-carbon electricity is key for large-scale application – even more so than having a sufficient supply of electric or hydrogen-powered vehicles themselves.
- Timely international action on greenhouse gas emissions from aviation and maritime transport is on the critical path if emissions from transport are to be decreased proportionally to those from other sectors of the economy.
- Reaching the long-term visions requires policy coherence on transport and climate between all portfolios of the European Commission and among levels of government including local government. Add-on policies will not achieve the envisioned decreases in emissions from EU transport, with the implication that the energy sector, for example, would have to achieve even steeper emission reductions.

Considerable doubt remains whether a sufficient decrease in carbon dioxide emissions from transport is feasible without a broad, frontal approach to achieve policy coherence. Such doubts are generated by the projected steep growth in transport demand – passenger and freight transport – and the lack of historic evidence that this trend can be reversed in the economy as a whole. Therefore, establishing a broadly supported ambition to achieve low-carbon transport is squarely on the critical path.

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Better use of bio-energy

With restricted worldwide capacity for bio-energy production, use of biofuels needs to be concentrated in those transport modes in which the greatest contribution can be made to mitigating carbon dioxide emissions and for which no alternatives are available.

These considerations on strategic *use* of bio-energy are over and above concerns about *production*, which have thus far received most attention. Therefore, a long-term and EU-wide strategy is needed to achieve cost-effective allocation of biofuels in energy and transport. In all probability, it would place different priorities than the current EU policy on biofuels.

For instance, advanced biofuels offer potential for reducing emissions from long-distance road freight transport, shipping and aviation, where significant alternative energy carriers are not available. In addition, bio-energy combined with carbon capture and storage in electricity production enables large emission decreases but

requires forward planning. Conversely, good alternatives are available for urban passenger transport and the like.

The EU policy-making context to achieve the 2050 vision

Getting into the right lane to achieve ambitious long-term visions has implications for EU policy-making. Importantly, the required institutional conditions are related to how the EU organises its role in the world, within the EU, and towards Member States.

Common challenges are found across the themes, which may contribute to developing long-term strategies. Clearly, there are physical links to consider. For example, decisions to concentrate future application of biofuels on specific transport modes have direct implications for energy production, agricultural and biodiversity resources and for transport. Over and above these physical links are a number of strategic similarities between the themes.

First, *diversity* emerges in several ways as a key asset in investing in an uncertain world. For example, it emerges as a need to pursue a wide spectrum of energy technologies rather than a selection of technologies. Diversity emerges in the land management styles for the EU to promote in its agricultural and regional policies.

Second, strategies to achieve an ambitious vision for 2050 hinge on *interim solutions* which may be either a risk of lock-in, or a plank to the long-term vision. For example, the Energy and Climate analysis indicates a risk that the EU energy system flounders on efforts to resolve energy security constraints of 2020, blocking low-carbon opportunities for 2050. Conversely, there is the Land Resources, Food and Biodiversity analysis of relative rates of agricultural productivity to catch up with the projected surge in global agricultural demand. While this transition is going on, global protection of biodiversity and ecosystems will need to be targeted in order to prevent unnecessary land conversion that is irreversible.

Third, strengthening *the EU role in the world* emerges as an essential condition to reach the vision. The role is somewhat time bound, as emerging players will dilute the EU's influence and the world becomes more crowded. Scaling up global resources for current processes to protect global systems is on the critical path, and is also time bound. This study identifies opportunities to integrate the external dimension into relevant EU policies, such as on biodiversity and on trade.

Fourth, achieving the vision calls for adjustments to EU internal governance structures and strategic objectives. In fact, 2009 to 2010 offers a multitude of opportunities to do this. Briefly, the requirement is for *policy coherence* across policy portfolios; between the EU and worldwide; and between EU short-term and long-term strategies.

This study reveals that reaching the vision for 2050 will require strengthening EU decision-making powers in specific areas. Moreover, the study identifies key infrastructure on a scale that transcends the long-term certainty that Members States can offer. The EU budget offers limited opportunities. One way forward is

to use EU regulatory possibilities to offer investors a long-term perspective on cost recovery through harmonised user fees.

Technology is not enough

Although not directly an issue of EU competence, unbalanced demand and growth in demand in high-income countries and elsewhere can erode or even undo the effect of the ambitious schemes studied and modelled. Without balanced demand, for example in mobility, new solutions are piled on top of old problems. Thus, the issue of continued growth in the use of natural resources per capita – through household consumption and through production – needs to be debated. Perhaps this is not an EU issue, but it is on the critical path to the vision for 2050.

However difficult, the *demand side* needs to be managed. For example, without a reversal in the trends of increased meat consumption or in transport intensity in EU production, the vision outlined cannot be achieved, regardless of achievements in eco-efficient production. Thus, addressing consumption is an issue on the critical path. The EU may not be considered to be the primary actor on demand-side issues, it nevertheless has a key role to play. The EU can help to structure public debate on consumption issues and to keep them at the forefront. It can use its comparative strength in initiating product standards. The EU can also promote a sufficiently broad and visionary concept of competitiveness in the framework of the renewal of the Lisbon Strategy and the Sustainable Development Strategy. For example, a target could be to make the EU the world's most transport-efficient economy.

The significance of the end of the decade

From a perspective of the economy and resource use, the end of the decade is particularly significant, although the underlying trends have been developing for some time. This is about the economic and climate crises against the background of signals that biotic resources are now managed in a way that will inevitably create major problems. They are a reminder that the EU is a community of values and founded with a wider perspective than a notion of profitability over a narrowly defined horizon.

Reviews are being prepared for EU policies that are key to these issues. The election of a new Parliament, the European Commission, the Lisbon Treaty and the Obama administration in the United States all combine to provide momentum for changing the relationship between public and private domains, and offers opportunities for institutional and strategy changes that can contribute to achieving these visions. In this light, many statements made by business representatives and senior politicians at the Beyond GDP conference of 2007 now fall into place. This study provides examples, as a primer for debate.

2

From Vision to Strategy

A visionary agenda for the EU for natural resource use requires action now to get into the right lane to meet long-term challenges. A long-term vision for 2050 can also help in guiding economic stimulus policies. Critical issues on the pathways to 2050 have been identified by the Netherlands Environmental Assessment Agency and the Stockholm Resilience Centre, as primer for debate on long-term strategies for the EU.

The focus is on the global challenges of feeding nine billion people while limiting loss of biodiversity, and limiting climate change while improving EU energy security and achieving low-carbon transport and mobility in the EU. Policy actions needed today are identified and the implications for medium-term and long-term EU policies.

Vision for 2050

The starting point of this study is a vision of Europe in 2050 in which the three challenges in focus – land resources, energy and mobility - have largely been resolved. From this starting point, backcasts (as opposed to forecasts) have been made along the pathways from the 2050 vision to the present, with the opportunities and challenges on the way.

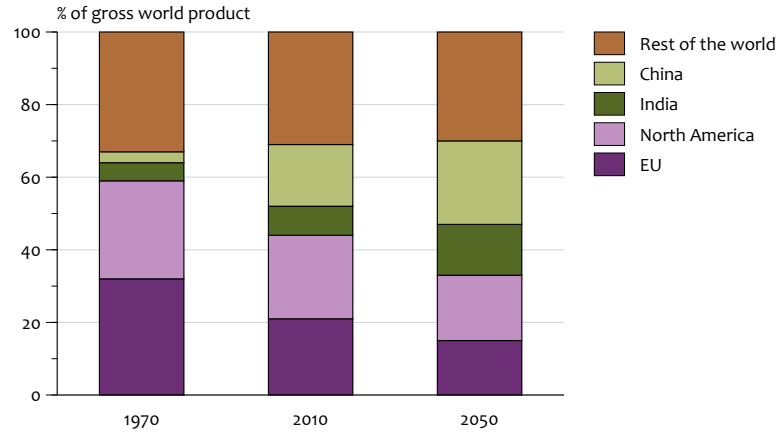
This approach of working back from vision to strategy is ambitious and differs from more conventional forecasting. It is typically applied to complex, long-term issues. The purpose is to broaden perspectives on actions and solutions, illuminate short-term decisions in relation to long-term objectives and thus to identify, for example, conflicting options or objectives.

Baseline expectations for 2050

The vision is set against a backdrop of the 'no new policies' baseline in the most recent OECD Environmental Outlook (OECD, 2008; MNP and OECD, 2008). Its core assumption is that rates of improvement in labour productivity in economies around the world will gradually converge.

Without new policies, major global issues are bound to mushroom, especially with regard to climate change and land resources. Yet, the scope for global cooperation on these issues may well shrink as the world moves towards 2050. Firstly, in a world that is becoming substantially more crowded, there is considerable risk of

GDP of major world regions, baseline projection **Figure 2.1**



Although in 2050 the EU will be one of several economic blocks, it will still exert considerable influence on production standards worldwide. Source: MNP and OECD, calculations for the OECD Environmental Outlook to 2030 (MNP and OECD, 2008). 003g_girl09

a less-than-perfect mood among global players. Secondly, the challenges of an aging population, in countries such as China, may well distract policy attention from cooperation on global resource issues. Thirdly, in a crowded world, inevitable mishaps along the way are likely to have significant consequences.

The EU in the world of 2050

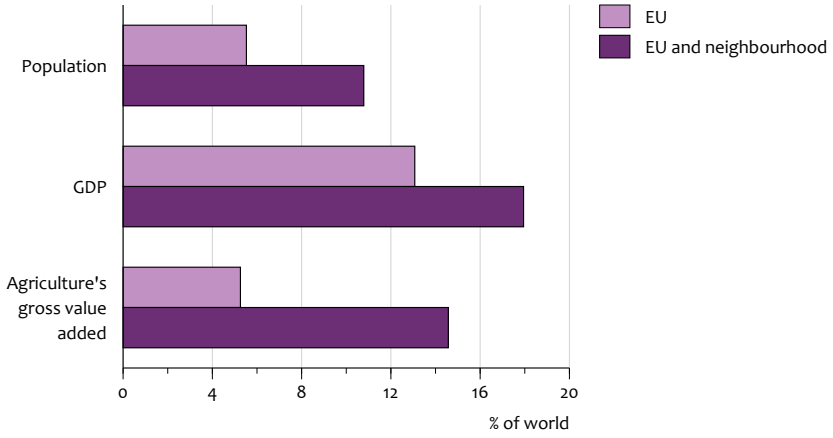
The approach taken in this study is to view the EU from a global perspective, as one of several economic blocks in 2050. By that time, the EU will be equalled, economically, by new players and outgrown in terms of population (Figure 2.1). But as a major importer of goods and services from economic blocks such as India and China, the EU is likely to exert considerable influence on production standards worldwide. Furthermore, the EU's global weight in 2050 could arguably include its 'neighbourhood', giving it greater leverage in issues such as agriculture (Figure 2.2). In addition, as one of the world's most affluent regions, the EU will be a very desirable place to live, with a diversity of landscapes and cultures.

While alternative expectations and views are possible, this study assumes that the future EU is a pro-active and consistent player on the world stage. The EU acts on the basis of values that go 'beyond GDP' and with a reputation for regional integration and global interest.

Three themes for long-term policy coherence

From this global perspective, a vision is postulated for the EU in 2050, based on three interlinked themes which are cornerstones of sustainable development. These themes are also in line with the key challenges identified in authoritative

Figure 2.2 **Population, GDP and agriculture's value added, 2050 baseline projection**



The EU's global weight in 2050 could arguably include its 'neighbourhood', giving it greater leverage on issues such as agriculture. Source: MNP and OECD, calculations for the OECD Environmental Outlook to 2030 (MNP and OECD, 2008). 026g_girl09

environmental assessments (IPCC, 2007; OECD, 2008; UNEP, 2007; IAASTD, 2009) as eliminating extreme poverty and hunger, reducing loss of biodiversity, and diminishing climate change.

The first theme is *land resources*, including water, and the EU's role in a world providing food for all, without further loss of biodiversity. This implies improving agricultural productivity in order to close 'yield gaps' in all regions, and containing biodiversity loss worldwide on the way to 2050. It also implies a strategy of diversity in EU land and agriculture policies. The second theme is *energy* and envisages a low-carbon energy system in the EU in 2050. This amounts to 80% decrease in domestic emissions of greenhouse gases by 2050, and connects with the EU's need to improve energy security. The third theme is *mobility,* with a vision for 2050 of low-carbon transport in Europe.

These ambitions for 2050 have far-reaching implications for EU policy and decision-making processes today. This is because the economy has a very large turning circle, often with long-term infrastructure and institutional arrangements that cannot be reversed or redirected at short notice. Furthermore, a long-term coherent strategy is required to make the best use of the EU's current leverage in global negotiations, a leverage which may well shrink towards 2050.

Challenges and opportunities

Within the framework of the vision for land resources, energy and mobility, long-term challenges are explored, together with choices that the EU will need to make in the short-term in order to get into the right lane to achieve the vision for

2050. No less important, this should help to guide plans for economic stimulus. Specifically, a long-term vision is offered for essential infrastructure, such as the power grid in 2050, and interim solutions that will not lead to the 2050 vision, are flagged.

The vision and strategies presented are by no means comprehensive and alternative visions are conceivable. This study, therefore, should be considered as a primer for debate, to explore and find ways to meet the pressing issues confronting us all in achieving a sustainable world by 2050.

The study aims to contribute to the political debate now at the forefront, as the new European Commission is formed, economic stimulus plans are revisited and the political agenda for the coming years is formulated. The time is now favourable to link long-term visions with medium-term strategic options for a sustainable future.

3 Land Resources, Food and Biodiversity

A global vision of 2050 is that of feeding nine billion people without further loss of biodiversity and minimising impact on ecosystems and climate. The vision for the EU is to nurture diversity in agricultural practices including creating a buffer against 'shocks' in a very crowded world.

3.1 Land resources, food and biodiversity today

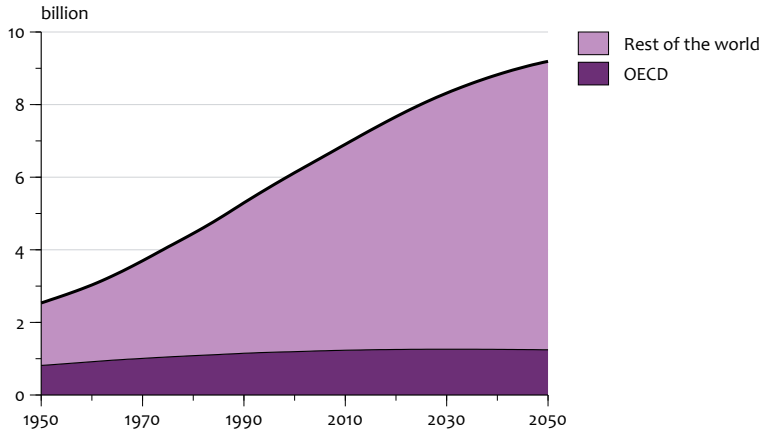
Recent global assessments provide evidence that increased demand for agricultural products including food, feed and bio-energy will increase agricultural land use worldwide by 2050, leading to significant additional loss of global biodiversity (UNEP, 2007; IAASTD, 2008; OECD, 2008).

By 2050, the global population will total nine billion: a 50% increase in today's population. Moreover, per capita demand for food, animal feed and bio-energy will be substantially larger than today. Although global assessments project continued increase in agricultural productivity, in terms of yield per land unit, this productivity cannot keep pace with the increase in global demand for agricultural products. Therefore, more agricultural land is needed, leading to conversion of natural areas to cropland and pasture. The first part of the key challenge is to meet this demand for food, feed, bio-energy, and other crops.

There is a political ambition to halt biodiversity loss and to enhance supply of ecosystem services. This is particularly relevant as demand for more agricultural production is expected to increase up to 2050, and, thereafter, to gradually diminish. As land conversion is often irreversible, the second part of the key challenge is to avoid unnecessary and large-scale conversion of ecosystems. Large parts of the agricultural expansion in the coming decades may not be needed after 2050. Thus, biodiversity loss due to temporary conversion of natural areas to agricultural land should be as small as possible.

The global issue of land resources is highly relevant to Europe. The EU is embedded in the global food system as a major producer of both bulk and high-value goods, and as a large importer and exporter of agricultural commodities. Furthermore, Europe is a major source of agricultural knowledge and innovation.

Global population, UN medium scenario **Figure 3.1**



The world is in the midst of a demographic transition to a 50 % increase in population. Source: UN, 2008. 012g_girl09

3.2 Current EU policies on land and biodiversity

A major challenge at EU level is to match targets for biodiversity with space for economic development and particularly agriculture. This challenge touches on several current policies and may reveal a need for new policies.

The Common Agricultural Policy has undergone profound changes over the last 20 years, and, by 2015, export subsidies and quota will be phased out. New challenges are to make Europe's agriculture more competitive while safeguarding traditions and regional specialities. The Common Agricultural Policy also has a role to play in climate adaptation and mitigation, as well as in meeting the biodiversity target. There are also important links with cohesion policy and rural development.

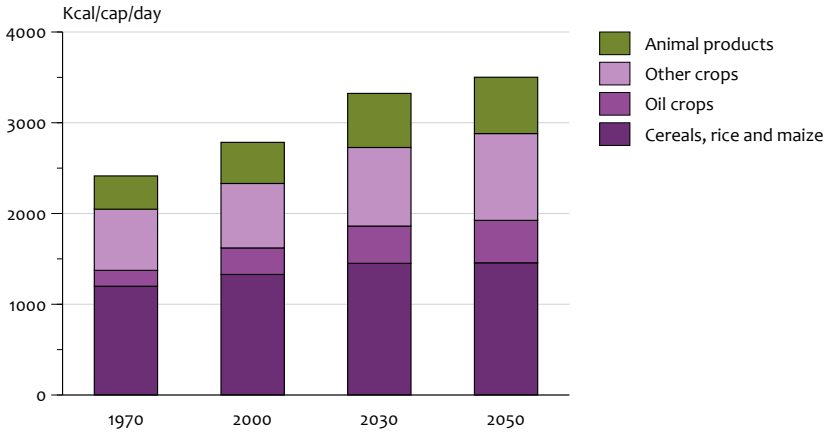
Dealing with an increased demand for agricultural products and the protection of biodiversity also has implications for Natura 2000, the Birds and Habitats Directives, EU Climate and Biofuels Policy, EU Developments Policy, the Action Plan on Sustainable Consumption and Production, and Sustainable Industrial Policy.

3.3 Issues confronting land resources and biodiversity

The problem in a nutshell

Towards 2050, global population will increase by a further 2.5 billion people (Figure 3.1) and in this period, per-capita income will more than double. The combination of more people and more consumption per person will cause a large increase in the demand for food (Figure 3.2), which in turn will exert pressure on land resources. Worldwide, agricultural production is projected to rise by approximately

Figure 3.2 **Global food consumption, baseline projection**



Over and above the population increase, the amount of food consumed per person increases, particularly oil crops and animal products. Source: MNP and OECD, 2008: calculations for the OECD Environmental Outlook 2008. 013g_girl09

80% (crops) to 100% (animal products), between 2000 and 2050 (PBL, 2008a). Furthermore, expanding urban areas will have a significant impact on pressure for land, not the least because urban expansion worldwide tends to sprawl on the best agricultural soils.

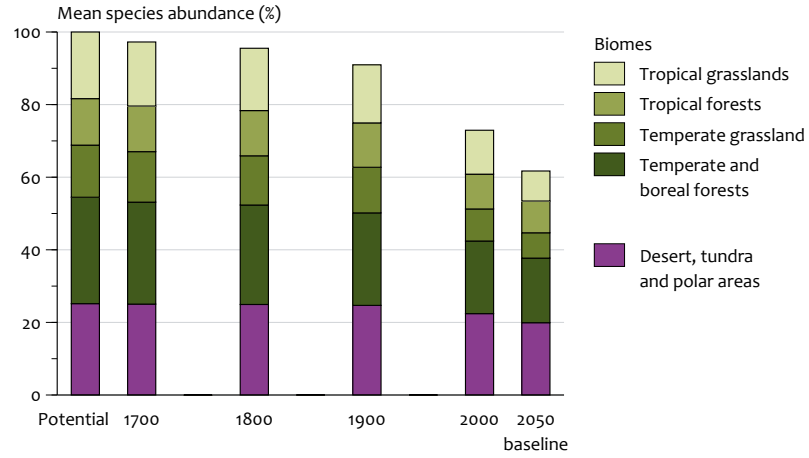
The pressure for land will lead to conversion of natural areas to agricultural production and, thus, threaten biodiversity (Figure 3.3). In many cases, areas under pressure of agricultural expansion are ecosystems and wilderness areas that are already vulnerable: the biodiversity hotspots (see Figure 3.9). This implies continued loss of global biodiversity, putting more pressure on sustainable provision of ecosystem goods and services.

Recent global assessments have revealed a complexity of issues on global land resources, food and biodiversity. This complexity is political and rooted in the diversity of perspectives on agriculture and food production. A major issue is how globalisation can be designed to be more sustainable.

More people create more demand for agricultural products

The United Nations projects that global population will increase to 9.1 billion people in 2050 (medium projection, UN, 2008), with uncertainty margins of 8 and 10.5 billion being the low and high estimates. In the medium projection, fertility is just above two children per woman, lower than the current level of 2.6 children. Up to 2050, regional differences in population will increase because, at present, 95% of the population increase is in non-OECD countries. From 2050 onwards, global population levels off. This is driven by increased development, triggering

Global biodiversity, baseline projection **Figure 3.3**



Biodiversity continues to decline with the exception of biodiversity in the tundra, desert and polar areas, which are on average less affected. Source: MNP and OECD, 2008.
015g_girl09

demographic transition from high to low fertility rates in all regions. At that time, the population in OECD countries is in decline.

More meat consumption increases demand for agricultural land

In the period up to 2050, world population will increase to 2.5 million, and income per capita will more than double. People with a higher income tend to include more animal products (meat and dairy) in their diet. For example, consumption of animal products per person almost doubled in China between 1990 and 2000. Thus, with greater affluence, average meat consumption per capita is expected to increase from the current level of 37 kg, to 52 kg in 2050 (FAO, 2006a; see also Figure 3.2).

This development contributes significantly to the increased demand for agricultural land, because more land and water is needed to produce animal products than would be needed to produce plant products of similar nutritional value (PBL, 2008b). A dietary switch to fish is not an option, since in that sector similar issues play a role. Exploitation of resources has led to a 24% decrease in biodiversity in the worlds' seas; fish have become smaller and less abundant (Watson and Pauly, 2001; Jackson et al., 2001; Alder et al., 2007).

At present, approximately 80% of all agricultural land, globally, is used for animal production. However, part of this land is used for extensive grazing where other types of agricultural production are barely feasible and the impact on biodiversity is limited. Future pressure on land for meat production will mainly be exerted by demand for livestock feed, currently taking about a third of the total cropland (FAO, 2006b). For instance, soy crops for animal feed more than quadrupled in Brazil,

between 1995 and 2003, and export to the EU tripled. In this period, export to China rose even more steeply.

Land demand for agriculture highly depends on productivity

In many regions of the world, crop yields are significantly smaller (by up to a factor of 10) than the potential yield. The dimensions of the problem are sketched for 2050. If agricultural productivity remains at current levels, the cultivated land area is estimated to increase by at least 36% in 2050, compared to 2010 levels. In the unlikely case that the gap between current and potential yield is closed completely (modelled under the assumption of no water limitation and no increase in potential production), the increase in demand for agricultural products can be absorbed. An additional 19% of agricultural areas can be taken out of production by 2050, compared to 2010. These figures show that land demand depends largely on productivity.

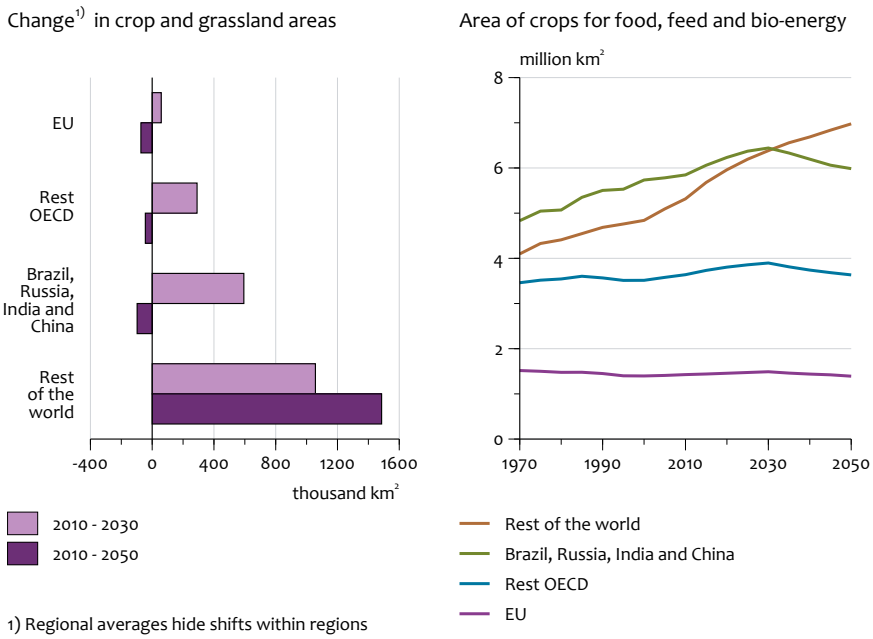
In a more realistic scenario, even with significant growth in productivity, more land will be used for agriculture in 2050, with the bulk of the expansion taking place before 2030. According to the extended FAO scenario used in this study, the total area of agricultural land is projected to increase by roughly 4% in 2030, compared to 2010. This is based on extrapolating assumptions from FAO towards 2030 (FAO, 2006a).

The outcomes of this projection vary considerably per region, as well as in time (see Figure 3.4). Towards 2030, the agricultural land area is projected to increase in all four regions. Globally, the agricultural area is larger in 2050 than in 2030. However, in 2050, the demand for agricultural area will be less in Brazil, Russia, India and China (BRIC), OECD and OECD Europe, compared 2030. So, the region 'rest of the world', compensates this decline and has such an increase in agricultural area that the agricultural area of the world as a whole is larger in 2050 than in 2030. In the second half of this century (i.e. after 2050), world population is expected to stabilise and the pressure to convert more land for agricultural production will decline. The challenge, therefore, is to meet future requirements for agriculture with as little loss of biodiversity as possible. This is especially important because after the demand for agricultural land will have peaked in 2030 in BRIC and OECD, and in 2050 for the world as a whole, more land will become available to accommodate biodiversity. It would be regrettable if this biodiversity was lost on the way.

It is important to realise that the FAO projection presented in Figure 3.4 is not a 'business as usual' scenario: It includes ambitious assumptions about productivity gains. For example, an increase of between 50 and 100% is projected for cereals (Figure 3.5) and a yield increase of 50 to 150% is assumed for oil crops (PBL, 2008c). Huge efforts are required to achieve these yield increases. However, there are also risks involved. A significant risk in intensifying agriculture, for example, by growing monocultures, using resistant crops and using more agrochemicals, is that the agricultural system will lose its resilience. If intensification of agricultural production leads to greater vulnerability, for example, to pests and diseases, then the average yield may well be smaller than expected. This would be the case, for example, when a few extremely small yields do not compensate the larger yields

Agricultural area, FAO projection

Figure 3.4



1) Regional averages hide shifts within regions

Even if past productivity growth in agriculture can be achieved, more people and a shifting diet mean more agricultural land use. Worldwide, the bulk of the expansion is projected before 2030. Later, technology is expected to catch up with increasing demand – first in OECD countries and BRIC. For the world as a whole, the expansion amounts to 30 per cent of the agricultural area of the United States. Source: IMAGE modelling to 2050 consistent with FAO Agriculture Towards 2030 (FAO 2006a; Stehfest et al., 2009). 023x_girl09

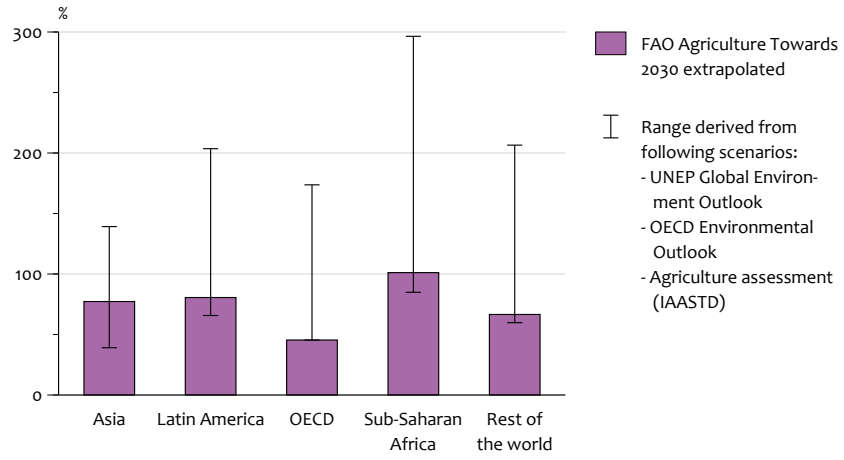
in the intensified system, in comparison with a system of lower yields and a higher reliability. Furthermore, intensification of agricultural production may lead to loss of other ecosystem services, such as carbon sequestration, which may be worth more than the gain in agriculture.

Water and climate change put drylands under more stress

Currently, production of food and other agricultural products accounts for 70% of freshwater withdrawals from rivers and groundwater (water for irrigation). Yet, this represents only a small proportion of water used in agriculture, which totals five times more than that used for irrigation when rainfed agriculture is included, and even ten times more when grazing lands are included. Agricultural use of freshwater competes with other human uses, such as for drinking water. The total water use in agriculture also competes with other ecosystems.

Availability of and demand for water in different parts of the world may be severely affected by climate change. Many drylands are projected to become even drier and water demand will increase in all regions, because of larger evapotranspiration

Figure 3.5 **Projected changes in cereal crop yields per ha, 2000 - 2050**



Many studies have even more optimistic productivity increases than the FAO projection, which is already considered to be substantial by some. Source: PBL 2008c. 025g_girl09

caused by higher temperatures. Furthermore, climate change may cause extreme weather events (including droughts) to occur more frequently and with greater intensity, increasing risks and uncertainty in food production. The problem is further aggravated by various interactions between water and land, for instance, increased water erosion on farmland from more intense rainfall, and further land degradation/desertification caused by droughts. However, the main reason for the downward trend in per-capita water availability is the increase in population, much less climate change.

Decreasing water availability per capita is a particularly important issue in the world's poorest regions that have the greatest need for increased agricultural production. Sub-saharan Africa and Asia are particularly vulnerable and will be confronted with increased risks of crop failure, which in turn will influence other regions through trade, migration, and conflict.

Ecological squeeze and loss of system resilience

A larger population and larger per-capita demand for agricultural products will increase demand for ecosystem goods and services, such as clean drinking water, water for irrigation, biodiversity, soils with sufficient nutrients for agricultural production, clean air, flood control, and climate regulation. These increased demands lead to greater environmental pressure affecting the system's ability to produce ecosystem goods and services. This process, known as ecological squeeze, refers to increased demand for ecosystem services – both in production and regulating services – while pressures on nature, land and biodiversity put pressure on supply. This effect is also apparent in the EU, where increasing and intensifying agriculture has decreased biodiversity and has simplified the agro-ecosystem

Vision for land resources, food and biodiversity in 2050

The vision for the world in 2050 is feeding nine billion people while minimising impacts on ecosystems and halting biodiversity loss before 2030. In 2050, the EU produces the same quantity and quality of agricultural products as today, but in more diverse landscapes that host more biodiversity. Crop yields have increased sustainably, worldwide, and human diets contain less animal products, making them also healthier. Furthermore, the EU has reduced its footprint – regarding land, water and energy use – on other parts of the world.

Increased agricultural productivity and system resilience

- *In 2050, worldwide agricultural productivity will have increased, specifically in those areas that, currently, produce little, but have high productivity potential. Productivity has increased by largely closing the gap between current and potential yields, also reducing pressure for converting natural areas to agricultural land, and providing opportunity for natural areas to be restored.*
- *Agricultural productivity has increased through efficient use of inputs, which also reduces emissions, and, in many areas, is combined with diverse and high-value biodiversity.*
- *Worldwide, the resilience of the agricultural system has improved, for example, in vulnerable or resource-constrained areas, by developing agro-ecological food systems that provide a mix of agriculture and nature next to other activities.*
- *Within this global vision of increased production and improved resilience of agricultural production systems, the EU has improved the management of its own vulnerable dryland areas.*
- *In 2050, European agricultural production has stabilised. Diversity in land management practices has increased throughout the EU. By increasing the resilience of the agricultural landscapes, larger and more stable yield levels have been attained. Diversity in land management helps to achieve Europe's share in biodiversity protection and to maintain the cultural landscapes that define Europe.*

Smaller demand for animal products and reduced food losses

- *Consumption of meat and dairy products in the EU and other regions with a Western diet has decreased by 20%. Consumption of red meat in current high-income countries has declined by a third. This leads to improved health and simultaneously to smaller feed requirement, and decreases pressure on the agricultural system.*
- *The feed conversion efficiency in animal production is significantly improved and so has animal welfare.*
- *The use of agricultural land for biofuel production is restricted to areas not suitable or not in production for annual food crops, and to areas of limited biodiversity value.*
- *Food waste (mainly in the developed world) and post-harvest losses (mainly in developing countries) are reduced by 50%, compared to 2009 levels.*

Protection of nature

- *Worldwide, selected areas of high biodiversity or threatened ecosystem services are protected, and financial arrangements are in place.*
- *Through targeted payments, farmers worldwide are stimulated to produce environmental goods and services that are appreciated by society.*

thereby increasing its vulnerability to shocks, such as extreme weather events, pests and disease.

Agriculture is the main driver of genetic erosion, species loss and conversion of natural habitats (MA, 2005). Conversion of natural habitats to cropland and other uses entails replacement of systems rich in biodiversity with monocultures and systems poor in biodiversity. At present, 30% of available crop varieties and only 14 animal species provide an estimated 90% of calories consumed worldwide (FAO, 1998). Decreasing biodiversity reduces the ability of ecosystems to supply services and, therefore, reduces resilience to recover from disturbances. Such disturbances include extreme weather events, pests and diseases, and other environmental shocks. Therefore, it is crucial to improve agricultural productivity without a negative impact on ecosystem goods and services.

3.4 Pathways to larger agricultural production without further biodiversity loss

The challenge is to increase agricultural production to feed nine billion people without doing irreparable damage to the planet's biodiversity. Ways must be found and implemented to increase agricultural productivity and the resilience of agricultural systems, globally, as well as within the EU. Other measures to meet the challenge include reducing livestock production and decreasing post-harvest losses and food waste. As land expansion will continue in the coming decades, targeted protection of areas with a high biodiversity value is also in order.

Increasing agricultural productivity and resilience

Investing in technology globally

A global effort is required to increase agricultural productivity, worldwide, to feed a population of 9 billion. Therefore, investments in agricultural research need to be brought back on track. An investment of a 1000 billion USD over the next 50 years is needed to increase food availability and to reduce the impact on biodiversity by reducing pressure on land (IAASTD, 2008). Research should partially be aimed at increasing agricultural productivity by making agriculture inputs more efficient and more compatible with sustainable land management practices.

The road forward is to nurture agricultural diversity, which goes hand in hand with creating a resilient agricultural system. Thus, agricultural productivity should be enhanced in a sustainable way. This can be achieved, for example, by stimulating different farm business models within different regions, where some regions and farms are more oriented towards agricultural production while others focus more on high-value products, delivery of public goods and recreation. Farmers can create sufficient income from a combination of primary production, provision of other (commercial) services and from payments for the provision of public goods. Diversifying the food system should also stress the importance of research and experimentation in coming to a diversified landscape. Resilience will also be enhanced by genetic variability of crops and within crop species.

The EU can make a substantial contribution to research and to agricultural investment elsewhere in the world, especially for increasing productivity in areas with large potential, in which current productivity is low. In this respect, additional support is needed for developing countries (see Section 3.5). Next to technical development, increasing productivity needs to be accompanied by socio-economic development and involvement of all stakeholders in order to produce practical and workable solutions.

Specific attention needs to be given to improving efficiency of water use in both rainfed and irrigated agriculture. This can be done through the use of increased soil water storage, shifting unproductive evaporation to productive transpiration, improved bridging of dry spells, and improved land management. Productivity per water unit can be increased by improving other production factors, such as soil/land and fertiliser, much in the same way as land productivity. For irrigated systems, options are improved systems management, creation of new water storage facilities, increased groundwater withdrawals (of course, this should not lead to water deficiencies elsewhere), increased use of wastewater, enhanced runoff generation and groundwater recharge, rainwater harvesting and storage, and managed aquifer recharge.

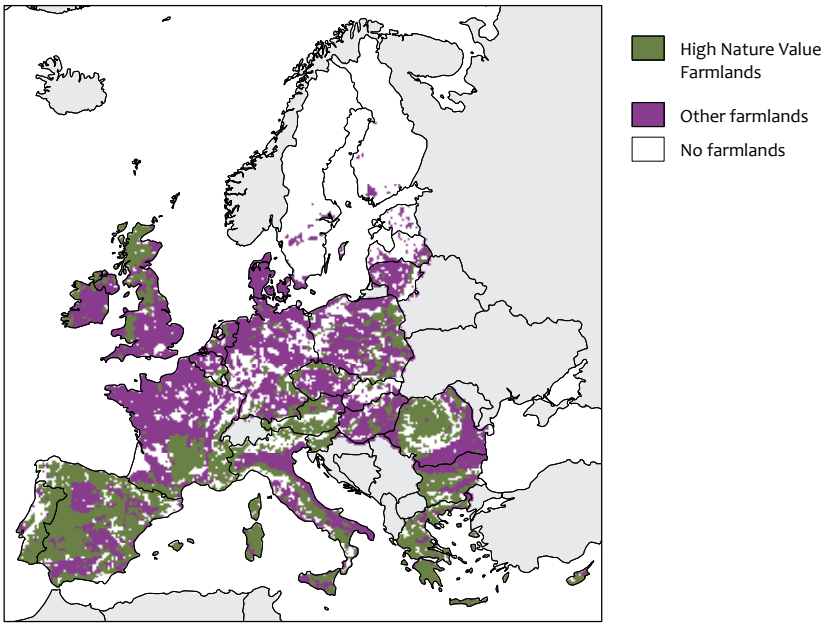
Investing in diversified agriculture in the EU

The EU and Member States need to invest in the diversity of European agriculture to achieve relatively large productivity with considerably less environmental impact. Two pathways are the investment in relevant research and creating an enabling policy environment.

The EU needs to support sustainable agricultural production within Europe while reducing the environmental impact of agriculture, and maintaining and restoring a diverse countryside. At present, the main policy instrument in this field is the Common Agricultural Policy (CAP). The main route is to shift agricultural policy to a spatially differentiated system of targeted payments to farmers and other land managers for delivery of public goods, such as biodiversity, landscape, water quality, flood regulation and carbon sequestration. An example is the High Nature Value Farmlands (JRC, 2008) (see Figure 3.6) which require extensive types of management in order to maintain their present state. Outside these areas, EU farmers could receive payment for certain public goods, such as landscape elements, with the focus in the most productive areas on optimising yields, while

Nurturing diversity in land management and agricultural practices in the EU improves resilience to shocks in the world food system. It also helps to maintain biodiversity and the cultural landscapes that define Europe.

Figure 3.6 **Farmlands and High Nature Value Farmlands in the EU, 2000**



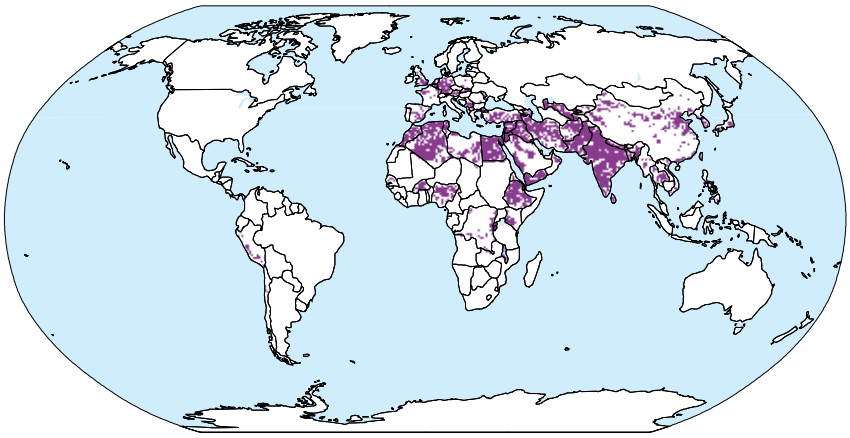
A large proportion of land in the EU is in agricultural use, ranging from semi-natural vegetation and extensive grazing to intensively cultivated land. Parts of these farmlands are High Nature Value Farmlands with valuable biodiversity. Source: JRC, 2008. 016k_girl09

respecting environmental standards. Such a differentiated approach will lead to more diverse agricultural systems and, thus, to increased resilience to different types of shocks.

This future Common Agricultural Policy should be coherent with other policy instruments, notably the Natura 2000, the Birds and Habitats Directives, EU Climate and Biofuels Policy, Water Framework Directive, Nitrates Directive, EU Development Policy, the Action Plan on Sustainable Consumption and Production, and the Sustainable Industrial Policy. This ensures that farmers receive consistent signals. For example, around 30% of Natura 2000 is agricultural land, hence, appropriate land management is crucial for achieving the Natura 2000 objective.

Investment in innovative research is necessary to create better management techniques that combine large agricultural production with small inputs, low emissions and high biodiversity value. Much of this type of research is not profitable for private companies, so will require financing by the EU and Member States.

Water availability per capita currently modest and declining towards 2050 **Figure 3.7**



Areas with low green-blue water availability (< 2000 m^3 per capita) and a decreasing trend towards 2050

The southern and eastern Mediterranean, as well as large parts of the Middle East and India, are expected to face a situation of decline in water availability per capita, while currently water is already only modestly available or scarce. Source: Adapted from Rockström et al., 2009 and Global Water News, 2009. 017k_girl09

The Mediterranean as a pioneer area

The Mediterranean could be seen as a pioneer for renewed agriculture and ecosystems policy in the EU. The countries of the southern and eastern Mediterranean and especially North Africa exploit close to 100% of their renewable water resources. Problems arising from water scarcity are projected to worsen, aggravated by climate change (Figure 3.7).

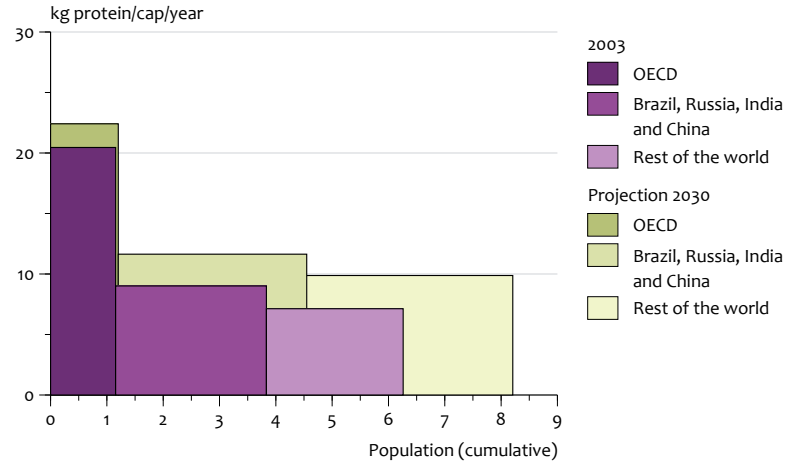
If solutions to integrate land use, water, agricultural and ecosystems policies can be found, the Mediterranean basin may well serve as an example for the EU, as well as for dryland regions outside Europe. Making dryland agriculture and territorial management a focus of the EU's outward agricultural policy would connect EU Neighbourhood Policy (and the Euro-Mediterranean Partnership) with EU internal policies, such as the Common Agricultural Policy.

In the dryland areas of the EU, where water is scarce and erosion risk large, the focus should be on high-value products with small water requirements. Areas of ecological risk should be identified for exclusion from agricultural production.

Influencing diets and reducing post-harvest losses

A shift towards a diet with less red meat and other animal products has several benefits. It decreases pressure on the agricultural system, which, in turn, decreases pressure on biodiversity. Furthermore, a diet with less meat reduces greenhouse gas emissions, can have substantial health benefits, reduces other emissions, and

Figure 3.8 **Per-capita consumption of animal protein, baseline projection**



Per-capita consumption of animal protein is projected to increase as average affluence increases. Source: FAO, 2009a; FAO, 2009b; FAO, 2009c; FAO, 2006a. 014g_girl09

reduces water usage. Although changing global diets is perhaps not directly an EU task, at least it should be included in the discussions.

Reducing meat consumption

The vision includes a dietary shift to less meat consumption in the next decades (in contrast to the baseline projections presented in Figure 3.8). In developing countries this means slowing down the trend of increasing meat consumption and in developed countries - such as the EU Member States – it means reducing the consumption of red meat and other animal products. However, reducing meat consumption in the developed world is a complex issue. While a small proportion of the population currently eats less or no meat, the majority of the population will not voluntarily eat less meat and diary products. Furthermore, only few instruments are in place to reduce the consumption of animal products.

Influencing consumer food habits raises important issues for policymakers. How far can and will the EU go in limiting the individual choice to eat less meat in favour of collective goods, such as climate and biodiversity?

In reducing meat consumption, the first step may be to invest in public awareness by stressing the health benefits and the reduced pressure on natural resources. Currently, there is very little awareness of these issues. Stehfest et al. (2009) calculated that a healthy diet worldwide would reduce the required area of arable land globally by 10%, and the area of grassland by 40%, compared to the FAO assumptions. An example of a healthy diet is the Willett diet, which includes 10g beef, 10g pork, 47g chicken and eggs, and 23g fish, per person, per day on average.

The associated reduction in costs for mitigation of carbon dioxide emissions could be as large as 50% in 2050, compared to the reference case (Stehfest et al., 2009).

Theoretically, another option would be to increase prices in order to internalise the negative effects. However, in practice, consumers in high-income countries do not respond strongly to rising prices for meat and even less so for dairy products (PBL, 2008b), and political support is lacking. This is largely explained by the small proportion of total expenditure on meat and dairy products. Another option would be to find high-quality meat substitutes.

Finally, as food habits are difficult to influence directly, consideration should be given to making current production chains more sustainable, either voluntarily, or by setting standards for products in the EU. For example, meat produced from well-managed extensive rangelands could be certified as 'biodiversity friendly'. However, in making international agreements between businesses, NGOs and governments, care should be taken to prevent additional costs falling on developing countries.

Cutting food losses and waste

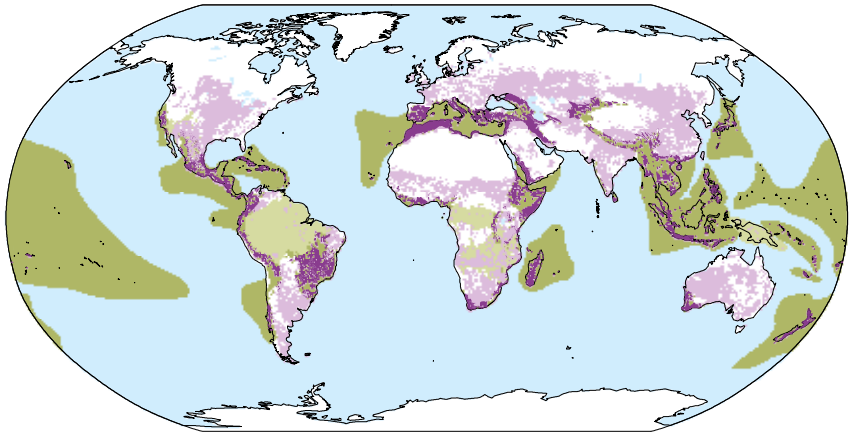
Another option to reduce the pressure on the agricultural system is to decrease post-harvest losses. A lot of food produced is never consumed. In affluent countries, such as the United Kingdom and the United States, some 30 to 40% of the food produced and processed, transported and purchased by consumers is thrown away. (Engström and Carlsson-Kanyama, 2004; Scott Kantor, 1997; Vidal, 2005; Milieu Centraal, 2007). In developing countries, crop losses in the field can be as large as 20 to 40% of the potential harvest, because of pests, rats and diseases (Kader, 2005).

Reducing losses during processing, transport and distribution, as well as reducing waste and using it, for example, for feed and energy, can make a significant contribution to feeding the world in 2050, while minimising biodiversity loss. To fight large post-harvest losses in most least-developed countries, action is needed to improve storage access and to improve the distribution infrastructure to markets. While decreasing post-harvest losses in developing countries directly delivers more food, using waste for animal feed will indirectly decrease demand for agricultural production by providing an alternative animal feed (UNEP, 2009).

Prioritise, protect and pay for nature

In the coming decades, dietary changes to less meat consumption and increases in agricultural productivity will not be able to keep pace with the increase in demand for agricultural products. In the period up to 2030, when the major expansion of agricultural land takes place, nature protection is vital. Beyond that time, demand for additional agricultural land is expected to gradually decrease. As land conversion is often irreversible, valuable ecosystems currently under pressure need to be protected, focusing on biodiversity hotspots with large numbers of species not found elsewhere (Figure 3.9), and on other nature areas rich in plant and animal species. Projected agricultural expansion is likely to threaten these areas, because agricultural expansion often occurs in areas adjacent to cultivated areas. Potential conflicts between agricultural expansion and the preservation of ecosystem

Figure 3.9 **Current agricultural areas, biodiversity hotspots and forest cover**



'Biodiversity hotspots' indicate areas known to hold large numbers of species not found elsewhere and considered vulnerable because of large-scale land-use change in the past, particularly land use for agriculture. Potential conflicts between agricultural expansion and the preservation of ecosystem services are to be expected in Latin America, parts of Africa, Southeast Asia, Central Asia and the Mediterranean. Source: Mittermeier et al., 2003; Myers et al., 2000, and PBL calculations (IMAGE) for agricultural area. *019k_girl09*

services are to be expected in Latin America, parts of Africa, Southeast Asia, Central Asia and the Mediterranean.

Protecting biodiversity outside the EU

In addition to protection of biodiversity within the EU – as formulated in Natura 2000 and other EU policy documents – the EU can contribute to protecting many valuable natural areas outside its boundaries. For example, by providing development assistance and targeted payment for conservation purposes. Other ways of financing nature conservation may be found through climate policies, such as the Clean Development Mechanism (CDM), or through current developments to protect tropical forests, with a view to preventing greenhouse gas emissions, for example, developments around Reducing Emissions from Deforestation in Developing Countries (REDD). The EU biodiversity policy could be broadened by strengthening its external dimension (see Section 3.5). Nature protection outside Europe is relatively cost-effective: money spent outside the EU, in most cases, conserves more nature than if spent inside the EU, because of differences in land value.

3.5 Connecting other EU policies and related issues

Agriculture linked in multiple ways to climate change

Agriculture has multiple links with climate change: animal farming and fertiliser production and use significantly contribute to global greenhouse gas emissions. Recent estimates of the contribution of cattle breeding to global greenhouse emissions vary from 12% (JRC, 2009) to 18% (FAO, 2006b). These emissions need to be significantly decreased in order to limit climate change. At the same time, ongoing climate change will compromise agricultural productivity, particularly in the poorest areas. Furthermore, bio-energy has a role in mitigating climate change, although this comes at a price. Biofuels compete with food production and biodiversity. To achieve the EU 10% target for biofuels will require putting additional land into production, in and outside Europe (MNP, 2008). More information on biofuels is provided in Chapter 4 (Energy and Climate Change).

Development in least-developed countries

A broad approach to development remains necessary, in order to increase agricultural productivity in the least-developed countries. Investments in roads, education, health and other services that contribute to development, remain necessary for successful implementation of technologies to improve agricultural productivity. To protect biodiversity and ensure that least-developed countries join a climate regime, money and technology, among other things, remain essential.

Growth in the agricultural sector is often vital to the least-developed countries. Thus, providing them with preferential trade rights to least-developed countries, as well as further reform of EU and US general agricultural subsidies will help to create the context for agricultural productivity improvement, necessary to reach the vision outlined in this study. An example of such a reform would be a further shift in EU subsidies towards payment for landscape and habitat management.

Trade and development policies need to take into account that, currently, 1.5 billion people depend on small farms. Thus, development of these farms remains crucial, for some time to come. Over the next decades, the EU and EU Member States remain in a position to support farmer co-operatives through Official Development Aid in order to make them more robust to price fluctuations, to get better perspectives on loans and to improve their position in the major distributive trade. Furthermore, the EU and Member States remain in a position to gear agricultural research more to the needs and the development of small-scale farms and improvement of crop storage and access to markets.

Incorporating food security in food production strategies

Large-scale hunger is a moral issue that cannot be ignored politically. Therefore, improving food security worldwide has to be an ingredient of any long-term strategy on global agricultural productivity and land resources. While food security in low-income regions of the world is strongly impacted by conflicts and poverty, it can be improved by a number of agriculture-related measures. These include larger tradable food stocks to dampen volatility in food prices (IFPRI, 2009) and technical collaboration to decrease post-harvest losses (see Text Box 3.1 and Section 3.4).

Recently, the positions in global agriculture are changing, as countries such as China and several countries of the Middle East, with little land or water suitable for agriculture, take measures to ensure food security by actively purchasing land elsewhere in the world.

Guaranteeing a basic food supply in Europe has always been one of the EU goals. Currently, approximately 90% of food consumed in the EU is produced within its borders and self-sufficiency will remain large in the future (MNP, 2004). Thus, in contrast to energy, self-sufficiency in food should not be a major concern for the EU towards 2050. Exceptions are protein-rich animal feed, such as soy, for which the EU depends heavily on imports, and bio-energy products.

Strengthening the external dimension of EU policies through international forums

To reach the 2050 vision for food and biodiversity, the EU needs a coherent and consistent policy approach to trade, agriculture, climate, development, biofuels, consumption and nature. This is also the case in international forums in which the EU participates. The EU position in the World Trade Organization, for example, should be consistent with efforts to achieve a post-Kyoto global climate deal and to reach the Millennium Development Goals of the United Nations.

Global processes are less well-established in food and biodiversity matters. However, EU Member States have been closely involved in the early steps to an Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and within the EU, in The Economics of Ecosystems and Biodiversity (TEEB). Furthermore, the EU and Member States can co-influence priorities in the work programmes of international organisations, such as the World Bank and Food and Agriculture Organization (FAO). Although highly complex and hard to organise, a more coherent and consistent input from the EU is crucial to achieve the vision for 2050 (see also Chapter 6). Within the EU, the external dimension of current policies needs to be strengthened because EU decisions on land, food and biodiversity have global consequences.

In terms of being recognised as global resource-use issues in need of policy, land and water for agriculture and ecosystem services are 25 years behind the climate issue. For example, the compilation of the Agricultural Assessment (IAASTD,

Text Box 3.1 Determinants of food security worldwide

Food security is a major issue in many parts of the world and is mainly determined by:

- *Availability of food, related to trade, investment and resources;*
- *Affordability of food: higher food prices mean limited access for poor people;*
- *Stability, requiring good government and absence of conflicts, but also less volatile food prices;*
- *Access to local and global markets for producers and consumers.*

Source: UNEP, 2007

2008) is testimony to the difficulty of bridging different views on land resources, agriculture and globalisation. In fact, lessons from climate policy development may well help in timely preparation for the upcoming global issues around land and water resources. One example is the way diverging perspectives have been brought together through UNFCCC and IPCC. Moreover, looking at the EU from a global perspective, its track record in transboundary environmental issues and climate policy, its agricultural endowment and its reputation for inclusive government strongly suggest that it is the best placed actor to take the initiative to set up a global policy debate on the use of land and water for agriculture and ecosystem services as a global resource issue. Ideally, this will lead to the timely recognition of one global food system, just like the reality of one global climate system has been helped forward to political recognition over the past two decades.

3.6 The critical path for the EU

The global issues of land resources, food and biodiversity of 2050 are complex and in some respects, controversial. Nevertheless, the EU can take a leading role in moving towards a more sustainable future, in 2050, and influence global processes in securing more sustainable use of land resources, food and biodiversity. Concerning the inevitable delays, the barriers to cross and the inertia of the system, there are some issues that need to be addressed sooner rather than later in order to achieve this vision. These issues are on the critical path.

Putting research investment in agricultural systems back on track

It is critical to invest both in new research and technology as well as in the implementation of existing technologies, especially in developing countries. The aim for the EU is to prepare for smarter agriculture – highly productive, as well as flexible, resilient and, where necessary, well-integrated in other functions. This should help to prepare for a crowded world where resources, such as land, water, and perhaps phosphate, will be scarce and regional climate conditions will change.

Make diversity a strategic aim of the Common Agricultural Policy

For the EU specifically, make diversity a strategic aim for the Common Agricultural Policy, its subsequent policies, and also for related regional policies. This is essential for maintaining and increasing agricultural productivity in the EU, in providing a buffer against shocks (for example, pests and food shortages) in a very crowded and interconnected world, and in helping to maintain the biodiversity and cultural landscapes that define Europe.

Facilitating the debate on reducing meat consumption

The EU should facilitate the debate on the amount and type of meat and other animal products consumed in the EU. The consequences of different diets for biodiversity, health and climate could be made clear to EU citizens. Furthermore, insight can be provided into the level of support for possible measures, which could help policymakers to decide on how best to influence consumer behaviour.

Prioritise, protect and pay for ecosystems

The EU can initiate and develop arrangements, in a global collaborative setting, to prioritise, protect and pay for ecosystems and related ecosystem services. This comes early on the critical path, because increasing agricultural productivity worldwide and changing the trend in diets will take time and most losses of biodiversity and ecosystems are irreversible.

Structure a worldwide debate

The EU can help to structure a worldwide debate to bridge the diverging perspectives on land, food and biodiversity in the context of globalisation, as has been done on climate change. The key challenge is to gain recognition of the existence of one global food system, linking national and local food systems and ecosystems and taking all ecosystem goods and services into account.

3.7 The bottom line

This chapter identifies specific actions for the EU, on the critical path to achieve the vision. The EU is an important actor, both globally and within Europe. The EU role at the global level includes contributing to the necessary investments in research programmes, helping to resolve current discussions on intellectual property rights, setting product standards that also take biodiversity into account, and guiding multilateral organisations to come up with coherent policies that go beyond individual policies on land, food, development and biodiversity.

Within the EU, the chapter identifies a strategic priority for the post-2013 Common Agricultural Policy and policies that will succeed it, namely to nurture diversity in EU land management. This will play out differently for Member States and their neighbouring countries. One of the implications could be the distinction between high-productivity agricultural areas and areas with other priorities.

In view of the scale of increasing pressures on the rural environment projected over the next decades, including climate change, there is a strong case for the Mediterranean basin to pioneer a renewed agriculture and ecosystems policy in, and possibly around, the EU. Moreover, if dryland agriculture and related territorial management were made an EU focal point, a new connection between the external dimension and internal policies would be created.

4 Energy and Climate Change

A vision for 2050 of a low-carbon energy system in the EU is analysed. Starting point is the ambition to limit the increase in mean global temperature to 2 °C. For this, emissions in high-income countries have to decrease by 80% or more in 2050 compared to 1990. Moreover, emerging economies such as India and China need to participate in emission reduction. The vision matches this by implementing a low-carbon energy system in the EU (80% reduction on 1990 levels without external trade in emission credits). It implies a significant reduction in the use of fossil energy without carbon capture and storage (CCS), and an increase in energy efficiency, CCS and renewables as substitutes for fossil energy. These changes improve security of energy supply for the EU by diversifying energy sources.

4.1 Current energy policy in the EU

Energy and climate

The EU and Member States are firmly committed to the objective of the United Nation Framework Convention on Climate Change (UNFCCC) to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The EU has interpreted this objective as limiting the increase in mean global temperature to a maximum of 2 °C above pre-industrial levels. Achieving this 2 °C target with more than 50% chance would translate to 80 to 95% emission reductions by 2050 on 1990 levels in the EU and other industrialised countries (Den Elzen et al., 2008a). In this respect, the Member States have made a modest commitment of 8% reduction by 2012 within in the context of the Kyoto Protocol.

The European Union has adopted a 60-80% emission reduction target on 1990 levels for 2050 in Council Conclusions (Council of the European Union, 2007). A medium-term target has been set for 2020 of 20% reduction on 1990 levels. This emission reduction target increases to 30% emission reduction if 'other developed countries commit themselves to comparable emission reductions and economically more advanced developing countries adequately contribute according to their responsibilities and respective capabilities' (Council of the European Union, 2007). This goal has been approved by the political leaders of the Member States, together with objectives to use 20% renewable energy in gross final energy use in 2020 and to be 20% more energy efficient by that time (Council of the European Union, 2007; European Parliament and Council, 2009b).

The emission reduction targets are incorporated in two EU laws - the emissions trading directive that covers mainly industry related emissions (about 45%) and the effort-sharing decision that lists country-specific targets for the sectors not covered by the Emissions Trading Scheme (European Parliament and Council, 2009a). In addition, the objective to reduce emissions is integrated in other EU policies and in specific product standards and subsidy schemes. Nevertheless, additional policies are likely to be needed in order to achieve the more ambitious long-term targets aimed for by the EU. These climate and energy policies should help the EU to convince other countries to take up similar efforts, since the climate problem clearly cannot be solved by the EU alone.

Security of supply

A key component of the EU energy policy is the interconnection of energy infrastructure between Member States, and between the EU and major energy exporters. Initially, interconnection aimed at facilitating and strengthening the internal energy market. Recently, future security of supply has become a compelling argument for infrastructure development. In securing EU energy needs, the European Commission proposes focusing on six major infrastructure projects: interconnection of the Baltic region; Southern gas corridor; Liquefied Natural Gas; Mediterranean energy ring; Central and southeast European Infrastructure; and a North-Sea off-shore grid (European Commission, 2008). Furthermore, the Commission aims to develop a vision for 2050, focusing on decarbonising the EU and global energy systems, ending oil dependence in transport; increasing small-scale energy production in buildings; and using a smart interconnected power grid (European Commission, 2008).

4.2 Issues confronting the EU energy system today

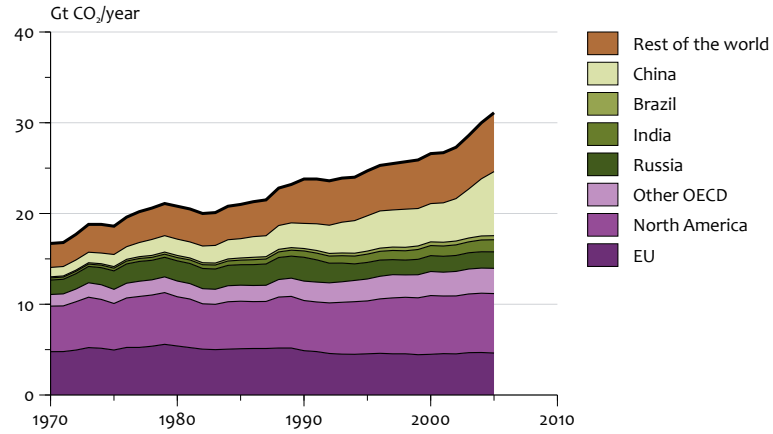
In ensuring a clean, affordable and secure energy supply towards 2050, the EU faces two key challenges - climate change and security of supply from imports. These challenges are interrelated to a certain extend as both are associated with the current use of fossil energy.

Reducing greenhouse gas emissions

Carbon dioxide emissions from the use of fossil energy account for about 70% of global greenhouse gas emissions (JRC/PBL, 2009). Global use of fossil energy is expected to continue to increase rapidly, driven by the growing world population, by increasing affluence in developed and developing countries, and by lifestyle changes associated with growing affluence. Without emission control policies, greenhouse gas emissions will further increase. The EU contributes currently about 17% of global energy-related carbon dioxide emissions (Figure 4.1) but this is expected to decrease to about 10% by 2050.

Studies indicate that risks of damage due to climate change can be mapped in relation to change in mean global temperature (Figure 4.2). Expectations are that even a small temperature increase (less than 1 °C) will affect sensitive ecosystems (such as coral reefs) and local systems (food supply). Further temperature increase (1-2 °C) is likely to have greater impacts, including melting of Arctic sea ice and parts

Figure 4.1 **Global CO_2 emissions from energy use and industry**



Global carbon dioxide emissions have increased over the last few decades, with emissions from the EU and USA dominating and China catching up rapidly. Source: JRC/PBL, 2009. 006g_girl09

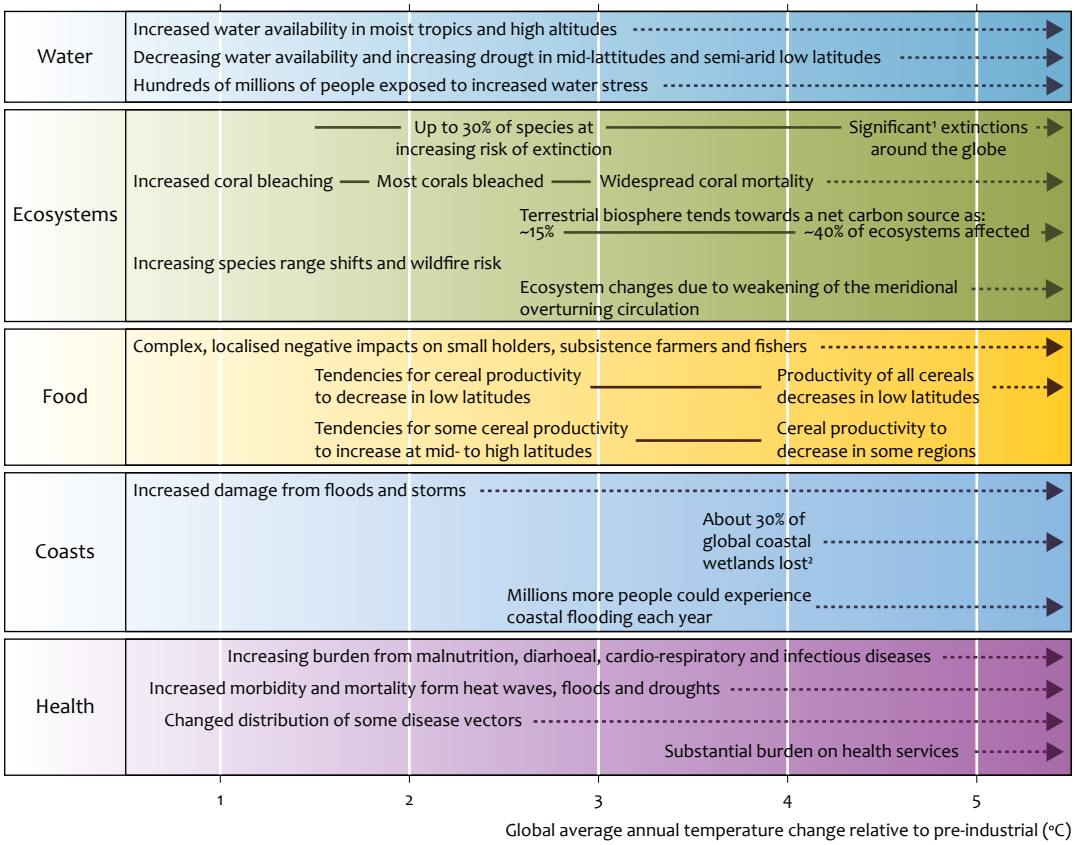
of the Greenland ice sheet with a significant rise in sea level, impact on worldwide food production, and collapse of the thermohaline circulation. Based on these insights, the EU has chosen to aim for limiting the average temperature increase to 2 °C above the pre-industrial level.

The implications of the 2 °C target for long-term greenhouse gas concentrations are illustrated in Figure 4.4. For a probability of more than 50% of achieving the 2 °C target, greenhouse gas concentrations need to be stabilised at less than 450 ppm CO_2-equivalents. For a 70% probability of achieving the 2 °C target, a concentration of 400 ppm CO_2-equivalents would be required.

There is no absolute relationship between emission reductions and concentration targets because of freedom in timing of policies and uncertainty about the removal rate of greenhouse gases from the atmosphere. Nevertheless, ambitious targets for greenhouse gas concentration require emission reduction in the short term, even if temporary overshoots of concentration targets are considered (Den Elzen and Van Vuuren, 2007).

Several studies indicate that a target of 450 ppm CO_2equivalents would correspond roughly to between 40 and 60% emission reduction worldwide in 2050 (Knopf et al., 2009; MNP, 2006). Although energy use is responsible for most greenhouse gas emissions, such reductions cannot be achieved by the energy sector alone. Contributions are also required from agriculture, land use and industry such as cement and ammonia production.

Examples of impacts associated with global average temperature change **Figure 4.2**



¹ Significant is defined here as more than 40%

² Based on average rate of sea level rise of 4.2mm/year from 2000 to 2080

Risks increase considerably beyond an average temperature increase of 2 °C. This is the basis of EU and G8 climate objectives. Impacts will vary by extent of adaptation, rate of temperature change and socio-economic pathway. Source: IPCC, 2007. 004s_girl09

Securing energy supply to the EU

The EU faces challenges with security of energy supply including availability of energy sources, energy prices and import dependency (Behrens, 2009; Le Coq and Paltseva, 2009). This chapter focuses on the EU dependency on imported energy from a small number of countries. Currently, the EU imports about 80% of its oil requirement and 60% of its natural gas (IEA, 2008b). This import dependency has major consequences for security of energy supply as well as for EU foreign policy. Major energy suppliers, such as Russia, have demonstrated their ability and willingness to use their energy resources to pursue strategic and political objectives.

Vision: a low-carbon energy system in the EU in 2050

A vision for the EU energy system in 2050 is that of a low-carbon energy system: an 80% reduction on 1990 levels in energy-related carbon dioxide emissions within the EU. A low-carbon energy system implies a considerable reduction in fossil energy use and an increase in security of energy supply through diversification of energy sources. The low carbon energy system envisaged for Europe in 2050 is outlined below.

Non-carbon and energy-efficient end-use

In a low-carbon energy system, the end-use of energy is based predominantly on non-carbon energy carriers such as electricity or hydrogen from low-carbon sources or biofuels (see Figure 4.3):

- *Most household energy use, such as heating and cooking, is based on electricity with a few Member States continuing to use natural gas.*
- *In the transport sector, passenger vehicles are envisioned to be all-electric, but trucks, aircraft and ships are fuelled either by biofuels or oil-based fuels (see Chapter 5).*
- *The energy system becomes considerably more efficient, for instance through improved insulation of houses and buildings, and the integration of industrial processes.*

Centralised use of fossil energy

The use of fossil energy is centralised to enable the use of carbon capture and storage technology (CCS).

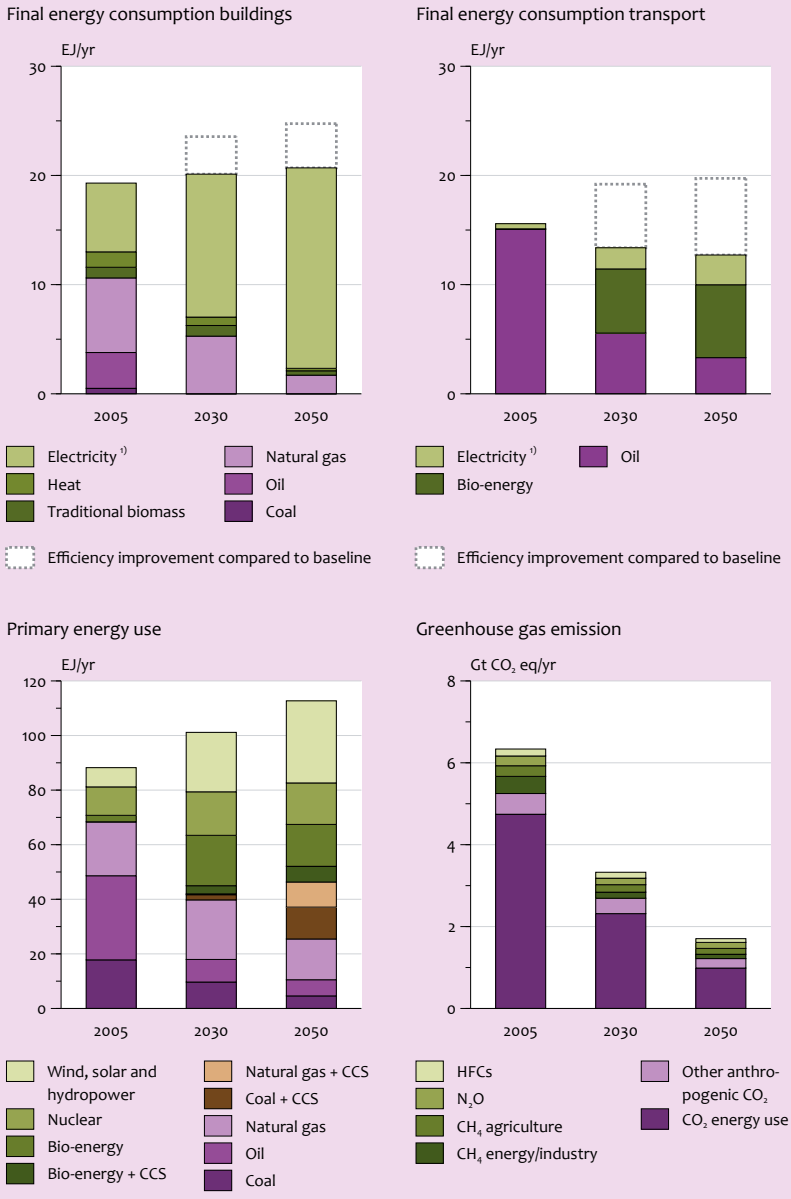
- *This implies that most fossil energy is used in large-scale power plants with integrated carbon capture and storage systems.*
- *The combination of electricity production from biomass with carbon capture and storage further reduces emissions, because these power plants have a net carbon uptake.*
- *CCS is also common practice in the industrial sector such as in steel, cement and ammonia production.*

Large-scale power generation

While there are differences between Member States, most electricity is produced in large-scale facilities and based on different sources of energy.

- *Fossil power plants are equipped with carbon capture units and preferably located near storage sites.*
- *While more use of nuclear power is consistent with a low-carbon energy system, its use depends on the acceptance and management of the controversial issues of nuclear waste and risk of plant failure. The use of nuclear energy is expected to vary widely between Member States.*
- *Large-scale renewable energy farms are located all over Europe with the area around the North Sea the major location for off-shore wind power and southern Europe for concentrated solar power, which may also be imported from North Africa.*

Towards a low-carbon EU energy system, vision **Figure 4.3**



1) Alternatively, the carbon-free carrier could be hydrogen

Calculations show that 80% domestic reduction in greenhouse gas emissions on 1990 levels is attainable with technologies already identified: greater use of renewable energy sources and carbon capture and storage. *007x_gir109*

Small-scale energy production by end-users

Use of low-carbon technologies increases electricity prices by about 20% compared to baseline development, which provides a stimulus for small-scale power generation by households, businesses and industries.

- *The main technologies for small-scale power generation are solar photovoltaic, small-scale wind turbines and distributed geothermal heating and cooling.*
- *Small-scale electricity production leads to less growth in the demand for centralised power-plants.*

A power grid that facilitates diversity

Large renewable energy farms are interlinked in a European high-voltage power grid connecting Member States to distant energy sources to reduce intermittency in renewable power supply and enable the use of the cheapest renewable resources.

- *Small-scale power production by end-users requires enforcement of local energy grids, to exchange electricity within districts.*
- *Excess electricity from renewables is stored, using pumped hydropower, compressed air, and the batteries of electric vehicles.*

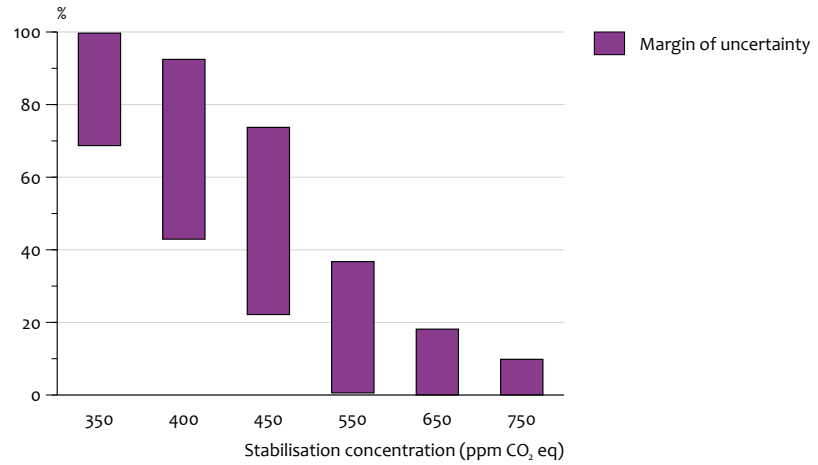
Diversified energy sources increase security of supply

In this low-carbon energy system, diversification of energy sources leads to increased security of supply through reduced dependency on imported fossil energy.

- *The increase in (endogenously produced) renewable electricity reduces the share of imported fossil energy in total energy use.*
- *Fossil energy is imported from a range of countries. For this purpose, a network of natural gas pipelines secures imports from Russia, Central Asia and North Africa, and LNG terminals ensure further diversification of imports. The demand for natural gas is roughly equal to the currently planned extension of pipeline capacity to the EU in the next decades.*
- *Coal and uranium can be imported from various regions and present no urgent issue in terms of security of supply.*
- *Bio-energy is produced in the EU, but a large share is imported from various world regions*

Based on the considerations described above, a global energy model was used to link energy demand, supply and trade. These calculations are based on the scenario of the OECD Environmental Outlook (OECD, 2008), with specific adjustments. The main assumptions are a rapid increase in the share of electricity particularly in passenger transport and buildings, carbon taxes leading to a rapid increase in energy efficiency, and 80% reduction in carbon dioxide emissions in the EU. The transport sector is assumed to reduce emissions by 80%, shifting towards carbon neutral road passenger transport and biofuels for heavy transport modes. The calculations of transport energy use are obtained from Chapter 5 of this report.

Chance of achieving the 2°C target **Figure 4.4**



The 2 ºC target can be achieved with more than 50% probability provided greenhouse gas concentrations stabilise at less than 450 ppmv. Source: based on Meinshausen (2006). 005g_girl09

Alternative visions for a low-carbon energy system in 2050

Both the vision for 2050 and the path to a low-carbon energy system require a series of choices that would lead to quite different results. For instance, a larger share of global emission trading would allow somewhat higher emissions, and thus possible low-carbon technologies based on natural gas instead of zero-carbon technologies. The envisaged low-carbon energy system can be extended with external emission trading to increase the formal EU emission reduction to 90% or maybe 95%.

The vision on energy supply focuses on diversification of sources and the benefits for security of supply. Alternative visions for energy supply can focus more on cost-effectiveness (e.g., more nuclear energy and carbon capture and storage), on phasing out fossil energy (fully renewable energy systems and more bio-energy), or decentralisation of energy supply.

The distribution of emission reductions over sectors is an inherent part of this vision and not necessarily the most cost-effective. Increased use of electricity in buildings leads to large emission reductions. Emission reductions in transport amount to an ambitious 80%. Such reductions are possible (see Chapter 5), although equal marginal costs across all sectors would possibly lead to somewhat smaller decreases in emissions from transport (50 to 60%). With regard to reductions in greenhouse gas emissions, economic sectors can be seen as 'communicating vessels': if emission reductions are smaller in transport, then the power sector needs to achieve greater emission reductions (up to 100 to 120%). Negative emissions can be achieved in the power sector by using bio-energy in combination with carbon capture and storage.

4.3 Pathways to a low-carbon energy system in 2050

To achieve a low-carbon energy system in 2050, major developments are needed in three areas:

- technology development and deployment;
- infrastructure development and adjustment;
- a coherent framework of policies and institutions.

Developing and deploying low-carbon technologies

A low-carbon energy system requires development and deployment of new and innovative technologies. These technologies range from batteries for cars to CCS for power plants, from small-scale urban wind turbines to concentrated solar power, and from energy-efficient appliances to off-shore wind farms. Many of these technologies have been identified and are technically available, but are not yet sufficiently mature for large-scale commercial application.

Stimulating further development and deployment of these technologies requires a balanced package of policy options. Technologies that are technologically mature and available such as wind power and heat pumps require market-pull policies on the short-term to stimulate technology learning and scaling up to become competitive. Such measures include targets for minimum market shares, subsidies or feed-in tariffs for clean technologies (Butler and Neuhoff, 2008) and uniform emission targets (e.g., g CO_2/km for vehicles or g CO_2/kWh for utilities). These measures can distort the level playing field of markets, which is best prevented by taking such measures at the EU level. An important aspect of technology deployment policy is to observe and prevent possible negative impacts of technologies and, if needed, adjust the level of ambition. The EU policy-making process already includes the open method of coordination, aiming to benchmark national policies and sharing best practices. Such an open method would be useful in exploring and stimulating the application of new technologies.

Many technologies still require considerable R&D effort, such as large-scale carbon capture and storage, and second-generation biofuels. Also, in some sectors such as transport, the winning technologies for the long-term cannot be identified as yet. A technology push through R&D investment is needed in the coming one or two decades. In the next five years, the 8th Framework Programme for Research and Technological Development provides an opportunity to direct funding to a broad range of energy technologies and to reverse the trend of decreasing R&D investment (IEA, 2008a).

Long-term emission reduction requires strategic choices and early action

If a range of low-carbon technologies is technically and commercially available, the market can be left to select the most attractive investment. Nevertheless, some choices in technology and policy are crucial to the development of a low-carbon energy system. For instance, a strategic decision for bio-energy is essential to make full use of its limited and uncertain potential.

A final issue is the long lifetime of energy installations. Power plants built today will probably still be operating in 2050. By that time, however, power plants have to be

equipped with carbon capture and storage (CCS) facilities. Therefore, regulation needs to be strengthened for 'capture-ready' power plants and clear targets set for phasing out fossil power plants without CCS. According to our calculations, a low-carbon energy system can only be achieved in 2050 if no new fossil power plants without carbon capture and storage would be built after 2025. This implies a major effort for research, development and deployment for the next 15 years. Setting such a target would provide a clear signal for the direction for R&D and investments in the power sector.

Acceptance of new energy technologies is crucial

All technologies needed in a low-carbon energy system have strengths but also bring certain risks, disadvantages and costs. If these problems are not resolved, social acceptance of low-carbon technologies might be insufficient and thus a low-carbon energy system will not be feasible. The most prominent issues are the safety and waste disposal risks associated with nuclear energy and the safety risks of carbon capture and storage technology. However, there are also concerns about other technologies such as the noise and visual hindrance of wind turbines. Therefore, effort is required to increase social acceptance of new energy technologies. In this respect, pilot projects need to be carefully planned and communicated and involve the participation of local stakeholders. This is the case especially with regard to carbon capture and storage, which is in the early stage of development and several projects have already faced serious opposition from local residents. As a financier of pilot projects, the EU is in the position to demand more attention for stakeholder participation and the communication of uncertainties.

Technology targets towards 2050

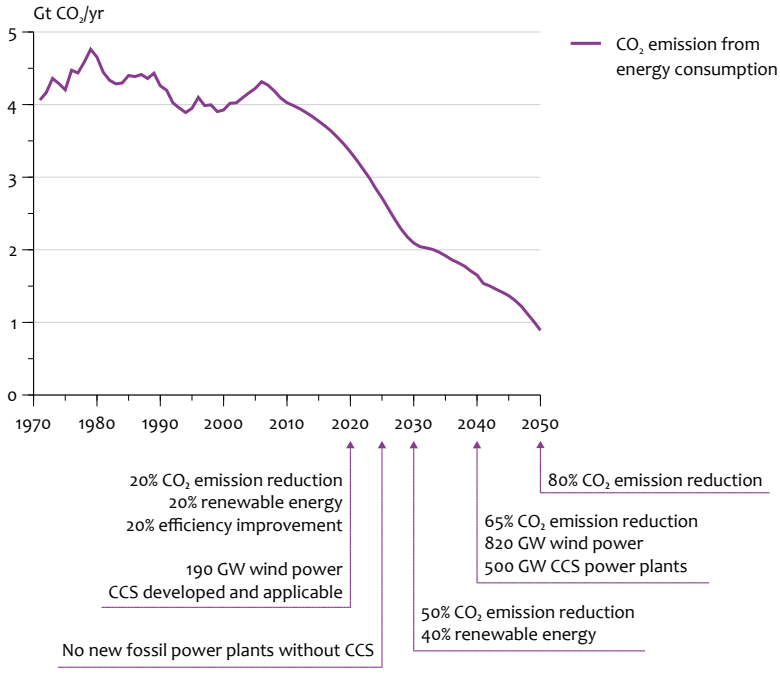
On the way to a low-carbon energy system in 2050, targets for the coming decades and actions for the next five years can be derived from the considerations on technology deployment. Figure 4.5 shows targets along the line of the current EU energy package that lead to the vision for 2050, for example 40% renewable energy in 2030 and 65% emission reduction in 2040. Including such targets in a long-term EU energy strategy builds trust in the low-carbon ambitions. However, these targets also translate to short-term actions. For instance, phasing out power plants without CCS in 2025 requires major technology development in the next decade to ensure that the technology is safely available by 2020.

Bio-energy is part of the solution but also part of the problem

Many studies on climate mitigation have identified bio-energy as a key option to reduce greenhouse gas emissions and as an economic opportunity to reduce poverty in developing countries. Based on energy security considerations, policymakers have focused on stimulating the use of biofuels in transport.

This push for biofuels, mainly in 2008 with blending proposals in the USA and fixed renewable targets for transport in the EU, has led to scientific and societal debate on whether biofuels are a sustainable solution. The debate is dominated by issues such as risk of biodiversity loss, increase in food prices and the greenhouse gas balance of biofuels being negatively influenced by N_2O emissions (Smeets et al., 2009) and indirect changes in land use (Fargione et al., 2008; Searchinger et al., 2008).

Figure 4.5 **Pathway towards a low-carbon EU energy system, vision**



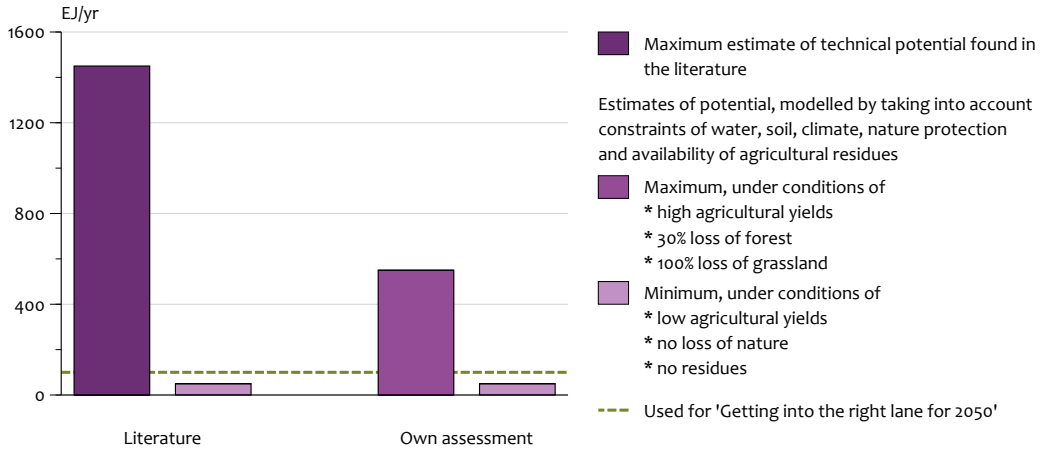
This graph shows targets and decision points on achieving a low-carbon energy system in the EU by 2050. Preparations need to be made now, so that application of low-carbon technologies can be accelerated in the period between 2020 and 2040. The power grid needs to be interconnected and expanded, infrastructure for carbon capture and storage developed, and bio-energy use targeted. *011g_girl09*

The European Commission has recognised the seriousness of these problems and has given attention to sustainability criteria for biofuel production in a proposal of January 2008, which was approved by the Member States and the European Parliament in December 2008. Nevertheless, the EU target for a 10% share in 2020 of renewable energy in transport is likely to increase demand for biofuels considerably. Up until 2020, this target will be met mainly by first-generation biofuels grown on the same productive land as food crops. Within Europe, an area of around 0.2 to 0.3 million km² would be needed to produce biofuels for the 10% target endogenously with existing technologies (Eickhout et al., 2008). However, as the estimated available land towards 2020 is about 0.16 million km² (EEA, 2006), it is likely that large amounts of biofuels have to be imported.

The production potential of bio-energy is limited and uncertain

Estimates vary widely on the global potential for bio-energy production.The long-term potential could be as low as 100 to 500 EJ/yr, taking account of uncertainties in yield increase, sustainability criteria, water availability, fragile states (e.g., civil

Estimates of global bio-energy potential, 2050 **Figure 4.6**



This study envisages worldwide use of bio-energy at the lower end of the literature-range of potentials. Source: Netherlands Environmental Assessment Agency (Van Vuuren et al., 2009b). 021g_girl09

wars reducing investment opportunities) and other external factors (Dornburg et al., 2008; WBGU, 2009).

Based on integrated modelling analysis of land use and energy (Van Vuuren et al., 2009a; Van Vuuren et al., 2009b) and because of uncertainties in production potential, this study limits the use of bio-energy to the lower end of the range. This is 100 EJ/yr global bio-energy production, partly based on waste and residues, partly on specific cultivation (Figure 4.6). This could require about 3 million km² of land. For comparison, the current total EU agricultural area is approximately 2.2 million km².

Application of bio-energy must be efficient

Given the limitation in bio-energy potential and likely negative side-effects of energy-crop production, bio-energy needs to be directed strategically to applications that maximise its contribution to decreasing carbon dioxide emissions and minimise the required inputs.

Currently, biofuel seems to be one of the few feasible low-carbon or zero-carbon options for aviation, shipping and road freight before 2050. Other options, such as electricity or hydrogen, are available for passenger vehicles and urban freight transport. Thus, technology development of biofuels could best be aimed at advanced bio-diesels for shipping and trucks and bio-kerosene for aeroplanes such as FT diesel or algae-based fuels. To achieve this, the current renewable energy directive needs to be aligned with a long-term vision on transport in the EU (see Chapter 5).

Use of wood-based bio-energy in power plants with carbon capture and storage generates a double benefit in decreasing carbon dioxide emissions: a take-up by crops, followed by subsequent storage. These net 'negative emissions' facilitate high emission reductions in the power sector (Gitz et al., 2006). However, this technology also requires a well-functioning legal framework to account for the double carbon benefits.

Using bio-energy in these applications enables large carbon mitigation with a small volume of bio-energy inputs and minimal pressure on nature and food production. This requires the EU to extend bio-energy strategies with specific targeted applications. It requires a long-term vision on the application and production of bio-energy and a bio-energy directive that stimulates innovation in the direction needed for the long term.

Infrastructure development for a low-carbon energy system

The design and construction of Europe-wide networks for electricity and carbon dioxide is a long process, requiring extremely large investments. Therefore, decisions made for the short-term have to be in line with long-term targets and a timely start needs to be made.

Renewable energy resources are unevenly distributed over the continent – wind potential in northern Europe and solar potential in southern Europe. Thus, developing a Europe-wide power grid provides access to the cheapest renewable resources for all Member States and increases the use of renewable energy by reducing intermittency of supply (EWEA, 2009; Roland Berger Strategy Consultants, 2008). The maximum share of wind and solar power in a power system is limited, because these sources are by nature intermittent and the power system has to remain reliable. This constraint might already play a role if these sources contribute 20% or more. Such limits to integration of renewable energy are reached earlier in national power systems than in a larger, integrated European power grid. Therefore, large-scale penetration of renewable energy in the power system requires a more interconnected and high-capacity power grid than now exists in Europe. Such a grid would require phased development, and could start with connecting the North Sea to the continent to ramp up off-shore wind power, and interconnecting Spain and France. Moreover on the local scale, a smart grid and reliable distribution are required to manage fluctuation in decentralised production of renewable energy based on combined heat-power production, solar PV and small urban wind turbines.

Other infrastructure essential to a low-carbon energy system is a network for transport and sequestration of carbon dioxide. In the long-term, the amount of carbon dioxide to be transported might exceed the present-day distribution of natural gas. Natural gas can play a major role in a low-carbon energy system – both for electricity production with carbon capture and storage and as low-carbon option for several end-uses. In our calculations, the demand for natural gas imports roughly equals the currently planned capacity for pipeline connections to Russia, Central Asia and North Africa, and LNG imports towards 2030 and remains stable afterwards. However, the expansion of natural gas import infrastructure

is conditional on the development of carbon capture and storage technology, to prevent a carbon lock-in of the energy system.

A crucial issue is finance. It is estimated that upgrading the power grid would require an extra investment of about 1000 billion euros up until 2030 in addition to the expected 2000 billion euros needed for 'business as usual' expansion (Roland Berger Strategy Consultants, 2008). It is uncertain whether Member States would be able to raise funds for this investment, particularly in the light of the current economic crisis. As the investment capacity of the EU is also limited, consideration could be given to developing a cost recovery scheme for Europe-wide connections to electricity end-users within the EU. This would provide certainty and attract private investors to these infrastructure projects.

Policy framework for a low-carbon energy system

Global action on climate change

Transition to a European low-carbon energy system is only effective and feasible in the context of global reduction in greenhouse gas emissions. An effective global mitigation agreement involves as many countries as possible and takes into account issues such as the concerns of energy exporting countries and the energy needs of developing countries.

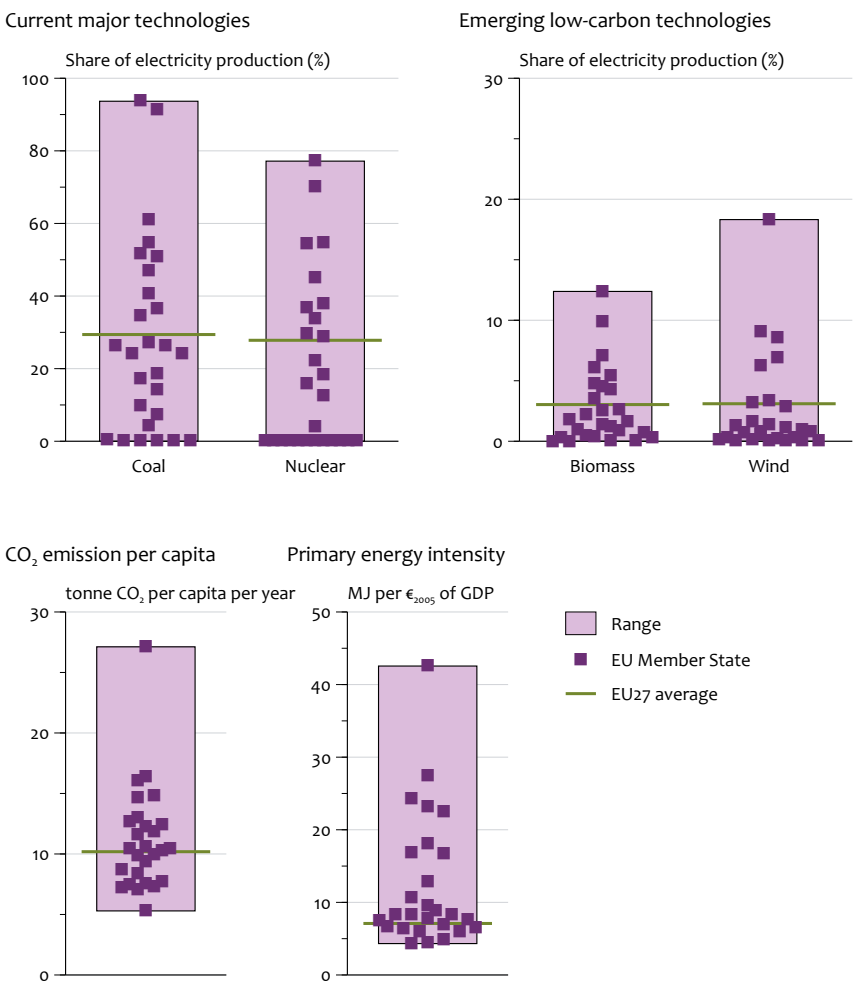
For a reasonable probability of achieving the EU climate change target of 2 ºC and limiting the costs of mitigation, early action is required (Bosetti et al., 2009). A 30% emission reduction in the EU needs to be achieved by 2020, other Annex I countries have to make a comparable effort, and developing countries reduce emissions by 15 to 30% on the baseline (Den Elzen et al., 2008b). Delay in the participation of major developing countries until 2030 would mean the 2 ºC target is no longer feasible. Many developing countries are already developing low-carbon strategies and the EU needs to stimulate that these countries join an agreement early. Therefore, financing emission reductions in developing countries by industrialised countries is essential to a meaningful climate agreement.

Common EU energy policy for a diverse EU

With the exception of renewable energy targets, there is largely no common energy policy within the EU. Current energy use varies widely between Member States (Figure 4.7 and Röller et al., 2007). Countries such as Poland and Estonia rely heavily on coal, whereas others, such as France and Lithuania, produce electricity mainly from nuclear sources. With respect to renewable energy sources, bio-energy has a considerable market share in Scandinavian countries and wind power plays a significant role in Denmark, Spain and Portugal. Annual carbon dioxide emissions vary from about 5 tonne per capita in Latvia to 27 tonne per capita in Luxembourg. The economies of Bulgaria and Romania are more energy intensive, compared to countries, such as Ireland, Denmark and the United Kingdom.

Some aspects of a European low-carbon energy system require greater coordination at EU level, while other issues can be left to the Member States. Therefore, we argue for developing and strengthening a common energy policy on those issues on which the EU can have added value or that interfere with the

Figure 4.7 **Diversity in energy systems of EU Member States, 2007**



Energy systems in Member States vary considerably but there are clusters of similarity. Data source: Eurostat, 2009. 031x_girl09

internal market. For instance, climate policy and carbon emission caps are essential to establish at EU level, but the technology choice to meet such caps can be left to the Member States. Some will choose nuclear power or carbon capture and storage, while others may prefer a fully renewable energy system.

Moreover, a continental power grid that can handle efficiently large shares of renewable energy requires EU initiative and coordination. EU legislation on the cost distribution of international infrastructure over electricity end-users and producers may help to attract private investment to these crucial infrastructure projects (Röller et al., 2007). This is especially important in view of the current economic

crisis, which is expected to limit the public investment capacity of Member States for the next decade. Finally, a EU energy policy would also have added value in increasing security of supply in negotiations with energy exporting countries on both energy imports and on climate change (De Jong, 2008).

Aligning medium-term strategy with 2050 goals
There is urgency for a long-term strategy for a low-carbon energy system in order to prevent medium-term constraints, of say 2020, determining the long-term future. For instance, every effort is needed to prevent short-term security of supply concerns leading to lock-in to coal-to-liquid solutions which are attractive as oil prices increase but which would be a barrier to reduce carbon emissions. The same is the case for coal-fired power plants without carbon capture and storage. Recent high prices for natural gas have triggered plans for 50 new coal-fired power plants in Europe (IEA, 2008b; Rosenthal, 2008), and these will still be operating in 2050. Moreover, a switch from coal to natural gas (driven by the ETS) might be attractive in achieving modest emission reductions in the short term, but without carbon capture and storage will not achieve the massive cuts needed in the long term.

Paradoxically, current climate policies focusing on cap-and-trade schemes and carbon market instruments may discourage investment in the breakthrough technologies needed for a low-carbon energy system. These technologies require a long period of R&D investment and when deployable require massive investment for large-scale application and infrastructure development. Even with built-in mechanism for tightening reduction targets in the long term, it is uncertain whether the EU Emission Trading Scheme (ETS) can contribute to such long-term investment. Carbon pricing alone is not sufficient and a complementary role can be played by non-pricing measures on R&D, public procurement, product labelling and deployment of promising technologies.

A more fundamental issue is that the transition to a low-carbon energy system will take several decades. Therefore, policy targets need to be credible and reliable in the long-term in order to generate significant investment and provoke changes in society and technology (Grubb, 2007). Confidence in long-term policy targets can be built by living up to short-term targets and by institutionalising long-term agreements and obligations. For example, an EU climate law or obligation for Member States to develop such a climate law could establish reliable long-term targets.

Trade-off and synergy between climate policy and security of supply
Policy directed to reducing carbon dioxide emissions may also benefit security of supply by reducing dependence on imported fossil energy. Examples are increasing endogenous production of renewable energy, decreasing transport sector dependence on oil, energy efficiency improvements and diversification of energy sources. The other way around, a strong focus on security of supply without due attention to climate concerns may have negative impacts on greenhouse gas emissions (Behrens, 2009). For instance, a shift from gas to coal in the power sector reduces import vulnerability but increases emissions. Diversifying infrastructure for natural gas import (new pipelines and LNG terminals) may be beneficial for both reducing greenhouse gas emissions and security of supply in the short term.

However, without investment in development of CCS technology this will lock Europe into a natural gas path that is not in line with the 80% reduction target in 2050.

4.4 Critical path to a low-carbon energy system

What actions are required in the coming decades to achieve a low-carbon energy system for the EU in 2050? Given the many slow-moving factors in the energy system, key actions in the next decade are:

Show leadership in worldwide climate agreements, organise global financing

Leadership in worldwide climate agreements requires a contribution to global *financing*, acknowledging the *needs* of developing countries and *consistent* messages to other global players by implementing a European low-carbon economy to set an example.

Stimulate acceleration in technology deployment, including the European power grid of 2050

EU coordination has added value for the development of a high-capacity high-voltage *power grid* throughout the continent and to North Africa in order to stimulate development of large-scale renewable energy. Application of *currently available* no-regret technologies, such as heat-pumps, solar-PV and wind power, needs to be stimulated. Emission *standards* need to be set for newly built power plants, a clear *target* for phasing out power plants without carbon capture and storage, and long-term targets for emissions reduction.

Stimulate a broad range of low-carbon technologies

Substantial funding for energy research needs to be provided and international R&D cooperation strengthened in a *broad range* of technologies that need further development: from small-scale renewable energy technologies to carbon capture and storage for large-scale power plants to nuclear and bio-energy.

Commit to a long-term vision on the EU energy system

Such a vision is needed to increase *long-term policy coherence* and to direct technology development and application. If emission targets are agreed on, *institutionalising* guarantees commitment over the coming decades. Such a vision needs to include a strategy for the most efficient application of *bio-energy*, the availability of which is limited – in part because its production lays additional claims on the world's land resources.

4.5 The bottom line

A low-carbon energy system can be achieved in the EU by 2050 using technologies currently identified. The initial steps have been taken in the EU energy package to increase energy savings, increase production of renewable energy, and decrease carbon dioxide emissions. However in the long term, the energy system in the EU

will need to undergo radical restructuring to make energy end-use carbon-free, and to develop a Europe-wide power grid and a power system that is low-carbon.

Market incentives alone are not sufficient to make the transition to a low-carbon energy system by 2050. Instruments such as cap-and-trade schemes are effective in achieving a gradual emission reduction. However, the development and application of breakthrough technologies needed in a low-carbon energy system depend on reliable long-term policy and command-and-control policies. In the short term, a massive investment in R&D and targets for technology deployment are essential to getting a transition process off the ground.

It is vital that the EU does not become locked into expedient short-term decisions that hamper achieving a long-term strategy for a low-carbon energy system in 2050. The choices made now will ultimately determine the energy system of 2050. In the next decades, security of energy supply remains a major concern with the risk of making the choice for coal to alleviate dependency on oil and natural gas. Such a move can be prevented with early implementation of policy measures that channel the energy system towards a low-carbon future. Such measures would include scaling up renewable energy production, mandatory carbon capture and storage, biofuel strategies, and setting challenging emission standards.

5 Transport and Mobility

A vision for 2050 is that of low-carbon transport in the EU by decreasing carbon dioxide emissions from all transport modes. Low carbon in this vision means 80% less carbon dioxide emissions (well-to-wheel) by 2050, compared to 1990 levels. This target equals the EU average decrease in greenhouse gas emissions as envisaged in this study. But it is more difficult to achieve, in view of the steep growth as projected for EU transport, without new policies. In fact, to achieve the target of 80% emission reduction relative to 1990 levels amounts to reducing emissions by almost a factor of 12 below those in the baseline scenario, by 2050.

5.1 Transport in the EU today

Transport accounts for about 7% of European GDP and for 5% of employment in the EU (EC, 2006). Although a major contributor to growth, transport also has significant societal costs including environmental costs, congestion, and traffic accidents. These costs are estimated at 4 to 7% of the GDP of the EU-15 GDP (EEA, 2006).

Transport currently accounts for a third of all final energy consumption in Member States and for more than a fifth of greenhouse gas emissions (EEA, 2009). Although carbon dioxide emissions in the EU decreased slightly between 1990 and 2006, emissions related to transport have risen by about 30% (EEA, 2009). As transport is one of the fastest growing sectors in the economy, energy consumption and greenhouse gas emissions are projected to increase significantly up to 2050. Action is needed to reduce emissions in line with climate change goals. However, the extent to which changes can be implemented depends on developments, such as low-carbon power production and advanced biofuels.

Furthermore, transport is highly vulnerable to unexpected changes in key external factors, particularly relating to energy security. Heavy reliance on fossil fuels makes transport extremely vulnerable to fluctuations in fuel price and supply.

5.2 EU transport policy in relation to climate policy

Multiple and difficult to reconcile goals

The 2006 Mid-Term Review of the Transport White Paper (EC, 2006) formulates the current objectives of EU transport policy as contributing to efficient, effective transport in the EU. The key objectives are to:

- offer a high level of mobility to people and businesses throughout the Union;
- protect the environment, ensure energy security, promote labour standards for the sector and protect passengers and citizens;
- develop and bring to market tomorrow's innovative solutions that are energy efficient, use alternative energy sources, or support mature, large intelligent transport projects;
- connect internationally, projecting the EU's policies to reinforce sustainable mobility, protection and innovation.

These objectives put transport policy at the heart of the Lisbon Strategy for growth and jobs (EC, 2006). The Lisbon Agenda states that, by 2010, the EU will become 'the most dynamic and competitive knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment'.

This is an ongoing process and has to be seen in the context of climate change, together with a slowdown in population growth, EU enlargement, and mounting economic challenge from Asia.

Commitment to emission reduction

Following the European Commission's proposals in January 2007, Member States made a commitment to reduce EU emissions by 20% by 2020, or by 30% as part of an international agreement. A commitment was also made to increase renewable energy and energy efficiency by 20%, by 2020 (see Chapter 4).

The EU has successfully negotiated with the Member States on regulations and harmonised methods for reducing greenhouse gas emissions from transport, along four lines:

- improving fuel efficiency and reducing carbon dioxide emissions from new vehicles;
- *promoting use and* production *of renewable fuels* as an alternative to fossil fuels, including a proposal, aimed at fuel suppliers, for a 10% reduction in greenhouse gas emissions produced by their fuels throughout their life-cycle (i.e. production, transport and use);
- including aviation in the EU Emission Trading System;
- stimulating R&D, innovation and education, for example, in the EU Green Car initiative, which is part of the EU economic recovery plan (EC, 2009a). It focuses on road electrification and electric cars.

Commitment to Trans-European Transport Network

The EU has an ambitious policy for the development of a Trans-European Transport Network (TEN-T) to ultimately achieve a single multimodal network that is both logistically efficient and environmental friendly. The policy aims to

provide infrastructure for the internal market to function smoothly and to meet the objectives of the Lisbon Agenda for growth and jobs (EC, 2009b). Achieving a balance between transport modes and sustainable transport was placed at the heart of the sustainable development strategy at the recent Gothenburg and Cardiff meetings. The network covers major road, rail and international waterway axes that traverse various Member States.

The 400 billion euros invested in the network, so far, have helped to complete a large number of projects interconnecting national networks. In the EU economic recovery plan (EC, 2009a), the European Commission indicated it wants to accelerate investments, launching a call for 500 million euros for TEN-T projects, leading to construction starting before the end of 2009.

TEN-T investments have, however, not been fully successful in achieving EU policy goals. Firstly, according to the TEN-T policy review (EC, 2009b), planning of the Trans-European Transport Network has not been driven by genuine European objectives, resulting from a lack of funding and sovereign responsibility by the Member States in infrastructure planning (subsidiarity). Secondly, the economic efficiency of TEN-T investment is subject to debate. The EU project TIPMAC has, for example, shown that the net economic impact of the TEN-T programme is very small in the period up to 2020. This is largely because a number of transport projects on the corridor list will have difficulties generating enough transport benefits in the next two decades (Rothengatter, 2009). Furthermore, TEN-T policy has not provided a sound basis for an effective contribution to climate change objectives.

5.3 Issues confronting EU transport today

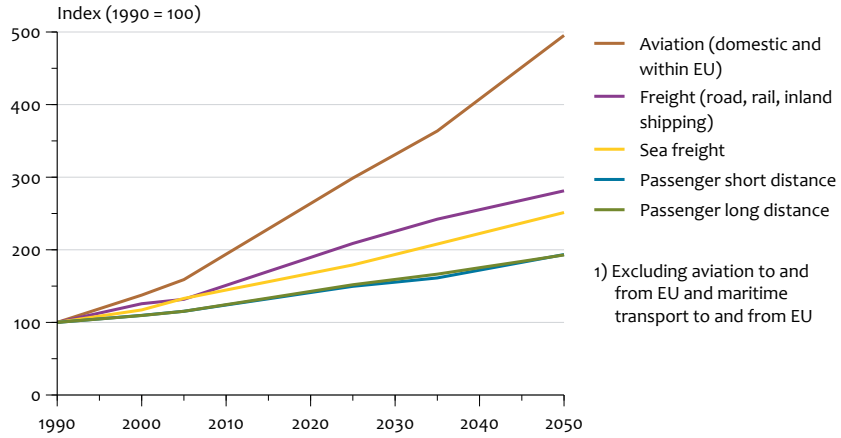
Growth is rapid in all transport modes

Passenger and freight transport have, before the economic crisis, increased year on year, as shown in Figure 5.1. Up until 2000, growth in freight transport kept pace with growth in GDP, but between 2000 and 2005 demand for transport led to substantial growth, exceeding growth in GDP. This growth reflects the substantial increase in commodity trading and especially container freight, following EU enlargement and market integration.

Scenario studies conducted before the current economic crisis show aviation and maritime transport to be the fastest growing transport modes:

- *Air passenger* kilometres are forecast to double (Petersen et al., 2009) or triple between 2005 and 2050 (Banister, 2009).
- *Maritime transport* is expected to grow substantially, with tonne kilometres increasing within and between Member States by about 90% between 2005 and 2050. Maritime transport between Member States and the rest of the world is projected to increase by 150% between 2005 and 2050 (Petersen et al., 2008). Worldwide, maritime transport is projected to grow by 150 to 300% by 2050, particularly due to container shipping, which is projected to grow by 425 to 800% by 2050 (Buhaug et al., 2008).

EU transport[1)] **Figure 5.1**



Under business as usual, volumes (as tonne km and passenger km) in all transport modes are projected to increase substantially, with air transport increasing at twice the rate of other modes. Source: Banister, 2009. 020g_girl09

- *Road freight* in the EU is forecast to increase by about 60% between 2005 and 2050, and long-distance road freight (trips longer than 150 km) to more than double (Banister, 2009).
- *Car* travel is forecast to increase up to 2050, by about 40% (Petersen et al., 2009) to 70% (Banister, 2009).
- Projections for *rail passenger* transport differ significantly, ranging from 30% (Banister, 2009) to double (Petersen et al., 2009), between 2005 and 2050.
- Growth in *rail freig*ht ranges from 25% (Banister, 2009) to treble current levels (Petersen et al., 2009).

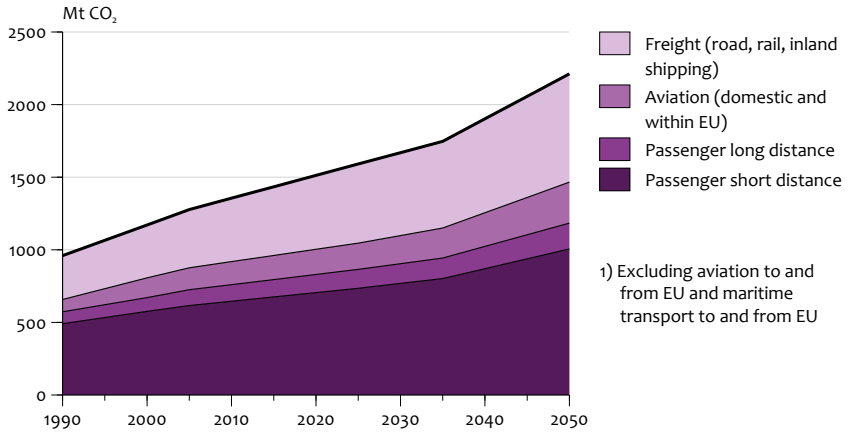
Growth in transport, particularly in freight transport, is likely to be delayed by about five years as a result of the current financial and economic crisis and subsequent moderate growth.

Transport is a fast growing contributor to climate change

Greenhouse gas emissions from transport, excluding international aviation and maritime transport, increased by 27% over the period from 1990 to 2006, compared to a reduction of 3% in emissions across all sectors (EEA, 2009).

The largest growth in carbon dioxide emissions, over the last decade, has been from international aviation and maritime shipping, which are not regulated by the Kyoto Protocol. Despite significant improvements in energy efficiency (albeit slowly diffused through the fleet), carbon dioxide emissions from international shipping will increase by 10 to 25% in 2020 and by 125 to 220% in 2050, under baseline assumptions (Buhaug et al., 2008).

Figure 5.2 **CO_2 emission EU transport[1)]**



Carbon dioxide emissions from all EU transport modes are projected to double in the baseline scenario in the period up to 2050. Source: Banister, 2009. 029g_girl09

Under the Kyoto protocol, passenger air travel outside the EU is not included in EU statistics on carbon dioxide emissions, but is five to six times larger than kilometres flown within the EU (Petersen et al., 2009). If these emissions are included, emissions from EU aviation by 2050 would be roughly equal to road freight transport in the EU. Increase in emissions from transport, excluding aviation to and from the EU and maritime transport to and from the EU, are presented in Figure 5.2.

Societal costs of transport due to climate change, congestion and noise are increasing

As well as being a major contributor to carbon dioxide emissions in the EU, transport also has significant societal costs including congestion, air pollution, and accidents. Total societal costs from transport (land-based modes, shipping and aviation) are estimated at 4 to 7% of GDP in the EU15 (EEA, 2006). The cost of climate change, congestion and noise is expected to increase in the coming decades. About 17% (21 million people) of the population of Europe's major cities (with a population of more than 250,000 inhabitants) live in areas where night-time noise levels from road transport have detrimental effects on health (EEA, 2009). Even though road transport is a major source of air pollution, emissions and related societal costs are continuing to drop as a result of EU policy (fuel standards, emission standards, and air quality standards), national policies, and local policy (such as low emissions zones). In 2006, some 43,000 people were killed and 1.7 million injured in road accidents in the EU (European Union Road Federation, 2009). This is a significant reduction on 1991 figures of 77,000 and 1.9 million, respectively. Further reductions in road accidents and related societal costs in the EU can be expected in the next decades.

Vision for low-carbon transport

The vision for 2050 is low-carbon transport, reducing carbon dioxide emissions from all transport modes. Low carbon means 80% reduction, compared to 1990 levels, of total carbon dioxide emissions (well-to-wheel) from European transport, by 2050. In many cases, measures for reducing emissions will also contribute to improving air quality.

The emission reduction target for transport is the same for all economic sectors and is directed to meeting the EU climate change target of restricting temperature increase to no more than 2 °C, compared to pre-industrial levels (see Section 4.3, Pathways to a low-carbon energy system in 2050).

This is neither a forecast nor a blueprint, but a vision of low-carbon transport in Europe in 2050. The potential emission reduction of technological measures are primarily taken from the OECD/IEA BLUE Map scenario (OECD/IEA, 2008). Under business-as-usual policies, carbon dioxide emissions more than double (Bannister, 2009; Figure 5.2). To reduce transport emissions by 80%, relative to 1990 levels, emissions in 2050 need to be reduced almost by a factor of 12.

Range of low-carbon technologies

The vision includes all transport modes – road and rail passenger travel, aviation, road freight and shipping. The reduction target is achieved by:

- *using low-carbon fuels, such as hydrogen, electric traction and biofuels;*
- *improving vehicle energy and logistic efficiency;*
- *reducing traffic volumes and shifting to more energy efficient modes, such as rail transport.*

The vision for low-carbon transport, based on 80% reduction in carbon dioxide emissions, is presented in Figure 5.3. It includes emissions outside the EU territory from aircraft and ships fuelled in the EU.

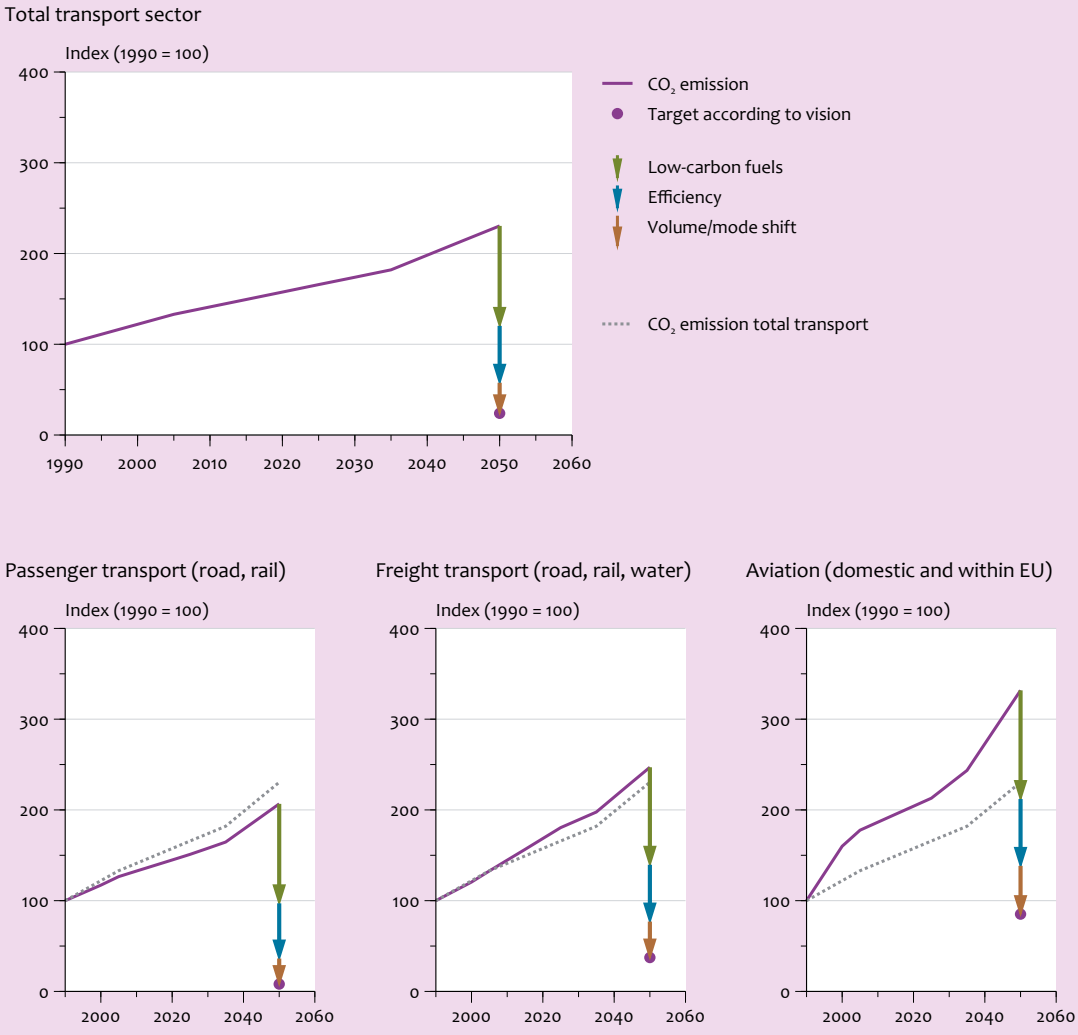
Differential emission reduction for transport modes

In achieving the 80% reduction target by 2050, reduction of carbon dioxide emissions is not the same in all transport modes. Passenger transport contributes most to the overall target. Road freight, aviation, inland shipping and maritime transport contribute less to the overall reduction target because fewer cost-effective technologies are available.

Zero-carbon road passenger vehicles

Road passenger transport reduces carbon dioxide emissions by 95%, relative to the baseline scenario in 2050 (by a factor of 20 to 25), largely by using near-zero emission vehicles and fuels. Current cars are replaced by electric vehicles and/or fuel-cell vehicles with hydrogen produced through electrolysis. Both technological routes require low-carbon or zero-carbon power generation technologies. In urban areas, people are walking more, and greater use is made of bicycles and public transport, as well as intermediate modes of transport, such as electric scooters.

Figure 5.3 **Route towards a low-carbon transport system in the EU in 2050**



To reduce carbon dioxide emissions according to the 2050 target of 80% reduction, compared to 1990 levels, EU transport has to compensate for the high projected growth in volume under baseline conditions (Bannister, 2009). In achieving this target, transport modes will contribute to different extents and with different means. *027x2_girl09*

Biofuels and improved efficiency in road freight transport

Road freight transport reduces carbon dioxide emissions by about a factor of 6, relative to the baseline scenario, by 2050, resulting from a complete shift to advanced bio-diesels and maximum improvement in vehicle energy and logistic efficiency, and, to a small extent, from mode shifts to rail freight and shipping. Changes in logistic organisations result in higher truck utilisation and fewer kilometres.

Gradual change to biofuels accompanied by modal shift

Emissions from maritime transport and aviation are reduced by a factor of 6 and 10, respectively, relative to the baseline scenario, by 2050. This is achieved by a 50 to 75% share of advanced biofuels and by a combination of technological, logistic and operational measures, including speed reductions (50 to 60% reduction in carbon dioxide emissions per vehicle km). Further emission reductions in aviation result from changes in travel behaviour. Demand for air travel is reduced and partly shifted to (electric) high-speed rail in the EU. High-speed, low-carbon rail is the main means of international passenger travel between Member States.

There is no single option to bring the emission reduction target within reach. The key elements for bringing about the 80% reduction are technological options and a reduction in transport demand, for example, through pricing mechanisms. Thus, a package of polices is essential.

5.4 Pathways to low-carbon transport in 2050

There is a wide range of low-carbon technologies moving towards commercial production or in various stages of development, that could be applied to different transport modes to reduce energy consumption and carbon dioxide emissions. Further reductions in emissions can be achieved by improving energy and logistic efficiency, and with modal shifts. As well as reducing emissions, low-carbon transport will make transport in the EU less vulnerable to volatility in oil supply and price.

Employing low-carbon technologies

Electric traction and hydrogen for passenger and urban freight

To achieve an 80% reduction in carbon dioxide emissions, near-zero carbon emission road vehicles – passenger and freight – are required, particularly for short-distance travel in urban areas. Almost complete decarbonisation of passenger road transport is technically feasible by 2050 (King, 2008). Most promising technological options are full-electric vehicles and fuel-cell vehicles, with hydrogen produced through electrolysis, for cars, buses and urban freight transport, such as urban delivery trucks, at least in the near to medium term.

However, to compete with fossil-fuel vehicles and fossil-fuel alternatives, several technological hurdles have to be overcome and the cost brought down considerably for wide-scale application. For instance, a significant hurdle to be

tackled is the development of practical and acceptable energy storage systems in these vehicles. While progress is being made, both electric and hydrogen passenger vehicles still have a long way to go in the development and commercialisation process. Commercialisation of the hydrogen cell is more problematic, largely because of the new infrastructure development required. The most likely route to making the transition from fossil fuels is gradual replacement of current fossil-fuel cars by hybrids, plug-in hybrids and then by full-electric and/or fuel-cell vehicles.

Electric and hydrogen road transport, whether full electric, (plug-in) hybrid or hydrogen fuel cell, bring additional environmental benefits. These technologies produce less noise at low speeds, reducing noise nuisance and air pollution in urban areas. Thus, low-carbon transport may trigger cleaner and quieter cities in Europe.

However, neither electricity nor hydrogen is well suited for long-distance road freight transport because of storage capacity. Hydrogen as jet fuel will require total aircraft redesign and vast changes in infrastructure (OECD/IEA, 2008). In addition, the global warming effect of increased water vapour at high altitude needs to be investigated. Fuel-cell utilisation in inland shipping has been shown to be complicated because of the large quantities of hydrogen needed and the limited on-board storage space (De Wilde et al., 2006).

Achieving low-carbon transport in the EU, in the coming decades, is closely linked with measures in the power sector, in three ways. Firstly, low-carbon electricity is required as an energy source for rail, urban transport and medium-distance transport – regardless whether electricity or hydrogen is used as an energy carrier. The consequences for the energy sector (Chapter 4) have been calculated for electricity as the main future energy carrier for urban and medium-distance transport. Yet, roughly the same amount of energy would be required to produce low-carbon electricity or hydrogen. Secondly, failure to decrease carbon dioxide emissions from transport will most likely need to be compensated in power production. Thirdly, retaining options for hydrogen as an energy carrier in transport will affect design features of the future power grid.

Biofuels for road haulage, aviation and maritime transport
Current state-of-the-art technology indicates few options for achieving substantial reduction in carbon dioxide emissions by 2050, for long distance road freight transport, shipping and aviation. Currently, some of the best options to reduce carbon dioxide emissions are advanced biofuels manufactured from a wide range of biomass sources. There is, however, a high degree of uncertainty surrounding wide-scale use of biofuels, such as second-generation and third-generation biofuels, biomass-to-liquid jet fuels, hydrogen and fuel cells (see Table 5.1.).

Further policies are needed to ensure smart use of biofuels in reducing carbon dioxide emissions across the economy. For instance, in the current EU policy framework for road transport, fuel targets carry the risk that the car users may consume too much biomass in relation to other transport modes (trucks, aviation, and shipping), as well as other sectors, such as heat and power. Thus, direct links need to be made between the EU vehicle efficiency targets and fuel targets.

There is an urgent need to prepare the way for low-carbon aviation and maritime transport by 2050. These slow changing transport modes are growing rapidly in terms of volume and emissions. Thus, every effort is needed to promote the development and adoption of low-carbon fuels for aviation and maritime transport. However, total emission reduction awaits biofuels becoming commercially available, and sufficient land becoming available for biofuel production. More information on biofuels is provided in Chapter 4: Energy and Climate Change.

Achieving emission reduction in aviation requires a shift to bio-kerosene. At present, there is no 'bio' equivalent for kerosene. An aviation biofuel has been developed and several test flights have been carried out, but without conclusive results. The European Commission has called for tenders on more research to evaluate the feasibility of these biofuels. Nevertheless, a substantial shift to bio-kerosene would achieve emission reductions in aviation (see Figure 5.3). In the OECD/IEA BLUE Map scenario, biomass-to-liquid fuels are assumed to account for 30% of aviation fuel by 2050, provided carbon prices are high enough. To achieve a reduction in carbon dioxide emissions in aviation, relative to 1990 levels, however, much higher levels of advanced biofuels will be needed, at least 50 to 75%.

Improving vehicle energy and logistic efficiency

Next to a substantial shift to biofuels, a significant contribution can be made to the near zero-carbon target by improving the technical and logistic efficiency of heavy-duty road freight vehicles. Efficiency improvements of 15 to 30% have been estimated using vehicle hybrid technologies (De Lange et al., 2008; Lensink and De Wilde, 2007; Hanschke et al., 2009). This potential is difficult to achieve for long-haul freight vehicles, because hybrid technologies are not very effective for vehicles operated at constant speed and power.

However, carbon savings can be achieved by improving logistic efficiency in road freight transport and modal shift to rail. Different logistic organisations, such as green, reverse and cooperative logistics, have great potential to increase truck utilisation and reduce truck kilometres (Rothengatter, 2009). Here, smart logistics are assumed to reduce intensity (transport input per unit of GDP) of road freight transport induced by higher fuel costs.

Logistic efficiencies to achieve maximum potential of technological and operational measures in international shipping, including speed reduction, may reduce emissions by up to 60% per tonne kilometre by 2050 (Christ, 2009; and IEA/OECD, 2008).

The BLUE Map scenario assuming a 'maximum technology' case, includes 10% improvement in technical efficiency, beyond the baseline scenario, by 2050. This represents a total improvement of 35% in fleet fuel efficiency on the current average and an additional 10% reduction in global aircraft energy use through the optimisation of operational systems. According to the UK Committee on Climate Change (2008), a production aircraft in 2025 flying in an improved operational environment can be 40 to 50% more fuel efficient than a new production aircraft flying in a 2006 operational environment. However, because of the long lifetime of aircraft, the potential reduction in carbon dioxide emissions is modest.

Cutting traffic volumes and shifting transport modes

Technology alone will not be sufficient to achieve an 80% reduction in carbon dioxide emissions from transport by 2050. Low-carbon transport requires full engagement and participation of all stakeholders to bring about changes in behaviour. It will also be necessary to reduce demand for transport and to stimulate a modal shift in both passenger and freight transport. This is particularly the case if European emissions include transport emissions caused by EU residents outside EU territory.

Thus, changing consumer preferences is an essential element in achieving a low-carbon transport. Changes in transport volume and mode shifts are assumed to contribute about 15% to the emission reduction target. This involves reducing short-distance passenger travel and long-distance passenger and freight transport, particularly air travel. For instance, reducing car use in urban areas for short distances requires a shift to non-motorised and public transport, and would need to achieve as much as a 20% reduction in car use in urban areas (see Figure 5.3).

Even with optimistic assumptions on energy efficiency improvements and use of advanced biofuels, significant reductions in air travel growth are needed in order to reduce carbon dioxide emissions from aviation to below 1990 levels. Here, growth is assumed to decrease from a forecast tripling of air passenger kilometres between 2005 and 2050, to a doubling or less.

Pricing is a key factor in bringing about change. Demand for air travel can be reduced by eliminating all subsidies and introducing taxes and charges and/or including aviation in a global carbon trading system which results in sufficiently high carbon prices (e.g., all permits are auctioned, and the cap is progressively lowered by reducing the amount of permits auctioned each period). Also, growth in air travel will partly be curtailed by higher fuel prices based on a higher share of bio-kerosene which is likely to remain more expensive than jet fuel. In addition, incentives are needed to partly shift passenger air travel to high-speed rail between European cities.

Re-aligning infrastructure development

Currently, a significant proportion of the EU budget goes to co-financing investment in Trans-European Transport networks (TEN-T). The overall cost of 28 priority projects is about 400 billion euros, 270 billion of which euros has yet to be invested. The TEN-T policy could contribute more to reducing carbon dioxide emissions and thus to EU climate change objectives if co-financing focused on projects with a proven economic rationale and with environmental benefits.

In this respect, more attention needs to be given to stimulating electric public transport. Investments in electrified high-speed rail, serving as a substitute for air travel, will help achieving low-carbon transport provided the power is produced from low-carbon fuel sources and seat occupancy levels are high enough. To achieve significant shifts from road to rail transport, at least 10% of projected investment in road infrastructure should go to rail infrastructure (Rothengatter, 2009).

Examples of carbon dioxide mitigation options in transport **Table 5.1**

Carbon dioxide emission reduction potential	Uncertainty in potential, costs or side-effects	
	Small to moderate	**Moderate to large**
Small to moderate	Current carbon dioxide efficiency standards	First-generation biofuels (ethanol, bio-diesel)
	Pricing measures, e.g. ETS for aviation and shipping, EU-wide road pricing for trucks.	Current commercial jet biofuels
	Energy efficiency measures for road freight, shipping, aviation	
	Logistical efficiency measures, e.g. green logistics	
	Land-use planning	
Moderate to large	Plug-in hybrid cars Heavy oil biofuel substitutes for inland shipping and maritime transport	Full electric cars Fuel-cell hydrogen road vehicles
		Second-generation biofuels for road vehicles (ethanol, bio-diesel)
		Second-generation and third-generation jet biofuels
		Biomass-to-liquid biofuels with carbon capture and storage

Examples of carbon dioxide mitigation options clustered by emission reduction potential and uncertainty in potential, costs and/or side effects.

Balancing potential and uncertainty of mitigation options in transport

To achieve an 80% reduction in carbon dioxide emissions in transport by 2050, relative to 1990 levels, new solutions are needed. Continuous incremental technological improvements can provide substantial emission reductions but are not sufficient. However, the potential emission decrease from new policies and technological options is more uncertain than from existing policies and from incremental technological changes. From a strategic point of view to reach the vision of 2050, options can be clustered according to their potential emission reduction and the degree of uncertainty in emission reduction potential, the costs, or the side-effects. As illustrated with some examples in Table 5.1, there are:

- a range of technology options that may deliver large-scale emission reductions over time, but are associated with a high degree of uncertainty, such as second-generation and third-generation biofuels, biomass-to-liquid jet fuels, hydrogen and fuel cells. These technologies require further technical progress leading to performance improvement and cost reduction, and also require radical changes in areas such as vehicle production, fuel supply and agricultural systems. Supporting innovation for these technologies, support from EU and Member States for relevant R&D projects, and effective carbon pricing policies will be crucial.
- options that have a low emission reduction potential and a low degree of uncertainty in technology or cost. Uptake of these technologies may lead to a small increase in vehicle or transport prices which may be offset by fuel savings. These technologies and measures are considered 'no-regret' measures for the EU on the way to low-carbon transport. They include carbon dioxide standards

for new vehicles, energy efficiency measures, ETS for international aviation and shipping, EU-wide road pricing schemes, and land-use planning.

- technologies and policy measures that have a high emission reduction potential and a low degree of uncertainty in technology or costs. In these cases, industry and consumers will have to accept the cost in order to benefit from reduction in carbon dioxide emissions. This is the case for biofuels substitutes in heavy-duty vehicles and shipping. Use of biofuels (essentially FAME or bio-crude) in the maritime transport and heavy-duty road vehicles does not pose any fundamental or insurmountable technology challenges. The key barriers to biofuels are economic rather than technical, particularly for biofuels replacing marine diesel fuel (AEA, 2007; Christ, 2009).
- first-generation biofuels that have low potential for emission reduction and major side-effects (see Chapter 4.3). For instance, commercial jet biofuels have low and uncertain reduction potential and thus should not be pursued by the EU.

5.5 Critical path to low-carbon transport

Achieving low-carbon transport in 2050 requires policy action in the coming decade, to set transport into the right lane to achieve this goal, because of the long lifespan of vessels and aircraft, many of which in operation today will still be operative in 2050. There is no single option to bring the emission reduction target within reach. The key elements to bring about the 80% decrease are technological options and a reduction of the increase in transport demand, for example, through pricing mechanisms. Thus, a package of polices is essential. The following steps are on the critical path to achieving this vision.

Take leadership in allocating responsibilities

A long-term policy framework to decrease carbon dioxide emissions from transport will provide stakeholders with a degree of certainty about carbon reduction in relation to other objectives. In this respect, EU needs to take leadership in allocating responsibilities to vehicle manufacturers, fuel companies and consumers. It also needs to enforce accountability and put in place policies and frameworks to allow and enable others to fulfil their roles.

Take leadership in action on maritime and aviation transport

The EU needs to take a leadership role to achieve international agreements for reducing emissions from aviation and shipping. A global strategy is the most effective, but also the most difficult approach in reducing emissions from these transport modes. It involves including international aviation and maritime transport in an emission trading scheme with the objective to tighten targets over time and to allocate rights through auction and not allocation. It would mean a more effective emission trading scheme than the current EU-wide scheme, and would also include shipping. If a global trading system is not possible, then an effective EU-wide scheme needs to be in place.

Support R&D to enable diversity of technology

A great deal of R&D is being done in the private sector and EU initiatives are needed to strengthen efforts to identify emerging and promising technology, such

as batteries and other energy storage technologies. Support is needed to bring these technologies to market (OECD/IEA, 2008). In this respect, partnerships with vehicle manufacturers may be particularly useful, giving them a stake in developing and commercialising new technologies. In addition, substantial R&D needs to be stimulated and financed on bio-kerosene (third-generation biofuels).

Furthermore, effective carbon pricing is needed to support innovative low-carbon transport technologies, such as biofuels for heavy-duty road transport and maritime transport. This approach will yield new technologies that could become future standards in developing countries and in transition countries which are having difficulties in meeting low-carbon goals.

Align transport and energy policies

The EU needs to formulate a coherent policy on achieving low-carbon transport, addressing the risks, vulnerability, security and resilience associated with diversified energy carriers for transport in Europe. This policy should become the basis for an integrated EU approach to both transport and energy aimed at facilitating transition to production of advanced vehicles and low-carbon energy carriers.

On the critical path to low-carbon urban transport is a sufficient supply of clean power after 2030, as well as a host of standardisation issues. Because of the slow pace of change where major infrastructure investment is involved, decarbonising the energy sector needs to be even higher on the agenda than is development of low-carbon vehicle technologies.

Develop long-term, EU-wide strategy for biofuel allocation

With restricted worldwide capacity for biomass production, biofuels need to be concentrated in those transport modes where they can contribute most to mitigating carbon dioxide emissions, and where no other options are available. For instance, advanced biofuels offer potential for reducing emissions from long-distance road freight transport, shipping and aviation, where significant alternative energy carriers are not available. Thus, a long-term and EU-wide strategy is needed to achieve cost-effective allocation of biofuels for energy and transport.

The cost-effectiveness of EU policies can be improved by closely linking current biofuel targets with EU vehicle efficiency targets. This could be achieved by establishing a carbon-intensity obligation for all fuels, such as in the California's Low Carbon Fuel Standard where carbon-intensity of fuels is reduced through a system of tradable credits, also applicable to biofuels. EU could also set up a wider road transport obligation which links carbon intensity of fuels to vehicle efficiency, possibly through tradable credits. Ultimately, road transport could be covered by a 'cap and trade' scheme such as the current ETS.

Link TEN-T development more closely with climate goals

Given the size of allocated budgets for Trans-European transport infrastructure, revising TEN-T transport policies is a priority in the short term. Infrastructure built in the coming decade will still be operational in 2050 and beyond. A key issue is to provide a stronger link between TEN-T policy planning, development and climate goals, as proposed in the Green Paper on future TEN-T policy. The implication is

that the EU would co-finance only those projects with a proven economic rationale and with environmental benefits, thus shifting investment from road to rail infrastructure.

5.6 The bottom line

Low-carbon transport presented in the vision for 2050 significantly reduces carbon dioxide emissions from transport, makes EU transport systems better able to adapt to future changes in energy supply and climate, improves robustness and resilience and increases long-term competitiveness of the EU economy. It will also trigger cleaner and quieter cities in Europe. A decarbonised energy sector and international agreements in shipping and aviation are crucial.

The current economic crisis is affecting transport more than most other activities, and this creates opportunity for changing business models and for the emergence of a new long economic cycle with different dynamics. But as yet, this is not substantiated. Given the longevity of transport infrastructure and spatial patterns, betting on the benign effects of such a paradigm is a risky strategy. Setting incentives to adjust transport to a long-term sustainability path is crucial, for instance, to reduce the transport intensity of freight transport.

The current economic crisis offers opportunities for stimulus spending in transport, such as the scrap premium now implemented in many Member States and also infrastructure investment. However, such stimulus measures are short term. Rather than pushing investment in a crisis phase, a long-term sustainability strategy for infrastructure development is needed, because infrastructure built in the coming decade will still be operational in 2050.

Considerable doubt remains whether a sufficient decrease in carbon dioxide emissions from transport is feasible without a broad, frontal approach to achieve policy coherence, EU-wide. Such doubts are generated by the feasibility of carbon reduction options, projected steep growth in transport demand – passenger and freight transport – and the scarcity of evidence that this trend can be reversed at the level of the economy as a whole. Thus, establishing a broadly supported ambition to achieve low carbon transport is on the critical path, including leadership to allocate responsibilities to vehicle manufacturers, fuel companies and consumers. It also needs to enforce clear accountability and put in place the policies and frameworks to allow and enable others to fulfil their roles.

6 Common Challenges for EU Policy Making

6.1 Introduction

Some of the overarching issues and conditions at EU level that will influence achievement of the 2050 visions presented in this study are addressed. Key issues on the critical path in the coming five years include an ambitious global climate policy, extensive research and development on low-carbon transport, strengthening trans-European transport and energy networks, developing global arrangements to protect biodiversity, and restructuring the common agricultural policy. These issues demand dialogues with a long-term perspective within and beyond the EU to overcome controversies about use of bio-energy, the global food system in relation to land and water resources, investment in infrastructure, and sustainable consumption and production policies.

The pathways to realize the long-term visions require EU action in the near future. The EU is a major global player in the economic and political arena and potentially provide substantial added value to the ecological and social debate. The challenge for the EU is to gain the mandate of the Member States for policy action at European level and to define a new direction for the 'common European project', in the spirit of Schumann and Monet. However, the way forward is currently hampered by Euro-sceptic criticism and prolonged debate on the Lisbon treaty.

This study has considered how the EU can accelerate achievement of the 2050 visions within the mandate of the Lisbon Treaty, assuming this treaty will enter into force. We further argue that where necessary the EU should not hesitant to debate institutional reform beyond this treaty.

6.2 Common challenges

A long-term strategy needs to be based on an integrated assessment that takes account of the linkages between the crucial themes of land resources, energy, and transport.

Investments and policy choices made or not made in the next four to five years will affect the world in 2050. For instance, infrastructure for transport and energy has long lead times in design and construction as well as a long operational life.

Likewise, power stations and houses designed and constructed in the next few years are likely to be still standing and operating in 2050.

Also, policies and institutional arrangements crucial to achieving the 2050 visions, such as reform of the common agricultural policy and global agreements for climate and biodiversity protection, take a long time to shape and to implement. Similarly, improvements in eco-efficiency, for example in crop production and energy use, and behavioural changes tend to evolve gradually on European and global scale.

Loosing room to manoeuvre to cope with the unexpected

The visions for 2050 suggest a portfolio of measures and investment options to achieve long-term objectives. A strategic notion taking shape in the three themes is that creating diversity is an effective strategy for dealing with risks and that room to manoeuvre is increasingly limited. What is more, the process of resource allocation needed to be guided at a macro level. If not, then valuable resources are likely to be used for activities for which viable alternatives are available to the detriment of social activities for which alternatives are not available. For example, this study shows that bio-energy is limited and would most effectively be used for heavy transport systems and biomass-based electricity production with carbon capture and storage (CCS). This requires readjustment of current EU policies that are geared to using bio-energy for cars and trucks.

Preventing 'lock in' to interim solutions that become dead ends

Key issues on the critical path to 2050 are the constraints of interim solutions. For example, when considered in isolation, energy security for the 2020-2030 period could lead to investment in low-cost coal and gas-based technology without carbon capture. Such investments are incompatible with a low-carbon economy by 2050.

Preparing to accelerate technology deployment by 2020-2030

This study specifies a vision for tomorrow in terms of technologies that are identifiable today, including those now used on a modest scale, such as satellite-controlled irrigation or electric motorbikes. If these technologies are to play a significant role in 2050, implementation has to be stepped up considerably between 2020 and 2030. This, in turn, requires extensive effort in up-scaling, training, decisions on test locations, involving citizens and triggering further development of new technologies.

A case in point is CCS, which is prominent as a cost-effective option in the projections made in this study. To achieve the technology mix projected in the 2050 vision for the EU energy system, no fossil-fuel based power plant should be constructed without CCS technology in the EU after 2025. The implication is that CCS needs to be operational by 2020 for which an EU regulatory framework needs to be in place as soon as possible. Part of this framework is provided in the current CCS directive (European Union, 2009). However, in order to achieve the policy goals, the directive needs to contain additional provisions such as minimum requirements for the technical installations and either direct or indirect phasing out schedule for the construction of fossil-fuel based electricity plants without CCS.

Identifying specific cases for EU arrangements

Achieving the 2050 vision for a dynamic, resource-efficient and low-carbon EU requires supranational collaboration within the EU, and between the EU and the rest of the world. In this respect, the EU has a specific role to play in:

- Negotiating common regulatory standards to maintain a level playing field for business and industry that is essential to triggering a system change;
- Developing long-term, secure investment frameworks, which is beyond the scope of individual Member States;
- Planning on European scale for future infrastructure such as the electricity grid and transport networks;
- Negotiating on global issues on the basis of a consolidated EU position.

6.3 Dealing with uncertainty and the unexpected

Long-term strategies for 2050 require not only strategies for *getting* into the right lane, but also for dealing with changing perspectives and with unexpected shocks and events. Thus, strategies are also required for *staying* or *getting back* into the right lane along the way. Several ways are suggested for enhancing capacity to deal with the unexpected on the road to 2050.

While less clear cut in terms of policy application, these ways of enhancing capacity to deal with the unexpected represent the cutting edge of analysis on the interdependency of social and economic systems. (Walker et al., 2009; Fischer et al., 2009). They are in part based on the large worldwide assessments that inspired this study.

Maintaining diversity to provide alternatives

Short–term efficiency is often enhanced by focusing on the most cost-effective option ('allocative efficiency': Rothengatter, 2009). In agriculture, for example, this leads to a focus on a few high-yielding crop varieties and livestock breeds. The subsequent loss of agro-diversity across and within species increases vulnerability to disease and can have massive impacts on food security (Heal et al., 2004).

Investment in a single option means few alternatives on which to fall back when unexpected changes or obstacles are encountered. A diversity of energy sources helps to increase security of supply thus diminishing vulnerability to disruptions in a single supply chain. Also, investing in several options for decarbonising motorised transport may help to overcome unexpected technological obstacles.

However, there are trade-offs between efficiency and diversity. Although difficult, it is essential to find a balance between the shorter-term competitive need for efficiency and the longer-term need to maintain diversity to deal with unexpected events. In this sense, the diversity of natural conditions, values, practices and cultures within and between Member States is a strength that should be nurtured.

Creating buffer capacity to deal with the unexpected

Buffer capacity provides manoeuvring space to deal with the unexpected. For instance, the spikes in 2007/2008 food prices may have been less severe

if global stock piles of staple cereals had not been run down. The decision by the International Energy Agency (IEA) to release strategic oil reserves was very effective in dealing with supply disruptions caused by Katrina in 2006. In a longer time perspective, strategies to lower energy demand can postpone depletion of non-renewable resources. This helps to "buy time" for developing and installing more sustainable energy production technology, as CCS can also do.

Managing regional and global connectivity to reduce risks

Increased connectivity, for instance in the form of global trade networks, can enhance ability of societies to deal with shocks, such as droughts that affect food supply, but currently often increases the vulnerability of Europe's trading partners. Moreover, increased connectivity increases the possibility that shocks will spread, such as the SARS virus outbreak or the effects of the present credit crisis.

A key issue for biodiversity and agriculture is the potential for disease and invasive organisms to spread in a world highly connected via intercontinental shipping and air freight. Yet, connectivity of natural areas can contribute to maintaining biodiversity and to strengthening the robustness of protected areas. An example of regional connectivity is the import of renewable sources of energy from neighbouring regions that increases energy security in the EU.

Encouraging learning and innovation to find the right lanes to 2050

The 2050 visions are a guide long-term strategic development. However, in practice the path to the visions will have to be found as we proceed. This requires continual learning and innovation to find ways to make transitions in all areas discussed in this report.

Within the EU, different types of policy instruments and incentive schemes could be tried to determine what works well under specific conditions, for example, finding effective approaches to stimulate uptake of renewable energy technologies. At EU level, the open method of coordination provides an institutional arrangement for Member States to learn from one another and to match solutions to local situations. The optimal coordination level, whether EU or Member State, will vary for different issues and may change with time, thus requiring continuous evaluation.

6.4 Strengthening the EU role in the world

Achieving the 2050 visions requires an increasingly global effort and the EU to play a critical role in this process. Yet, it is often observed that the EU has not been able to realise its full potential in international forums. The following options are considered for strengthening the EU's role on the world stage to achieve the 2050 visions.

EU leadership can make a difference

The EU has demonstrated a leadership role in climate change (Oberthür and Roche-Kelley, 2008), and could strive for a similar role in poverty reduction in relation to

biodiversity and ecosystem services, and in international transport in mitigation of climate change.

The EU approach is usually to seek multilateral solutions through the UN and Bretton Wood institutions, organisations that are currently under pressure to improve their capacity to deliver. The Member States are currently overrepresented in international organisations, notably the UN Security Council, IMF and World Bank. A single seat for the EU in these organisations may become a reality in the light of the likely reduced economic role for the EU in the international system in a 2050 perspective.

The EU could seek new and strengthened coalitions. Showing generosity to emerging and developing countries is likely to help the EU in building alliances with these economies. In return for giving up overrepresentation in the short term, the EU could ask for meaningful commitment in international climate negotiations, in greening the WTO, and in strengthening the United Nations Environment Programme.

EU external policies require further political alignment

Despite progress in recent years, EU external policies are not well aligned with environmental and social objectives. Such alignment is required for effective use of EU external power and for maintaining international credibility. Although EU citizens and politicians regularly proclaim the importance of social and environmental objectives, other objectives are often prioritised in political decisions, such as short-term economic or sectoral interests. Therefore, political debate and ownership of long-term visions is needed in specific policy areas such as transport, energy and agriculture.

Another issue in EU foreign policy is the extent to which Member States are willing to pursue more integrated policies relevant to achieving the 2050 vision by placing EU policy domains in a joint long-term perspective. These policy domains include development cooperation for agriculture, payment for biodiversity and greening trade.

Other countries expect the EU to operate as a bloc in international negotiations as is the case in trade negotiations. However in practice, coordination of Member State positions and joint external representation is often cumbersome. The EU ability to promote its objectives beyond its borders is undermined by the different modes of external representation in various policy domains. Formulating international policy priorities often requires decision-making by consensus, which has become a real stumbling bloc since the enlargement to 27 Member States. To achieve the transitions described in the visions, Member States need to commit to strengthened and coherent EU external representation that convincingly speaks with one voice.

EU policies can initiate global social and environmental standards

Experience shows that the EU can initiate environmental standards beyond its geographical remit. This has happened, for example, with air pollution standards for cars and energy efficiency of consumer appliances. This market power can be

used to the full in the coming decade, after which the EU is likely to become one of several large economic players in the world and will have less influence in the global market. Furthermore, the EU could aim to gradually convert voluntary agreements and private sector initiatives, such as on palm oil and illegal logging, into legally binding international commitments. Other opportunities include joint standards, for example, for electric vehicles, technology sharing, investing in education and research, and shared monitoring in relation to sustainable development – open access to data.

Global resources and funding need scaling up

Member States contribute significantly to international environment and development policies. However, financial contributions are not sufficient to achieve the 2050 visions worldwide. To raise the finance, more use could be made of innovative finance mechanisms, such as the Clean Development Mechanism (CDM). Although its contribution to sustainable development is contested, the CDM has led to private sector investment in carbon reduction initiatives in developing countries. Furthermore, the 2% levy on CDM transactions has created a fund for adaptation to climate change in developing countries that does not depend on voluntary contributions. Another potential source of revenue is pricing of international transport by taxation on kerosene and bunker fuels. However, such measures have encountered opposition and thus require carefully prepared international dialogue, which the EU could initiate.

6.5 Adjusting EU internal governance structures

The 2050 visions will work only if seen as a common project of the Member States; a common project that bridges the cultural and economic differences in the EU and that enhances cohesion. To this end, there are several options to adjust EU internal governance structures.

Strengthening EU decision making powers in key areas

Analysis of the issues has shown that EU leadership in some areas will require the transfer to Brussels of legislative and coordination powers on specific issues. This is the case, for example, in developing a European electricity grid, for which the EU can provide coordination and play a role in providing a reliable, long-term investment framework. With respect to establishing trans-European networks for energy and transport, current efforts are insufficient to strengthen interconnection between Member States and strategic regions. This too, also suggests a stronger role for the EU.

This process is underway to some extent with the provisions of the Lisbon Treaty illustrating the increasing importance attached to European cooperation, for example, in climate change and energy. This is not to suggest that the EU level is by definition the most effective to address policy issues. Achieving the 2050 visions also implies action by the Member States.

Improving EU policy coherence

Achieving environmental policy objectives depends on activities in other policy domains, such as energy, agriculture and transport. Thus, coherent policies to achieve the 2050 visions require not only high level political commitment and backing, but also strategic choices about the allocation of administrative capacities and responsibilities. Combining climate and energy capacities in the Commission is likely to lead to further integration of these policy areas. However, some may be concerned that this action will dilute attention to climate change and environmental policy in other areas, such as external relations, transport and agriculture.

Many practical opportunities exist to further integrate EU external objectives on environment and poverty reduction into EU policies such as aid, trade and security. The EU has started to integrate climate change objectives into its development cooperation policies. Similar initiatives could be considered in issues, such as integrating biodiversity and ecosystem goods and services into development policies. More consideration needs to be given to the effects of the Common Agricultural Policy, and of EU policies on biofuels and GMOs on food production and biodiversity in other countries. A mechanism to improve policy coherence is the Impact Assessment, in which greater attention needs to be given to the external impact of EU policies.

Developing EU instruments for long-term policy

Large-scale investment to accelerate deployment of breakthrough technologies requires ambitious, coherent and reliable policy. In this respect, the EU has done well by agreeing the climate and energy package in 2008, which sets out legally binding targets for 2020. In light of the tremendous challenges beyond 2020, the issue is whether current policy instruments are sufficient to achieve the 2050 visions. The ETS alone, for example, may not achieve the transition to low carbon energy (Henningsen, 2008). Direct support and more funds for innovation are required as well as longer term targets for 2030 and 2040 to pave the way towards 2050. Policy frameworks, therefore, need to be designed to trigger substantive innovation and deployment, and to avoid investment in the 'wrong' technologies.

The challenge is to prepare for scaling up deployment of new technologies and to accelerate change across the board. Options include investing in energy efficiency and renewable energy, strengthening sustainability criteria in the disbursement of structural and agricultural funds, debt for nature swaps, and regional bodies to deal with tightly linked local eco-system issues such as river basins.

Securing a route to investment

A stumbling block in all three themes is funding. The current EU budget is too small to enable redistributive policies and large-scale incentive schemes. Funds can be considered substantial only in agriculture and regional policy, with research and development catching up slowly. More resources are required to speed up the transition to a sustainable economy, but there is little support in the Member States for expansion of the EU budget.

The EU could concentrate on providing a reliable long-term policy framework to stimulate investment in for example the electricity and transport networks on a continental scale and to facilitate cost recovery. With regard to current EU budgets, both allocation of funds and disbursement criteria could be geared to more sustainable energy production and consumption, use of global land resources, and transport.

Improved coordination of national resources could yield benefits as well. This is particularly relevant for infrastructure where about 70% of funds are allocated by Member States with little attention to cross-border interconnection. Another area is reform of agricultural policy and budget. This provides opportunities for a more sustainable direction for land use and biodiversity. It needs to be backed by the European Parliament, which will obtain more powers over the agricultural parts of the EU budget and over agricultural policy when the Lisbon treaty enters into force. Spending criteria could be widened to give more attention to provision of ecosystem goods and services.

Another budget-related issue requiring attention is taxation. Member States retain veto over decisions on tax measures. Earlier attempts to introduce an energy tax in the EU were unsuccessful. It may be necessary to re-consider taxation measures, for instance to discourage use of unsustainable energy sources or transport means in order to provide sufficient incentives to achieve the 2050 visions. This is a politically sensitive issue.

All in all, consistent long-term regulation remains the EU's key policy instrument.

6.6 The EU and changing consumption patterns

In achieving the 2050 visions not only technology improvements are needed, but also attention to the demand side is required. For example, manufacturing systems tend to increase transport demand by operating logistic systems such as just-in-time delivery and by conducting manufacturing phases at different locations sometimes at considerable distances apart. But the discussion here focuses on consumer behaviour and a potential role for the EU in influencing consumer behaviour in the period up to 2050. The most closely related EU policies in this respect are Sustainable Production and Consumption (European Commission, 2008) and the upcoming review of the Sustainable Development Strategy (European Commision, 2009).

Changing consumption crucial in reaching the visions

Global and EU demand for land resources, energy and mobility have increased considerably in the last few decades, when EU imports are taken into account. While new technologies have made global production and consumption considerably more efficient, they have not been sufficient to prevent a net increase in land conversion and greenhouse gas emissions.

This trend is further strengthened by changes in consumption as affluence increases bringing increased demand for electric appliances, red meat and heavier

cars. Based on past and expected trends, consumption cannot continue unlimited and unregulated. Continuing growth in demand erodes and even can even undo the effect of ambitious policy. Thus, consumption patterns are another crucial element on the pathways to the 2050 visions. Whether the EU is to play a role in changing consumption patterns is a political decision and to be considered in the light of the principle of subsidiarity and considering the EU's limited legitimacy basis.

Raising awareness is not sufficient

Raising consumer awareness, for example through eco-labelling of the external implications of individual resource consumption, has not been sufficient to substantially reduce global climate change and biodiversity loss. While EU citizens consider tackle issues of sustainable development to be important, they do not act accordingly as individual consumers. Individual behaviour is difficult to change in the face of general trends in consumption. A survey in six Member States indicated that citizens expect governments to take measures to resolve this social dilemma (MNP, 2007). Although raising awareness alone will not be enough to change consumption patterns, awareness of the urgency of the problems is a key precondition for acceptance of government measures, such as a ban on incandescent light bulbs and higher taxes on the carbon content of fuels.

Another issue is that raising prices of meat or fuel has only limited effect in high-income countries because these items are a small proportion of total household expenditure and political support is lacking. As directly influencing consumption patterns and lifestyle changes is a sensitive issue, the more practical route is to influence consumer choices indirectly. For example, by setting product standards and taking into account the whole production chain.

The EU has opportunities to set product standards

The EU can widen and sharpen standards for a broad range of products. The effect is most likely also be felt beyond the EU because of its market power as an importer. Recent examples are televisions and emission criteria for cars. Recent strict EU standards for televisions will very likely mean that large plasma screens vanish from the market.

One step further is to ban non-efficient products. Whereas product standards would, for example, allow electric Hummers on the EU market, an EU ban would not. Restricting supply is accepted in several areas, for instance, the ban on softening agents in children's toys and the regulated admission of medicines to the EU market. Analogously to these examples, specific products with a major impact on climate or biodiversity could be banned or discouraged, and alternatives favourable to climate and biodiversity stimulated or made mandatory. However, the question remains how far can and is the EU willing to restrict individual consumer choice in favour of collective goods such as climate and biodiversity.

6.7 Investment in green recovery

The current economic crisis dominates the policy agenda, but climate, food and energy crises are never far away. Projected drops in emissions, mobility and

commodity prices due to the crisis are expected to be temporary. Wise policy strategies mean addressing the economic crisis with measures that support or at least not to compromise sustainable long-term environmentally friendly growth (OECD, 2009). For instance, in a stimulus package, infrastructure that locks in a pattern of high greenhouse gas emissions for many years to come should be avoided. Such measures increase difficulties in future emission reductions and blunt incentives for technological improvement and innovation (Bowen et al., 2009). In fact, discourse is emerging that combines thinking about solutions to the economic crisis and adjustments to face long-term challenges on environment and resource use.

The current economic contraction and the interest of Member States in kick-starting a worldwide recovery present opportunities to tackle long-term economic and environmental challenges simultaneously (Stern and Edenhofer, 2009). With an appropriate mix of policies, action to tackle climate change can be a central component of a fiscal package designed to curb the economic slowdown. A 'green' fiscal stimulus can be more effective in the long-term, building the foundations for sustainable, strong growth in the future rather than unsustainable bubbles.

The IMF has suggested (in December 2008) that the G20 could undertake collectively fiscal expansion of 2% of annual GDP very soon. Bowen et al. (2009) added that a 'green' stimulus of 20% of the total would be appropriate. In addition, the United Nations Environmental Programme has forcefully argued for a Global Green Deal (Barbier, 2009; UNEP, 2009). Their plea is to invest 1% of global GDP in green infrastructure.

According to the Schumpetarian view, a crisis can open up old routines, break old trends and start development of new structures. Even though most stimulus packages were settled in the first half of 2009, the economic compass will have to be adjusted in the coming years. Policies to stabilise the financial system and actions to stimulate short-term demand have to be accompanied by policies to strengthen long-term sustainable growth.

Innovation policies aim at strengthening the economic structure of economies and thus reinforcing the potential for long-term economic growth. Reforms aimed at strengthening innovation in the context of broader reforms to address the crisis can help countries emerge stronger from the crisis and help put them on a more sustainable growth path (OECD, 2009). The revision of the Lisbon strategy and the review of the EU Sustainable Development Strategy can play a role in this.

Pointing the way forward

An effective fiscal stimulus is targeted, timely and temporary (IFS, 2008; Summers, 2009). Promising investment in a green recovery include thermal insulation in the residential sector; infrastructure for public transport and a smart electric grid); and more R&D on renewable technologies.

While recognising the need to invest in a diversity of solutions, cost effectiveness of policies is a crucial consideration. For example, the OECD indicates that current bio-energy policies in some countries may cost more than $1000 per tonne of carbon

dioxide emissions saved. Highly successful car scrappage schemes, such as 'cash-for-clunkers' in the USA, may offer environmental benefits. However, the 'cost per tonne of carbon dioxide saved' is way off the scale and from a climate perspective the money would be better spent elsewhere to reduce emissions. The World Resources Institute (WRI, 2009) suggests the US scheme costs about $500 for each tonne of carbon eliminated. With strained government budgets, cost-effective policies are required more than ever.

In times of growing budget deficits, increased government spending will be more difficult to achieve. An effective policy package to restructure the economy in a sustainable direction requires more than fiscal measures. A powerful instrument is regulation. One example is scope for greening taxes, for instance, reform of energy taxes based on the carbon content. This would make coal-based electricity more expensive than gas-fuelled electricity. In a similar vein, perverse energy subsidies should be removed.

As prices in the short-term do not reflect scarcities in the medium term (for instance, energy), governments need to adopt a medium-term perspective in their recovery plans (OECD, 2009). An example is the recent sharp decline of permit prices in the European Emission Trading System (ETS). If this were the only government signal, it would not be sufficient to reassure long-term commitment to development and implementation of low-carbon technologies in the medium term.

While stimulus packages are directed to preventing a deep recession by boosting aggregate demand, the next phase is to concentrate on the supply side. Thus, entrepreneurs can be encouraged to develop innovative technology and organisation, and market entry of new technologies facilitated by state support. This could be done through a sustainable policy strategy with an appropriate regulatory framework, a consistent taxation policy, a carbon trading scheme and charging systems for the transport sector.

The role for EU

The economic crisis and the challenges identified in this study call for EU initiatives to complement policies of the Member States. With regard to fiscal policy, the EU has limited power. However, dealing with global public goods calls for policies on the widest possible scale. Within that global framework, the EU has a role with the following tasks (OECD, 2009):

- Developing international cooperation and collaboration for large-scale projects on clean technology, such as electricity grid and international public transport;
- Removing trade barriers for environmentally sound goods and services in a follow-up to the WTO Doha Round;
- Providing a clear price signal, such as a minimum ETS price, to internalise the cost of environmentally damaging activities.

6.8 The bottom line

On a time horizon somewhat closer ahead of us than the birth of the European Community is behind us, this study presents visions for 2050, the achievement of which is largely determined by EU policies prepared in 2010-2015.

Momentum is created by a combination of factors including the current economic, food and climate crises, the election of a new European Parliament and the College of Commissioners, the likely entry into force of the Lisbon Treaty, the Obama administration in the USA, and the increasingly visible power of emerging economies. The time is ripe to set out European visions and to analyse them critically, to debate and to adjust them. As primer fo debate, this stuyd provides some examples.

Getting into the right lane for 2050 requires strategic choices now. We cannot afford to ignore the signals that natural resources are currently managed in a way that will lead to major problems in the future.

The EU was founded as a community of values with a perspective beyond economic integration. In line with these values, the critical junctions identified in this report are based on a belief that the EU needs to more closely align social, environmental and economic objectives in a global perspective.

Units and abbreviations

BRIC
Brazil, Russia, India and China

CAP
Common Agricultural Policy

CCS
Carbon Capture and Storage

CH_4
Methane

CHP
Combined Heat-power Production

CO_2
Carbon dioxide

CSP
Concentrated Solar Power

EJ
Exajoule =F 10^{18} Joules

ETS
Emission Trading Scheme

FAME
Fatty Acid Methyl Ester

FAO
Food and Agriculture Organisation of the United Nations

GDP
Gross domestic product

HFCs
Hydro fluorocarbons

IEA
International Energy Agency

IMAGE
Integrated Model to Assess the Global Environment

IPBES
Intergovernmental Platform on Biodiversity and Ecosystem Services

IPCC
Intergovernmental Panel on Climate Change

LNG
Liquefied Natural Gas

MDGs
Millennium Development Goals

MJ
Megajoule

N_2O
Nitrous oxide; dinitrogen oxide

OECD
Organisation for Economic Co-operation and Development

PBL
Netherlands Environmental Assessment Agency

PV
Photovoltaic

REDD
Reducing Emissions from Deforestation in Developing Countries

SDS
Sustainable Development Strategy of the Eurepean Union

SRC
Stockholm Resilience Centre

TEEB
The Economics of Ecosystems and Biodiversity

TEN-T
Trans-European Transport Networks

TWh
Terawatt hour = 10^{12} Wh

UNEP
United Nations Environment Programme

UNFCCC
United Nations Framework Convention on Climate Change

WHO
World Health Organization

WTO
World Trade Organization

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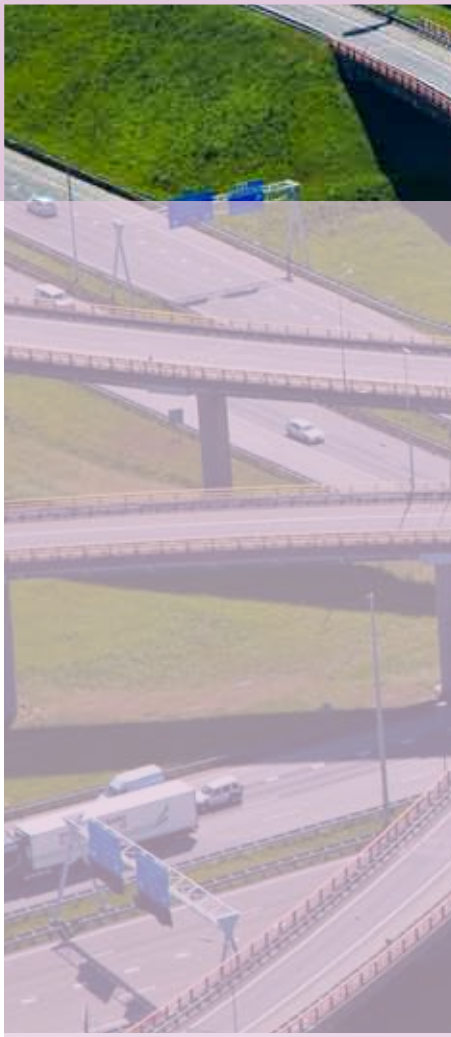

Getting into the Right Lane for 2050

The European Union is placed in a visionary global perspective for 2050 of producing food for a global population of nine billion while minimising biodiversity loss; mitigating climate change while enhancing energy security; and developing a low-carbon transport system in the EU.

Reasoning back from 2050, specific strategic actions are identified for the EU in the coming five to ten years. Key factors in the analysis are the magnitude and inherent slow pace of change as well as the longevity of capital goods with the implication that realigning institutions and constructing large-scale infrastructure take decades to achieve. It is also imperative that interim solutions such as securing energy supply in 2020 do not lock in the EU energy system for 2050. In moving towards 2050, diversity of options emerges as a key factor in securing low-carbon energy supply and transport in the EU, while in global land use, diversity helps to protect against 'shocks' to the agricultural system in a very crowded world.

The EU is shown to have a pivotal role in establishing the investment framework for continental–scale infrastructure such as a power grid for cost-effective use of low-carbon energy. In the world arena, timely action is needed before EU leverage, for instance on global product standards, shrinks as new players become more prominent towards 2050.