European RESPONSES to climate change

SEVENTH FRAMEWORK PROGRAMME

RESPONSES project

European responses to climate change: deep emissions reductions and mainstreaming of mitigation and adaptation

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Guidance on a Strategic Climate Assessment Approach

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Executive Summary

The purpose of this EU deliverable is to translate insights gained during the RESPONSES project into guidance of relevance for the practice of policy appraisal. Rather than simply summarize results by policy sector, which is how the RESPONSES project was organized, we identify six sets of cross-sectoral concerns.

A. Procedural requirements for policy appraisal

Policy appraisal can include both formal and informal processes for analyzing the consequences of a decision. With respect to the former, the EU requires impact assessment (IA), strategic environmental assessment (SEA), and environmental impact assessments (EIA) at various stages in the policy process. Examining those three, we conclude:

1. The climate change mitigation and adaptation impacts of European measures are beginning to be considered in impact assessment and strategic environmental assessment, but the practice is still highly uneven.
2. Guidance on integrating climate issues into policy appraisal is currently voluntary and non-binding; introducing clear mandates and constraints would provide a harder edge to climate appraisal.
3. Appraisal is currently ‘front loaded’ in EU sectoral policy cycles. The need for more adaptive management of climate-related risks suggests a rebalancing towards a greater emphasis on monitoring, assessment and learning throughout the policy cycle.

B. Appraising the consistency of policy proposals with future emission reduction targets

European policy makers are currently planning how to transform the continent's energy sector into one that produces no net greenhouse gas emissions, by the third quarter of this century. Proposals for projects, programmes, and policies outside of the energy sector could play an important role in facilitating this transformation, but they could also hinder it. RESPONSES research suggests that in appraising such proposals the following factors are important:

1. The effects on total energy demand are one consideration, but decoupling energy use from greenhouse gas emissions is more important.
2. Appraisal should consider the extent to which a proposed action reduces demand for liquid or gaseous fuels, or shifts energy demand from fuels to electricity.
3. In the next few years, once EU policy makers have made important choices concerning particular technologies for decarbonization, it will be possible to more clearly appraise whether other policies or proposals are consistent with changes in the architecture of the energy system.

C. Treatment of the 2°C target within policy appraisal

It is the express policy of the EU and its institutions to prevent climate change from exceeding 2°C average warming above pre-industrial temperatures. Whether this occurs, however, is largely out of EU policy-makers’ control, and there are reasons to believe that temperature rise will exceed this value. Relevant for the practice of policy appraisal, RESPONSES researchers have reached the following conclusions:

1. Even in relatively progressive jurisdictions, there is evidence that adaptation planners in key sectors insufficiently take into account the prospect of more extreme levels of warming than 2°C in their day-to-day work.
2. There is reason for concern about the validity of current and past policy appraisals, because of a widespread failure to consider the robustness of proposed actions to conditions associated with warming far greater than 2°C.
3. The results of independently conducted assessments of climate impacts in different sectors are often not transparent, comparable or transferable.

D. Adaptation goals in the context of policy appraisal

In appraising whether a particular policy proposal is furthering key adaptation objectives within Europe and the member states, a non-trivial problem is identifying what those objectives actually are. RESPONSES research has shown that these goals are not constant across policy sectors, countries, or time, and suggests the following insights:

1. Adaptation goals range from conservative (securing existing policy objectives under conditions of climate change) to transformative (reformulating policy objectives given what is feasible and desirable under conditions of climate change).
2. Given high uncertainty, the identification of adaptation goals and strategies may need to be devolved to lower levels of governance.

E. Dealing with uncertainty in the context of policy appraisal

In the area of climate policy, decision-makers are confronted with numerous and often cascading uncertainties, all of which can make it very difficult to say what the climate will look like in the future, how it will affect people, and what responses are most important. RESPONSES researchers have examined this problem in the context of policy appraisal, and suggest the following insights:

1. Uncertainties in future climate impacts are unevenly distributed, implying a need for geographical and temporal specificity in the practice of policy appraisal.
2. Formalized tools to identify optimal strategies under conditions of uncertainty require too much data to be practical, and hence analysis may want to focus instead on identifying qualitatively robust strategies.
3. Uncertainties in social systems, rather than the climate, may dominate the type of adaptation that is needed and possible; appraisals need to keep an open mind concerning what adaptation actions take place ‘down the road’.

F. Considering vulnerability and adaptive capacity in policy appraisal

The academic literature on adaptation makes clear that in many places, the most productive policies are not those that directly respond to an anticipated climate impact, but rather that change the conditions creating an underlying vulnerability, such as by empowering people to be more adaptive in their daily practices. The RESPONSES team has examined this notion within the context of policy appraisal, arriving at the following insights:

1. Vulnerability reduction is less important in the European context than it is globally, primarily because extreme poverty and its associated vulnerabilities are largely absent.
2. Adaptive capacity and sensitivity vary across regions, and indeed many newer EU member states lack the capacity to develop effective adaptation plans.
3. Local decision-making capacities often matter the most, and hence policy appraisal can focus on the extent to which a proposed policy will enhance or reduce decision-making capacity at the local level.

1 Introduction

The RESPONSES project aimed to provide strategic input for European policy-makers as they integrate climate adaptation and mitigation concerns into programming, policy-development, and decision-making. The project looked at EU policies in five sectors—water and agriculture, biodiversity, regional development and infrastructure, health, and energy—where adaptation and mitigation mainstreaming issues and options can be appraised and tested. Drawing on insights from across the five policy sectors, this report highlights five substantive issues for policy assessment and appraisal as it relates to climate change. In addition to these substantive issues, it also reflects on the procedural aspects of assessment and appraisal.

In dealing with a complex, dynamic and uncertain issue like climate change, there is a special role for assessment and appraisal, not only in framing policies at the start, but also in enabling learning about what works through the policy cycle. Our aim in this report is to build on existing policy assessment and appraisal processes in the EU. After over 20 years of development this is a mature system, which now needs to be adapted to the challenges of greenhouse gas emissions reductions and building resilience to the impacts of climate variability and change.

We begin by describing the existing state of policy appraisal in Europe, and the extent to which appraisals already include a consideration of climate policy concerns. We evaluate whether there is a need to overhaul such appraisal practices, such as by extending the range of decisions for which appraisal is required, changing the role of appraisal within decision-making processes, or mandating particular climate-specific indicators or impacts for such appraisals to quantify. While highlighting a number of weaknesses, we conclude that there is no short-term need for major reform. Rather, there are a number of substantive issues that are conceptually problematic, and for which additional guidance would be valuable. The remainder of this report provides such guidance.

We highlight five key issues covering a range of questions across the spectrum of mitigation and adaptation:

- How can one appraise consistency of a proposed policy with the European goal of deep emissions cuts? The challenge here is that deep cuts imply a transformation of the European energy system, whereas appraisal will often be concerned with a more limited review of a policy or programme.
- How ought one to reconcile the European target of mitigating CO_2 emissions so as not to surpass 2°C global average warming with the fact that this target is likely to be exceeded? Beyond 2°C average warming by the end of this century is a plausible outcome given global emissions trajectories, and this needs to be considered in EU adaptation planning.
- When appraising the consistency of proposed interventions with European adaptation goals, what in fact are those goals? The goal of adaptation is normally seen as making adjustments to secure current policy objectives, but this may in some cases require an impracticable level of adaptation effort, forcing a deeper reconsideration of the policy objectives themselves.
- How ought one to deal with high levels of uncertainty when appraising consistency with European adaptation goals? Assessments of vulnerability to climate change will continue

to be faced with a large measure of uncertainty, and this will shape how climate-related risks are handled in future.

- When appraising consistency with European adaptation goals, what is the importance of adaptive capacity? Most adaptation will be done by private actors operating in the context of available knowledge, resources and networks; but these adaptive capacities vary greatly across Europe, something public policies can address.

2 Appraisal practices in Europe

2.1 Introduction

Policy appraisal is concerned with understanding the impacts of a core task of the European Commission– the design, codification and implementation of public policy. Monitoring and appraisal are among a variety of procedures available to policymakers as they seek to integrate climate change considerations in the design and implementation of policy. Different forms of monitoring, reporting and appraisal can be applied at different stages of the EU policy cycle (see Figure 1 for the example of Cohesion Policy). Here we use a broad definition of appraisal to include all those procedures in policy design and implementation involving a technical assessment that can be seen as guiding the allocation of public resources or the regulation of activities.[1] Appraisal therefore needs to be seen as embedded in a specific policymaking context and as a continuous activity throughout the policy cycle. Making a sharp distinction between procedures involving appraisal and those that do not can be misleading. Some level of assessment is intrinsic to all stages of policymaking. Moreover, each policy sector will have its own reporting and appraisal requirements. For instance, the Habitats Directive (1992) requires an ‘appropriate assessment’ to be done of all plans and projects that may have a significant effect on a protected site, with the express aim of preventing development that could endanger such sites. In addition to this there are formal and generic appraisal procedures for EU policies, programmes and projects, and these are the focus here.

Ex ante appraisal of the impacts of policies, programmes, plans and projects is an important part of European policy and decision-making. Within the EU there are a number of routine procedures. Here we review briefly *impact assessment* (applied to all EU legislative proposals with significant economic, social, environmental impacts) and *strategic environmental assessment* (applied to ‘plans and programmes’ of national governments, especially in relation to land use planning). Environmental Impact Assessment relates to specific projects, and is applied whether or not they receive EU funding. We conclude with three insights about integrating climate into EU appraisal instruments, and extending monitoring and evaluation to support more adaptive management approaches.

[1] Detailed comment on the relevance of cost-benefit and cost-effectiveness analysis (CBA and CEA) can be found in Responses Deliverable 9.5.

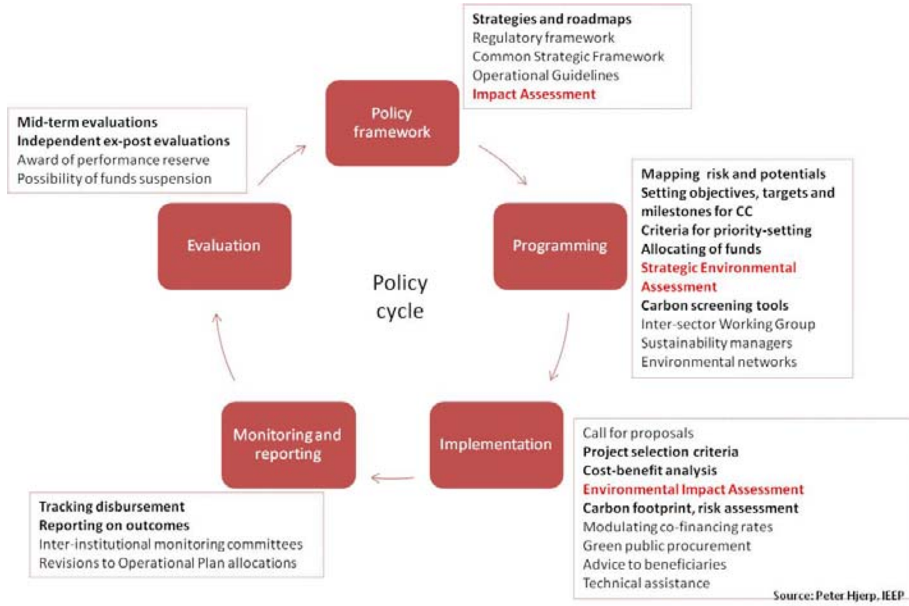


Figure 1 Appraisal in the context of climate mainstreaming procedures through the policy cycle: the case of Cohesion Policy (all appraisal procedures in bold, formal appraisal instruments in red).

2.2 Impact Assessment in the European Commission

Impact Assessment (IA) in the European Commission is about a decade old. Originally, the Commission put forward IA as a "tool to improve the quality and coherence of the policy development process" (European Commission, 2002: 2). In doing so, it made clear that impact assessment did not replace political judgment. Its importance for mainstreaming has been highlighted by, among others, Pollack and Hafner-Burton (2010), in that IA:

- Encourages wide involvement of Commission services and other stakeholders.
- Is intended to reflect on policy objectives, impacts of options, developing alternative options, assessing impacts, and recommending a preferred option (if possible).
- Has potential to provide 'hard incentives' to bureaucrats to implement mainstreaming (if appropriately strong quality control systems are in place).

2.2.1 Scope and practice

IA applies to all major Commission initiatives, defined as "…all legislative proposals of the Commission's Legislative and Work Programme (CLWP) and …all non-CLWP legislative proposals which have clearly identifiable economic, social and environmental impacts (with the exception of routine implementing legislation) and for non-legislative initiatives (such as white papers, action plans, expenditure programmes, negotiating guidelines for international agreements) which define future policies" (EC, 2009: 6). In other words, more or less the full range of Commission activities, as long as they are likely to have significant impacts, will be subject to IA. During an initial 'screening' stage, decisions are made on whether a proposal needs to have an IA and, if it does, what aspects the assessment should cover.

The Directorate General (DG) within the Commission responsible for the proposal or initiative is also responsible for the corresponding IA. IAs consist of a number of stages, but issues of scope and specific approach must be proportionate and are left open to discretion (see Figure 2). Guidance on how to conduct IAs is evolving. Since its initial launch in 2002, guidance has been revised twice, in 2005 and 2009, the most recent revision incorporating a reference to adaptation to climate change (European Commission 2009: 37).

The guidance offers best practice examples to guide those conducting the assessments. In the central 'impact analysis' stage, a number of key questions are suggested under the three different pillars of sustainability: economic, social and environmental. In the 2009 IA Guidance, some consideration is given to climate change under the environment heading, with three open questions covering mitigation and adaptation:

- Does the option affect the emission of greenhouse gases (e.g. carbon dioxide, methane etc.) into the atmosphere?
- Does the option affect the emission of ozone-depleting substances (CFCs, HCFCs)?
- Does the option affect our ability to adapt to climate change?

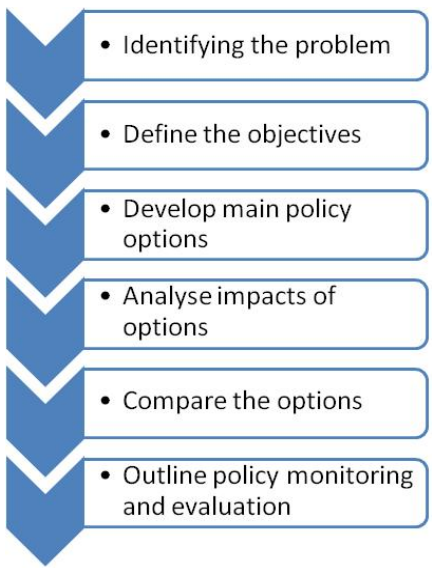


Figure 2 Stages in IA (EC, 2009: 5).

The Commission phased in the use of impact assessment. In 2006, they created the Impact Assessment Board (IAB) in order to improve the quality of impact assessments. The IAB reviews draft IAs, and returns these for improvements if it judges the first attempt to be unsatisfactory. Through 2010, the IAB had considered 382 Impact Assessments, of which roughly two-thirds were legislative proposals, and the remaining non-legislative such as white papers. Its level of scrutiny appears have to grown more stringent, as the resubmission rate (the proportion of Impact Assessments for which the IAB requests improvements) has risen from 9% in 2007 to 42% in 2010 (Impact Assessment Board, 2011).

2.2.2 Mainstreaming climate change in Impact Assessments

There is an age-old saying: "If it ain't broke, don't fix it." If one is interested in making sure that policy-makers are adequately mainstreaming climate concerns in the process of IA, and is considering changing IA to this end, then it is essential first to look at the extent to which climate concerns are presently omitted. Towards this end, we examined how climate change was covered by eleven impact assessments of Commission initiatives (listed in Table 1). These legislative and non-legislative proposals all had implications for climate mitigation or adaptation, covered the five policy sectors assessed by the RESPONSES project, and were conducted over a period spanning the 2009 revision of the IA Guidelines. This allowed some consideration of whether the new guidance had affected the way in which climate issues were handled in the assessment. A number of criteria were used to analyse the content and coverage of the assessments.

Table 1 Impact assessments of EC proposals and initiatives reviewed for their handling of climate change (Adeler, 2011).

Impact assessment published pre 2009		
Adoption date	**Commission proposal**	**IA report**
2006/18/01	Assessment and management of floods	SEC (2006) 66
2006/22/05	Communication for the Commission on Halting the Loss of Biodiversity by 2010- and Beyond. Sustaining ecosystem services for human well-being.	SEC(2006) 607/2
2006/17/07	Environmental quality standards in the field of water policy	SEC(2006) 0947
2006/02/08	An EU Strategy for Biofuels	SEC(2006) 142
2008/20/05	Legislative proposals following the Communication on the 'Health Check' in the Common Agricultural Policy	SEC(2008) 1885/2
Impact assessment published post 2009		
Adoption date	**Commission proposal**	**IA report**
2009/07/10	Investing in the Development of Low Carbon Technologies (SET-Plan)	SEC(2009) 1297
2009/20/10	Solidarity in health: Reducing health inequalities in the EU	SEC(2009) 1396
2010/26/10	Towards a stronger European disaster response: the role of civil protection and humanitarian assistance	SEC(2010) 1242
2010/17/11	Energy infrastructure priorities for 2020 and beyond – A Blueprint for an integrated European energy network	SEC(2010) 1395
2011/28/03	Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system	SEC(2011) 0358
2011/03/05	Our life insurance, our natural capital: an EU biodiversity strategy to 2020	SEC(2011) 540

This analysis showed a great deal of diversity in the depth and handling of climate change across of IAs (see Figure 3, Adeler, 2011). For instance, while some considered mitigation and adaptation measures, nearly half considered neither. Quite a large number of assessments acknowledged trade-offs and synergies, either between mitigation and adaptation, or between climate-related actions and traditional sectoral objectives. But these tended not to be considered in great depth. Only two of the assessments reviewed dealt with the uncertainties associated with climate change impacts. Part of this heterogeneity is explained by the domain-specificity of the assessments, but it is also an outcome of the considerable discretion available in the assessment process. No clear changes were evident in the handling of topics between the IAs conducted before and after the 2009 IA guidance revision (see Figure 4).

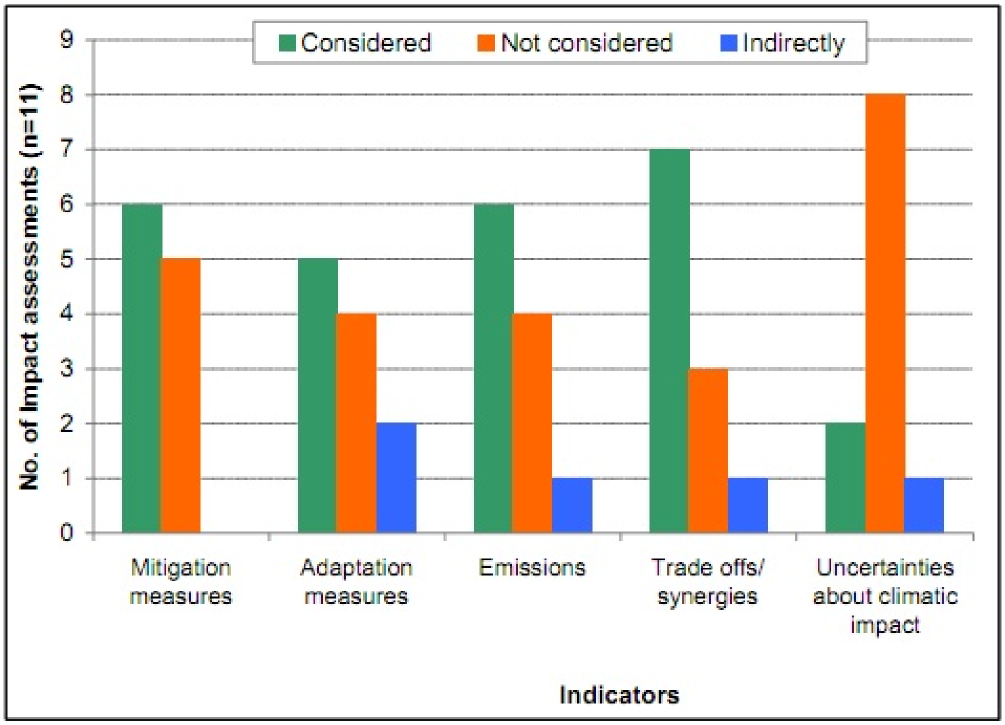


Figure 3 Topics covered in eleven IAs of climate-relevant EC proposals (2006-2011).

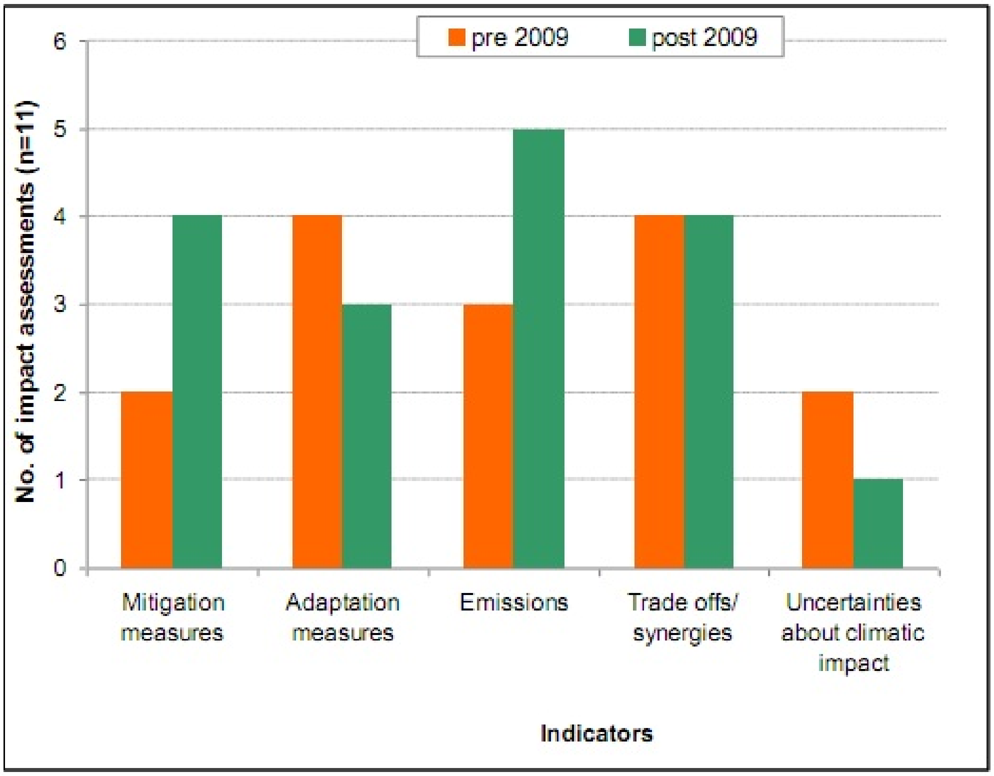


Figure 4 Comparison of the coverage of topics between pre-2009 and post-2009 impact assessments of climate-relevant EC proposals.

During an initial ‘screening’ stage, decisions are made on whether a proposal needs to have an IA and, if it does, what aspects the assessment should cover. The wider literature has found a mixed picture. It appears that the type of evidence deemed relevant to IA and the way it is interpreted depends to a large extent on the relative power of different DGs involved in the inter-service working groups that oversee the production of IAs. Timing of the IA report preparation can also be significant in determining whether or not the assessment can have a ‘contributing’ impact on the policy process, or whether it plays more of a ‘legitimising’ function (Thiel, 2009). Hirchl *et al.* (2012) examined the role of scientific evidence and impact assessments in the policy process leading up to the adoption of the 2009 Renewable Energy Directive. Their analysis clearly shows that several scientific analyses pointed to a number of risks linked with the massive expansion of first-generation biofuels production. They explain the failure of this opinion to be represented in the assessment as being due to the different ways of framing and interpreting uncertainty, noting how the framings adopted in the report downplayed the negative aspects of a policy proposal that had powerful backers in DG Agri and DG Ener. Avoiding these value-contests in appraisal remains a major challenge.

2.3 Strategic environmental assessment

Europe has a two-tier system for environmental assessment of planning decisions. At the discrete project level, Environmental Impact Assessment (EIA) has been mandated since 1985 (85/337/EEC). This is what would need to be done when a project with significant expected impacts, such as a roadway, is built.

Since 2001, a directive (2001/42/EC) has required environmental assessment earlier in the policy process, namely at the time at which authorities are developing strategic plans or programs: Strategic Environmental Assessment (SEA). There is also an SEA protocol (2003) that is separate from the EU, associated with the United Nations Economic Commission for Europe (UNECE), which binds member countries to roughly the same procedures as the SEA Directive.

SEA is what would be required as a 'competent authority' is planning or programming at a more strategic level, for example, a strategic evaluation of its road infrastructure and transportation planning, or river basin management. Legally, an assessment report needs to be prepared before a decision is adopted. Ideally, to maximize its influence, it should be carried out in parallel with the development of a strategic plan or programme. As with Impact Assessment, SEA needs to identify the objectives of the proposed action. It then needs to provide information on:

- The present environmental situation, including existing problems, and its likely evolution without the new plan;
- The environmental attributes that would likely be affected by the new plan;
- The existing environmental objectives agreed at the Member State or European level;
- Possible significant effects on the biodiversity, population, human health, flora and fauna, soil, water, air, climate, material assets, cultural heritage, and landscape;
- The measures to prevent negative impacts;
- Alternative options to proposed plan; and
- Needs for additional information and data monitoring.

As with Commission-level Impact Assessment, SEA needs to include public consultation, and follow a process that allows and encourages stakeholder participation.

Previous reviews have judged that climate change issues were poorly addressed in SEAs (COWI, 2009). This is also the case for the programmes that SEAs review. As an example, we examined National Strategic Reference Frameworks (NSRF), required under EU Cohesion policy, and found something similar. Of 17 NSRFs analysed, only seven referenced national climate emissions reduction plans, while only three referred to a national adaptation strategy, although six noted the need for adaptation to be accounted for in EU-funded projects.

This patchy coverage, across a range of sectors, is despite a growing amount of additional guidance, at both the European level and in some member states. For instance, Scottish National Heritage, the body responsible for implementing the Habitats Directive in Scotland, has recently published guidance on appropriate appraisal of plans or projects under the directive (Scottish Heritage, 2012). Likewise the Commission issued guidance in 2009 related to the Water Framework Directive under which member states are encouraged to do a 'climate check' of proposed measures in new River Basin Management Plans (Wright et al. 2011). The Commission is due to publish two sets of guidance on integrating climate change and biodiversity into SEA and EIA. This guidance suggests a much more comprehensive treatment of climate change mitigation and adaptation in EIAs and SEAs, with a longer set of 'guiding questions' to de dealt with (Figure 5).

One explanation of a poor take-up of guidance may be lack of awareness. Our study of climate mainstreaming among managers in European river basins, found that although there was broad awareness of climate-related impacts on water flows and temperatures, posing risks for the 'ecological status' of surface waters, as well as a local capacity to assess and respond to such risks, there was little awareness of European guidance (Brouwer et al., 2013). This may also be because the guidance itself is ambiguous about the significance of climate change impacts over the timeframe of the Water Framework Directive, in this case targeted to those developing river basin management plans.

Table 11: Guiding questions for identifying (scoping) key climate change mitigation issues

Concerns related to:	Key guiding questions that could be asked within the assessment - at the screening and/or scoping stage of the EIA
Direct greenhouse gas emissions	Will the proposed development emit carbon dioxide (CO_2), nitrous oxide (N_2O) or methane (CH_4)? How can these emissions be expressed in carbon dioxide equivalent units (CO_2e)[14]? Whilst construction emissions are often small in proportion to operations emissions, will the proposed development involved construction that is particularly carbon-intensive (e.g. energy intensive and/or extensive uses of resources like concrete and structural steel)?
Indirect greenhouse gas emissions through increased demand for energy	Will the proposed development directly or indirectly increase or decrease demand for energy? How can these changes in energy demand be expressed in the carbon dioxide equivalent units (CO_2e) given the GHG emissions from the local energy supply mix?
Greenhouse gas emissions from transport	Will the proposed development significantly increase or decrease personal travel – i.e. the number and length of journeys made and
Greenhouse gas emissi from agriculture and horticulture	

Table 12: Guiding questions for identifying (scoping) key climate change adaptation issues

Concerns related to:	Key guiding questions that could be asked within the assessment - at the screening and/or scoping stage of the EIA
Habitat protection	Can the project directly or indirectly affect important habitats and migration corridors? How seriously will this impact on the habitats and corridors be, considering the fact that they can be also adversely affected by changes in the climatic conditions?
Flood regimes	Is the proposed development located in areas that may be inundated by floods, sea level rise or sea water surge during storms? Will the proposed development reduce or enhance the capacity of existing ecosystems and flood plains for natural management of floods and flash floods? Will the proposed development reduce or enhance risks of landslides, or bank erosion? Will the proposed development increase the exposure of the vulnerable (e.g. the elderly, unwell or young people) or sensitive receptors (e.g. critical infrastructure) to floods?
Sea level rise, storms surge, coastal erosion, hydrological regimes and saline intrusion	What are the key aquatic, riverine and coastal habitats and migration corridors that may be significantly adversely affected by sea level rise, coastal erosion, changes in hydrological regimes and salinity levels? How will the proposed project impact them? What are the key infrastructural assets (e.g. road segments and intersections, water supply infrastructure; energy infrastructure; industrial zones and major landfills) at risk due to their location in areas that may be inundated by sea level rise or subject to coastal erosion? Will the proposed project reduce or enhance these risks? What areas may be affected by 4ppt saline intrusion? Will the proposed project reduce or enhance these risks?
Droughts	Will the proposed development increase water demand? Will it discharge any effluents into water bodies? What will be the combined effect of water intake and effluent discharges on the likely expected future baseline trends for water quality, especially during droughts? Can the project be adversely affected by increased water pollution (which may reduce pollution and nutrient dilution capacity in water bodies, reduce oxygen absorption, features algae blooms, saline intrusion, etc.) or reduced water availability during periods of prolonged droughts? Will the proposed development increase or reduce the resilience of landscape/forests to wildlife fires? Will the proposed development increase the exposure of the vulnerable (e.g. the elderly, unwell or young people) or sensitive receptors (e.g. critical infrastructure) to droughts or wild fires?
Heat waves	Will the proposed development reduce or enhance urban heat island effect by: o emitting heat and fine particular matters? o reducing or expanding green areas and open water surfaces in the urban areas? o reducing or expanding surfaces that absorb the heat or reduce evapotranspiration? Will the proposed development increase the exposure of the vulnerable (e.g. the elderly, unwell or young people) or sensitive receptors (e.g. critical infrastructure) to heat waves?
Strong winds	Will the proposed development be at risks because of storms and strong winds? Will the proposed development reduce or enhance risks associated with storms and strong winds?

Figure 5 Draft guiding questions from SEA Practical Guidance (2011).

2.4 Key insights from the RESPONSES Project

Insight 1: The climate change mitigation and adaptation impacts of European measures are beginning to be considered in impact assessment and strategic environmental assessment, but the practice is still highly uneven

While in some EU policy sectors, including cohesion, agriculture, biodiversity and water, there is widespread awareness of the potential to contribute either to emissions reduction or reducing vulnerability to climate change impacts, the practical expression of this in formal EU appraisal practice remains quite limited. They are expressed primarily in the non-binding, normative appeal of 'key questions' that guidance documents suggest ought to be considered in IA and SEA. Such guidance is becoming more detailed with respect to GHG emissions reduction and climate vulnerability and adaptation. Awareness of guidance remains an issue. Lack of consensus on future climate impacts also presents a 'cognitive barrier' to procedural mainstreaming (Larsen and Kornov, 2009).

But even where there is awareness and a good knowledge base, inclusion of climate dimensions of plans and programmes will be determined by institutional capacity, the balance of interests and the existence of external factors that provide opportunities for 'win-wins' in pursuing climate mitigation and adaptation.

Insight 2: Guidance on integrating climate issues into policy appraisal is currently voluntary and non-binding; introducing clear mandates and constraints would provide a harder edge to climate appraisal

While IA and SEA are required in law, the findings cannot normally be challenged in court. There also exists a large measure of discretion in the conduct of appraisals. Guidance is non-binding and voluntary with the goal of encouraging appraisals that attract the broadest possible participation and are 'fit for purpose'. The danger is that without clear mandates or constraints (a shift that has been successfully made in biodiversity appraisals in the United States (Farber et al., 2011)), appraisals will be subject too much to political negotiation about what evidence is gathered, how it is interpreted and the consequences for substance of policies, programmes and plans. Since IA and SEA are 'advisory assessments' their impact on final plans, decisions and investments remains ambiguous. It is clear that many opportunities for emissions reductions are not being taken and that potentially maladaptive decisions may be proceeding (including, support for large reservoirs, biofuels and structural funding on potentially vulnerable infrastructures).

Insight 3: Appraisal is currently 'front loaded' in EU sectoral policy cycles. The need for more adaptive management of climate-related risks suggests a rebalancing towards a greater emphasis on monitoring, assessment and learning throughout the policy cycle

Conventionally, EU policy appraisal is done before a new piece of legislation or funding allocation is made. It operates as a filter before choices are finally made. *Ex post* appraisals of policy effectiveness are done in the run-up to periodic decisions about funding allocations, such as the Multiannual Financial Framework, and while proposals are being prepared for policy revision. Such assessments are explicitly intended to prefigure policy change, being less concerned with experimenting and learning as a policy unfolds. Given the need for learning in respect of a transition to a low carbon economy, and since there are many uncertainties about climate impacts and adaptation responses, many commentators believe that there is a growing case for a more 'adaptive' approach to policy design and implementation. One of the prerequisites of adaptive governance is the monitoring and appraisal of existing policy *ex durante* and *ex post*. The capacity to learn is intrinsic to the capacity to adapt, and therefore needs to be built into design and timing of policy appraisals at EU, national and local levels. A greater degree of *ex durante* assessment might also operate as a safeguard against policies that are implemented in advance of clear scientific input regarding some of their detrimental effects, such as biofuels policy (Dunlop, 2010).

3 Appraising consistency of policies with deep emissions cuts

Among the many goals and targets that show up in EU climate policy, perhaps the most important—and likely most difficult to achieve—is to mitigate greenhouse gases to the extent necessary to prevent total average warming over preindustrial times exceeding 2°C. In the following section we will deal with the particular challenges for appraisal that the possible—some would say inevitable—failure to meet that target creates. In this section, however, we deal with the implications of that target, taken at face value, for appraising consistency of policy measures with climate policy goals.

3.1 Implications of the 2°C target

A cursory review of a number of assessments—IA, EIA, and SEA—reveals that they have looked at the mitigation aspects of a broad range of sectoral policies. The main factor assessed in these assessments has been whether the given policy or project will reduce the consumption of energy. Moreover, in the draft guidance notes for evaluating climate impacts in EIA and SEA, the need for a progressive reduction in CO_2 emissions is stressed. But how can one assess such a decline in emissions? Most of the assessments we have examined did so by noting the marginal change in energy use associated with the implementation of the policy under consideration, and then translating this into tons of CO_2 saved, assuming a particular carbon intensity to the energy system (Ecologic 2007).

From a short-term perspective this makes perfect sense. Two types of changes can lead to emissions reductions in the energy sector: reducing total energy use, such as through improvements in energy efficiency, or decoupling the provision of energy from greenhouse gas emissions. If the needed emissions reductions were of the order of 10, 20, or even 30%, improvements in energy efficiency could suffice. Moreover, it seems logical that policy proposals *outside the energy sector* could have a direct impact on total energy use, but little impact on the form of energy that is used. Consider, for example, a proposal to harmonize education throughout the EU. That could lead to greater mobility of students, and hence more travel. Perhaps it could also facilitate the exchange of academic faculty, lessening the overall need for students to travel. Both would imply impacts on total energy use. It would likely not contain, however, any specification of whether that travel be powered by biofuels or fossil fuels.

From a longer-term perspective, it is this latter type of issue that is most important. In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) analyzed what it would take to achieve the 2°C target that the EU—and many other jurisdictions—have set (Metz et al. 2007). A new very low emissions scenario developed in the RESPONSES project (Deetman et al., 2012b) also shows a need for a fully-decarbonised European energy system by the third quarter of this century, with a possible need for a period of negative emissions (i.e. actively removing CO_2 from the atmosphere and sequestering it somewhere) for several decades thereafter. To stand a chance of eliminating emissions on time, the IPCC suggested further, it would be prudent to set a target for 2050 of halving emissions globally. Given both equity and efficiency concerns, the IPCC concluded, the emissions reductions by 2050 would be concentrated in industrialized countries. Developing countries, where *per capita* emissions are much lower to begin with, would need to reduce their emissions by something less than 50%, while the industrialized countries would need to reduce their emissions by at least 80%. More recent analysis has confirmed these figures (Hulme and Neufeldt 2010).

Given a long-term target of over 100% emissions reduction, it is clear that there will have to be a complete decoupling of energy from emissions. Once such a decoupling has occurred, there may be other environmental or social reasons to limit total energy use, but there is no direct link between energy use and greenhouse gas emissions. The primary factor determining the achievement of the 2°C target, then, is the pace at which a complete decoupling can occur. Of secondary importance are the total emissions generated while such a decoupling is underway. These emissions do depend, to some extent, on total energy use and energy efficiency.

Hence, appraising the consistency of proposed actions with EU climate goals based on the effects on total energy use is not irrelevant, but it does miss the main part of the problem: whether a given policy or action is consistent with efforts to decouple emissions from energy use. It seems clear that policies outside the energy sector are unlikely to have a direct impact on the mix of fossil fuels versus other energy sources. There is good reason to believe, however, that they could have profound indirect effects. To understand these, it is important to think a little bit about the energy system of the future.

3.2 How will Europe decouple energy use from greenhouse gas emissions?

The European energy sector is divided roughly evenly between electricity production and use, transportation powered by liquid fuels, and heating and industrial processes powered by solid, liquid, and gaseous fuels (Schellekens et al. 2010). Creating non-fossil substitutes for liquid and gaseous fuels requires the use of biomass, and there are multiple concerns with scaling up this practice too far or two quickly: that it will lead to land degradation, and a spike in CO_2 emissions because of freed-up soil carbon; that it will require unsustainable supplies of fresh water for irrigation, draining underground aquifers; and, that it will compete with food production, leading to higher food prices, and widespread hunger among the world's poor (IPCC 2011). By contrast, substituting renewable sources for the coal, oil, and gas used to generate electricity faces relatively fewer constraints. Globally, the economic potentials of both wind and solar power outstrip total energy demand, in the case of solar power by more than an order of magnitude (IPCC 2011; de Vries, van Vuuren, and Hoogwijk 2007). Nuclear fission already generates a large share of electricity in some countries, and it may be possible to expand this. Carbon capture and storage (CCS) offers the possibility of eliminating up to 95% of the CO_2 emissions from large point sources, and large point sources are primarily coal- and gas-fired electricity generators (Metz et al. 2005). Hence, three requirements emerge:

- Substituting bio-fuels for oil and gas in the transportation and heating sectors;
- Reducing the consumption of bio-fuels to sustainable rates through a combination of efficiency improvements and electrification;[2] and
- Eliminating net CO_2 emissions from the production of electricity.

[2] In addition to electrification, basic chemistry and numerous sets of analysis suggest that one could also use hydrogen as a fuel, provided that hydrogen is produced in a carbon neutral manner. In practice, the two are to a large extent equivalent, as hydrogen can be viewed as a way of storing electricity, with a hydrogen fuel cell being equivalent to a battery.

Researchers in the RESPONSES project have examined all three of these options, primarily through the use of integrated assessment and energy system models. Of tremendous importance for European climate policy, but not necessarily for the practice of mainstreaming climate concerns into the appraisal of policy proposals more generally, they have found that implementing them at a pace necessary to achieve the 2°C target is technically possible but would require massive changes in investment, that the needed changes in investment may be so large and so disruptive that there may be reason to reevaluate the 2°C target in the first place (Deetman et al. 2012a, 2012b, in press; den Elzen and van Vuuren, 2007; Meinshausen et al. 2006).

What does stand out as important for the purposes of appraisal, however, is the following: when it comes to eliminating net CO_2 emissions from the production of electricity, there are several possible technological pathways available, and for a variety of reasons it is not entirely clear at this point which pathway policy makers will take (Deetman et al. 2011). This matters for appraisals because the alternative energy transition pathways have profoundly different implications for the overall architecture of the European energy system. It would be good if it were possible to appraise whether a proposed action is consistent with Europe's future energy system architecture, but given that that architecture has yet to be determined, this is simply not yet possible.

Three sets of technologies are available to provide decarbonized power over the coming decades: nuclear fission, CCS, and renewables. Each has their strengths and weaknesses, the details of which go beyond the scope of this report. What is important here is that both scaling up nuclear power, and implementing CCS, would require very little in the way of changes to planning and operating the power system by EU and national level decision makers (Lilliestam, Bielicki, and Patt 2012). By contrast, the scaling up of renewables would require some fundamental changes. First, it would likely require greater cooperation between EU member states, to the possible extent of unifying national power markets into a single European market (Patt et al. 2011). Second, it could require initiating cooperation with non-European producers of renewable electricity, including the situation whereby the EU region as a whole would import a substantial share of its electricity (MacKay 2009). Third, it would almost certainly require the construction of a substantial new power transmission networks that cross national borders, in turn requiring enhanced cooperation between EU member states, and potentially third parties, over their planning, financing, and operation (Battaglini, Lilliestam, et al. 2009). If the renewables path were to dominate, then it would be relevant to appraise consistency with greater cooperation and interdependency on issues of energy and infrastructure planning and operation. IA, SEA and EIA currently do not consider these much broader strategic questions. Consistent with the findings in the RESPONSES project, the recently completed EU roadmap for achieving 2050 emissions cuts leaves all options open (European Commission 2011).

3.3 What about energy efficiency?

Energy efficiency and reductions in energy demand remain important criteria for appraisal for three reasons. First, total energy use will influence greenhouse gas emissions as long as the energy system as a whole generates net greenhouse gas emissions. Second, total energy use will influence the sustainability of biofuel use. There is a direct effect in the case of energy demand in the transportation and heating sectors, where reduction in energy demand will lead to an overall decline in the demand for biofuels. There is an indirect effect in the case of demand for electricity. Here, some share of power will likely be supplied by solid biomass combustion, and this could divert fuel stocks away from liquid biofuels production, reducing the supply that could be considered sustainable. Third, and potentially most important, is that the single most important factor constraining the pace at which CO_2 emissions can be eliminated from the production of electricity is the rate at which market actors can plan, gain permits for, finance, and ultimately construct new infrastructure (Schellekens et al. 2011). This could include renewable power plants and transmission lines, nuclear power stations, or CO_2 transport and storage facilities. The lower the overall energy demand, the slower the pace at which new infrastructure will be needed, and the more rapidly can infrastructure associated with fossil fuels be phased out.

In the context of appraising effects on energy efficiency, however, it is important to take into account the so-called "rebound effect," a feature of energy demand often ignored in current appraisals. Owing to the rebound effect, increasing energy efficiency may result in lower energy savings than *ex-ante* analyses, which typically involve some engineering-economic assessment, suggest. The literature (e.g. van den Bergh 2008, Berkhout, Muskens & Velthuijsen 2000, Greening et al., 2000, Herring & Sorrell, 2009, Madlener and Alcott 2009, Sorrell 2007) typically distinguishes between direct, indirect and macro-economic/economy-wide rebound effects:

- With the *direct rebound effect*, demand increases because improved energy efficiency lowers the price of using energy services. For example, purchasing a fuel-efficient car may induce people to drive greater distances, or faster.
- With the *indirect rebound effect*, one considers that energy efficiency also results in lower energy costs, which outweigh higher investment costs (for a more energy-efficient bulb or car), disposable income increases. People spend this money on other things, for which there is associated energy use.
- The *macro-economic rebound effect* results when radical innovations, resulting in additional applications of energy-using technologies, result in additional economic growth at the societal level. Notably, the development of more efficient steam engines spurred industrialization, causing a huge increase in energy demand (first observed by Jevons, 1865).

While the literature generally agrees that rebound effects exist, their size, relevance and explanations are controversial (Sorrell, 2007). Most empirical analyses of rebound effects refer to the household sector, in particular to transportation (in the US) or to space heating and lighting. Only a few studies explore rebound effects in industry (e.g. Saunders 2013). According to the literature synthesis by Maxwell et al (2011), the rebound effect for applications in the household sector tends to range between 10% and 30% (notable exceptions include Frondel et al. 2008, 2012). That is, 10% to 30% of the technical energy savings are eaten up by the various types of rebound effects. The (combination of the various) rebound effects may even result in 'backfire', i.e. over-compensate the energy efficiency effects and result in an *increase* in energy use. Unless power supply is carbon-free, or other countervailing measures are implemented, the rebound effect, which is typically defined for energy use, translates into lower than expected greenhouse gas emission savings.

Since empirical estimates are context-specific, generalising findings from one region or period in time is not appropriate. For example, the degree of energy service saturation (which is expected to depend on income levels) varies widely across countries and time.

In principle, rebound effects should be considered in policy impact assessments. For example, in its most recent World Energy Outlook, the IEA (2012) assumes an overall rebound effect of 9%. Similarly, the US Department of Transportation assumes a rebound of 10% in the Regulatory

Impact Statement to assess the effects of the Corporate Average Fuel Economy (CAFE) Standards for passenger cars and light trucks. Our analysis of appraisals in the EU does not reveal a consistent approach to dealing with the rebound effect.

3.4 Key insights from the RESPONSES project

Insight 1: In appraising consistency of a proposed intervention with EU climate mitigation goals, the effects on total energy demand are one consideration, but decoupling energy use from greenhouse gas emissions is more important.

The EU goals for mitigation see a building down of CO_2 emissions over time. For 2020, the goal is to reduce emissions from 1990 levels by 20%, for 2050 it is 80%, and shortly after 2050 it will need to be 100%. Improvements in efficiency can and will play a direct role in helping Europe to achieve its 2020 targets, and these direct effects are largely linear. For the longer-term targets, however, the effects become increasingly indirect, as the overall carbon intensity of the energy system declines, and ultimately reaches zero. Owing to these indirect effects, it is not possible to translate a reduction in energy use into an amount of emissions avoided, and compare competing proposals in this manner. This is because there is not likely to be a linear relationship between declining energy use and the feasibility of complete decoupling.

In calculating the effects on energy demand, moreover, it is important to pay attention to the rebound effect, both direct and indirect. The rebound effect means that improvements in energy efficiency, when driven by cost-saving measures such as improvements in technology or processes, will shift consumption patterns in such a way as to create additional energy elsewhere, reducing the net savings. When reductions in demand are driven by increases in energy prices, the rebound effect can be avoided. In the extreme, the rebound effect can lead to backfire, whereby total energy use actually increases as a result of improved efficiency. Estimates of the size of the rebound effect vary widely, and appear to be context-specific, and so to the effect that a quantitative appraisal of total energy use is sought, considerable attention becomes necessary.

Insight 2: Appraisal should consider the extent to which a proposed action reduces demand for liquid or gaseous fuels, or shifts energy demand from fuels to electricity.

The greatest constraints to the provision of carbon-neutral energy will likely be with respect to liquid and gaseous fuels. Such fuels would almost certainly need to be derived from biomass, and the global capacity to provide feedstock in a manner that is both sustainable and equitable is limited, likely below possible demand.

There are two main ways of reducing energy demand. The first is to reduce overall energy demand in the transportation and heating sectors. If people drive less, either because the price of driving rises, or because the need to drive declines (such as through improved spatial planning), or some combination of these, then the demand for gasoline and diesel fuel will fall. This will lead to reduced emissions immediately, and also make it more likely that future biofuels production can satisfy demand in a manner that is sustainable. Improved building insulation can provide similar benefits in the area of heating.

The second is to electrify transportation and heating. For the former, this can involve a greater reliance on electrified rail and bus lines, as well as the diffusion of electric cars, trucks, and buses, while the electrification of either air travel or shipping would appear to be difficult. For example, proposed actions that concentrate development along public transportation lines, or which somehow facilitate the use of charging stations, could have a positive effect, while urban sprawl would have a negative effect. For heating, it may mean the conversion of heating systems to geothermal systems of heat pumps. This is often difficult to do in old housing stock, but relatively easy in the course of new construction. Measures to increase the turnover of the housing stock, for example, might be assessed as having a positive effect.

Insight 3: In the next few years, European policy makers will face important choices about which sets of technologies are at the heart of decarbonization. Once they do so, it will be possible to more clearly appraise whether other policies or proposals are consistent with that technological pathway.

Decisions not yet made, but likely to be reached over the coming decade, will determine the extent to which Europe expands renewable energy, develops nuclear energy, or implements carbon capture and storage, and these will have profoundly different implications on the structure of the energy system, energy markets, and the need for international cooperation. This is most clearly the case if expanding renewable energy comes to be the dominant approach. In such a case, there will need to be greater international cooperation in the planning and operation of power systems, a major expansion of the existing power transmission grid, and potentially a need to smooth power demand throughout the day and the year.

What may be particularly important is the future availability of hydro-electricity. Currently, hydro is the major source of renewable electricity. Because of geographic constraints on the one hand, and adverse environmental effects on the other, it is unlikely that hydro will see much growth in the future. However, the fact that hydro is dispatchable—turned on and off quite quickly, without throwing away energy—means that it may play an increasingly important role balancing the supply of intermittent renewables, namely wind and solar. One of the main factors that could play a role in constraining hydro, or limiting its flexibility, is the necessity to maintain environmental flows, namely keeping river flow rates above a certain level in order to sustain aquatic ecosystems (Brouwer et al 2013). Factors that affect the hydrology of a watershed, such as changes in runoff or in demand for irrigation, can affect the sufficiency of environmental flows.

As the results from the RESPONSES project suggest, however, it is too early to tell which mitigation approach will be dominant. Likewise, the current EU Roadmap to 2050 leaves all options open. If Europe is to stay on track towards the 2°C target, analysis reveals, substantial changes in investment will need to take place between now and 2020, meaning that the choice of pathway is something that policy makers need to confront quite soon, if not immediately. The urgency is particularly profound given the tendency for society to lock in to new technologies. As they do so, and as the future shape of the European energy system become more certain, then precise guidelines on appraising consistency with that architecture will become both possible and imperative.

4 Exceeding the 2°C target

Since 1996, the EU's official commitment has been to hold average global temperature increases to a maximum of 2°C, the threshold after which 'dangerous' climate change (in the language of the UNFCCC) is considered to occur. Given the political importance of this commitment, the question arises of whether consideration of the implications of higher temperature changes and associated impacts may be discouraged. If so, there could be implications for the robustness of EU policy and/or decisions at lower 'tiers' of governance, including project level. According to Stafford-Smith *et al* (2009), concerns about 'mal-adaptation' could be realized if, on the assumption that the 2°C target will be reached, society invests in activities that prove, at best, costly and pointless if a 4°C future materializes, and at worst may have prevented more transformative measures (see also O'Brien *et al.* 2012). In this section, we offer a brief literature review on important scientific aspects of the issue, highlight some evidence for the issue being problematic in current assessments, and suggest guidance to decision-makers on how to deal with it.

4.1 The importance of the issue, and problematic nature of current assessment practice

4.1.1 The growing prospect of exceeding 2°C

Concern is growing among climate scientists that the continuing growth in emissions, led by China, means that the probability of staying within 2°C is diminishing. By 2015, 'lock-in' caused by continued investment in carbon-intensive infrastructures around the globe could mean the door to achieving the target is effectively closed (IEA 2012; PWC 2012). Other influential commentators, including a former Chair of the IPCC, have suggested that the door has already closed (Ghosh 2012), i.e. the 'emissions gap' highlighted by UNEP (2012) cannot be made up.

Moreover, peer-reviewed analysis suggests not only that 4°C mean temperature rise could eventually be the effect of current emission trends, but that this could occur even as early as the 2060s (Betts *et al.* 2011). Figures 6 and 7 below illustrate this possibility. There is evidence that changes will be more severe and quicker in some spatial areas than others – e.g. boreal, arctic (Joshi *et al.* 2011).

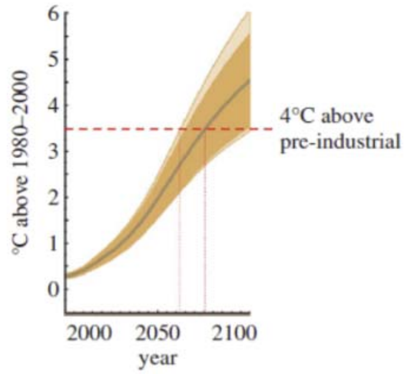


Figure 6. Projections of global warming for the A1FI emissions scenario. This is widely considered to be a "business as usual" scenario, and indeed falls the closest to actual emissions since 2000. Since there had already been roughly 0.5°C warming by the period 1980-2000, the dashed red line indicates 4°C warming above pre-industrial. Unless there is an immediate departure from "business as usual," the 2°C threshold will be exceeded with near certainty. Source: Betts et al (2011).

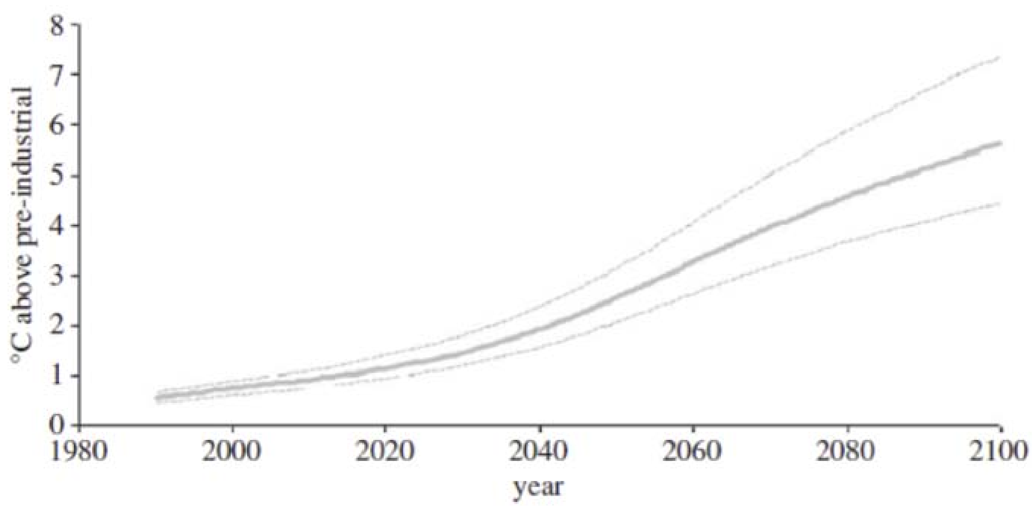


Figure 7. Projections of global warming for the A1FI emissions scenario. Source: Betts et al. (2011).

4.1.2 Scenarios used in EU research and policy making

Given the diminishing probability of staying within 2°C of warming, we should expect EU policy making to be informed by scenarios assuming high emissions, including the fossil-fuel intensive scenarios that the world appears to be following (i.e. A1FI). Here, we find some cause for concern.

For the Commission's Adaptation White Paper, PESETA project analysis was used, showing how Europe could be vulnerable based on selected potential impacts for both B2 and A2 scenarios. According to the DG Climate Action's own commissioned project on *Climate Proofing of Policies in the Short Term* (Altvater *et al* 2011), the lack of consideration for higher emission scenarios is more widespread than this one policy document:

- 'Most of the existing scenarios suffer from being 'too plausible' and almost systematically avoid inclusion of discontinuity (high impact low probability extreme events). This compromises the role of scenarios as a tool for exploring a wide range of possible futures and hence to help to prepare 'Plan B' in order to be able to act more adequately in extreme situations' (Altvater *et al* 2011: 126).

The Impact Assessment for the *Energy 2050 Roadmap* provides a clear example of the Commission apparently assuming the 2°C target will be achieved. The document explicitly states that '[c]onstant climate conditions were assumed over time. This simplification may be justified given that all decarbonisation scenarios assume that the climate targets are met' (European Commission 2011: p39). This effectively rules out the possibility that even *if* the EU were to meet its decarbonisation objectives, expressed in the Roadmap, global GHG concentrations could still reach a level that leads to the target being exceeded, with correspondingly more severe impacts set in train. The potentially serious consequences arising from higher impacts for the EU's ability to achieve its stated objectives, i.e. the kind of de-carbonisation envisaged (if hydropower was more constrained by more severe water shortages, biomass imports became less available, etc), remain unexamined.

In a vulnerability assessment on behalf of DG Energy, Rademaekers *et al* (2011) suggest that the IPCC's A1B is the worst-case scenario in terms of climate change effects and the most commonly used. A1B projects that carbon emissions will continue to grow until 2050, after which they will begin to decline and that global surface temperatures will increase by 3.4ºC by the end of the century. This scenario is used as the point of departure because it is viewed as the 'most likely and most troubling realistic GCM scenario in the academic sector and is referred and used in comparable studies' (Rademaekers 2011: p44). Significantly, however, the possibility of a higher emission *A1FI* scenario does not figure. Researchers in *Responses* Work Package 8 suggest that it is in many cases external constraints, namely the amount of funding, which prevents analysis of more and very diverse scenarios, rather than a lack of awareness.

The *Responses* Work Package on Regional Infrastructure (WP6) stresses the need for multi-model data to reduce uncertainty (see *Climatic Change* paper). They find that the choice of GCM/RCM simulation has a huge influence on climate impact assessment results and their spatial patterns. For instance, some trends appear to be particularly certain (e.g. increased fire risk in the south), while others are quite uncertain (e.g. trends on heat and fire in France) Flood risk seems to be particularly difficult to predict in the south (due to increasing climate extremes in particular in those regions).

There is a further issue related to the comparability of scenario building in the EU across the range of relevant policy sectors, where concern has been raised in the literature. Altvater *et al* (2011) comment that existing European scenarios have been developed independently, with each using different combinations of emission, climate and socio-economic scenarios, assumptions, projections for different time horizons and communication of uncertainties.

- 'This makes it difficult and sometimes impossible to compare the results from different studies and to form a vision of the possible ranges of future developments, needed for a coherent climate adaptation policy. Such a coherent vision requires a standard set of

> emission, climate and socio-economic scenarios, which can facilitate comparability on European-wide scale. Selection of variables, plausible range for these variables and causal mechanisms and linkages among different processes for such a set will need the deployment of probabilistic methods, with probabilities chosen in consultation with relevant stakeholders. In addition, standardised rules for development of sectoral assessments, based on the above mentioned standardised set of emission, climate and socioeconomic scenarios is also missing, making the results of each comparison of climate impacts in different sectors for the need of adaptation subjective and not transferable' (Altvater *et al* 2011a: 128).

While flexibility to use different assumptions can be valuable, a deliverable from the FP6 MACIS project highlights how many futures and scenario studies have been undertaken by research teams without a specific decision-making audience, and have not been sufficiently designed or communicated for their use in decisions-making (Wilson and Piper 2008: 67). The European Environment Agency's SWOT analysis of some selected studies (EEA 2008) makes similar points about the transparency and consistency of scenarios.

4.2 RESPONSES research on mainstreaming climate change beyond 2°C

In principle, it could be argued that the continued high level EU political commitment to 2°C, while a 4°C world looms ever closer, is less problematic than might be feared, for two reasons:

- At national/ local level, adaptation planners are well aware of, and taking into account in their day-to-day work, the prospect of much higher levels of warming.
- In many cases the preparation required for 2°C and 4°C worlds will effectively be the same, as the divergences between impacts associated with each will occur after mid-century, *beyond the lifetime of many of today's planning/ investment decisions*.

However, findings from the MACIS project suggest that the failure to test robustness of policy against a range of scenarios filters down to lower tiers. Wilson and Piper (2008: 66) comment that 'it is clear (for instance, from the stakeholder workshops … on the EU Green Paper on Adaptation) that for the most part existing policy review tools, such as the EU's Impact Assessment procedure, and EU-wide obligations on Member States such as EIA and SEA, are not systematically using these scenarios [IPCC, MEA and UNEP] to assess the robustness or resilience of plans or projects to climate change under different socio-economic conditions'.

Regarding (b), *Responses* Work Package 4 covering the water sector suggests that River Basin Management Planning may be one case where the divergence between impacts between 2°C and 4°C does indeed take place beyond the lifetime of current decision-making. In the first planning cycle of the Water Framework Directive, planning documents (see e.g. the Oder and Vistula RBMP) suggest that the foreseen climate changes will be of very little importance for the actions envisaged. In Poland, 2°C temperature increase is probable only in the second half of the 21st century. It is expected that within the time frame of WFD implementation (til 2027) a climate change signal will thus not be statistically distinguishable from the effects of other human pressures. Most investments undertaken in the electricity sector now do not last into the second half of this century. For instance, conventional power plants rarely have a lifetime of more than 40 years, while renewable power generation installations such as wind turbines tend to last about 20 years. Therefore, current investments in such installations are generally not affected by whether a 2°C or 4°C world emerges in the second half of the 21st century.

But there are cases where investments have a longer lifetime, and where a precautionary approach (in line with the EU's founding Treaties) would suggest assuming the greater level of warming. A substantial proportion of infrastructure built in the next five years will still be in use long after 2030 (DEFRA 2011). Even if infrastructure is built with a 40 year design life, it can remain after that (and equally if not more importantly, so can the changes in land-use that it may have facilitated). Parts of London's sewage system are 300 years old, but were not built with that timescale in mind (DEFRA 2011). In the electricity sector, although individual installations may have a relatively short lifetime, the system as a whole, whose structure is - at least in parts - being determined now for future years, possibly also beyond 2060, might be affected by the implications of a 4°C as opposed to a 2°C world. More specifically, the way the power system is organized, i.e. how much power is transmitted and how interconnected the system is might influence its vulnerability. More extreme weather events might require more resilient grid infrastructure (Government Office for Science 2012). Furthermore, one could argue that R&D undertaken now to develop power plants and power system components that will be built after 2050 should factor in challenges a 4°C world presents, including possible extreme events.

Particular dilemmas arise in the case of planning for biodiversity, where decisions need to be taken regarding the spatial prioritization of protected sites in the face of future uncertainties (Kujala 2012; Kujala *et al*, in press). In the *Responses* project, the biodiversity work package has shown that climate impacts are much larger in a 4°C scenario, even when accounting for some negative effects of mitigation actions on biodiversity. Uncertainty in projections for biodiversity is substantial (Garcia *et al* 2012), and derives mostly from the bioclimatic envelop models, and less so from the climatic models. Biodiversity research encourages the use of model ensembles to account for some of this uncertainty (Garcia et al 2012; Araujo et al, in press). Commenting on post-fire management in alpine forests, Steffen *et al.* (2009) argue that the trees that will provide nesting hollows and microclimates for many other species in 120 years' time need to be established now; yet in 120 years different tree species are likely to be successful under different futures. In this case, Steffen *et al* suggest that the only option is to hedge risk by promoting the establishment of different species in different parts of the same landscape, in the certain knowledge that some of them will turn out to be the wrong choices. The fact that some adaptation decisions may be so awkward needs recognizing, particularly as the likelihood of a 4°C world increases (Stafford-Smith *et al* 2009). We note that the issue is only briefly touched on in the Commission's new Guidance document on managing the effects of climate change on the Natura 2000 network (EC 2012), in a discussion about reviewing the need for new protected areas.[3]

Regarding point (a) above, according to Stafford-Smith *et al.* (2009), planners/ practitioners are *not* sufficiently aware of such uncertainties surrounding decision making. Work Package 4 offers some evidence that this may indeed be the case, for example in Poland.[4] In the energy sector, even in the UK, where adaptation policy making is relatively advanced, a member of the Treasury's advisory committee *Infrastructure UK* has suggested that assumptions currently informing UK infrastructure planning for energy are at odds with the Environment Department's

[3] This discussion quotes work by Esteve-Selma *et al* (2010).

[4] Climate change was not included in the CBA for the Wielowieś Klasztorna reservoir (although its lifetime is certainly more than 40 years). But note that including it may have strengthened the case for the reservoir. The most recent policy document concerning climate change (due by end of 2012) is the Strategy for climate change adaptation for Poland. In preparation of the Strategy analyses were conducted based on ENSEMBLES scenarios, mostly A1B. The highest increase for the average temp. in Poland was estimated at the level of 3 degrees.

warnings that the planet is on course for 4 degrees of warming (Nick Mabey, E3G, pers.com). The *Infrastructure UK* committee has warned that practice will need to improve from the position in the past where '[g]overnment has not produced a coherent view of the long term needs for UK infrastructure. Too often, there has been an emphasis on individual projects rather than taking into account the wider picture and the dependencies between sectors. The importance of maintenance, resilience and renewal of existing assets has often been neglected' (HM Treasury and Infrastructure UK 2010). The fact that planning of infrastructure development is fragmented and relatively short-term compared to the lifespan of its assets discourages consideration of climatic change impacts expected to occur during that lifespan. Instead climatic changes are adjusted-to incrementally through a reactive rather than proactive, systemic approach (Government Office for Science 2012).

Further survey work would be needed to establish to what extent adaptation planning 'on the ground' does take into account worst-case scenarios. Significantly, however, such research may not be conclusive either way; a recent review by the UK's Adaptation Sub-Committee of reporting by water companies of their responses to climate risks stated that:

- 'it is clear that water companies are actively considering current and future climate risks across the range of their operations. However, the reports did not provide sufficiently detailed information for us to assess whether water companies are systematically accounting for long-term climate risks in their investment planning in relation to managing the supply demand balance' (ASC 2011: 60).
- 'In our assessment, the current guidance on investment planning does not fully account for the uncertainty associated with climate change. Neither do water companies present a robust assessment of the implications of climate uncertainty in their plans for future investment that use this guidance. *Planning focuses on a medium climate change scenario*, along with an additional supply buffer. While companies are asked to sensitivity test their investment plans to different future scenarios, it is *not clear that this is comprehensively factored into decision-making*. This means it is hard to know how well water supplies would cope if futures outside the medium scenario were to be realised' (ASC 2011: 60, emphasis added).

Difficult decisions about adaptation are being made now, and harder choices are going to have to be made in the future. Yet for the time being, even in the most widely publicized examples of adaptation decision-making, such as the Thames Estuary 2100 study, it has been observed that the evidence needed to explore climate risks and the costs of adaptation from several perspectives is not transparently available (Hall *et al* 2012). The decision-makers' toolkit needs a greater diversity of instruments, and skills in deploying them need to be improved.

4.3 Key insights from the RESPONSES project

Insight 1: Even in relatively progressive jurisdictions, there is evidence that adaptation planners in key sectors insufficiently take into account the prospect of more extreme levels of warming than 2°C in their day-to-day work.

As adaptation planning has started in earnest in the EU, researchers in a number of projects—RESPONSES, but also MEDIATION and others—have begun to assess the state of the art for such planning. They have found that adaptation planners often have very little guidance on the practice of adaptation appraisal. In particular, there is a great deal of confusion concerning the level of climate change and associated impacts to expect in the coming decades.

This lack of awareness is of direct consequence for planning specifically geared towards adaptation. It also may have an indirect consequence for the mainstreaming of climate concerns into other planning efforts. People look to adaptation plans for indications of the seriousness of the threat. When those plans understate the severity of possible future climate changes, this may be reflected in decision makers' assumptions throughout a wide range of policy sectors, and undermine the process of mainstreaming.

Insight 2: There is reason for concern about the validity of current and past policy appraisals, because of a widespread failure to consider the robustness of proposed actions to conditions associated with warming far greater than 2°C.

The 2°C threshold does not come out of thin air: it represents the best estimate of the overall level of climate change at which impacts will start to be felt broadly, many of them beyond the ability of ecosystems and human societies to adapt. Below 2°C, it may be possible to assume that the world will look more or less the same as it does today. Above 2°C, and there may be important discontinuities. Important ecosystem services may fail, communities may need to migrate. It is impossible to predict most of these changes with certainty, but at the same time one can imagine many of them occurring with some substantial probability, should total warming go significantly beyond 2°C.

Organizations like the World Bank have started the process of screening their investment portfolio to see what projects—both those already existing and those in the planning stages—might be vulnerable to such changes. In the context of appraisal within the EU, however, such considerations have been largely absent. This may be because the EU has adopted the formal target of 2°C for mitigation, which then creates the justification for overlooking impacts associated with higher levels of global warming. Regardless of the cause, however, there is reason to be concerned that proposals have been put into place, and are continuing to be put into place, without consideration of whether they create conditions that will increase vulnerability to extensive climate change impacts.

Insight 3: The results of independently conducted assessments of climate impacts in different sectors are often not transparent, comparable or transferable.

One of the governance challenges of the 21st century is to take advantage of interactions across different policy sectors, integrating different policies so that they may serve society's core objectives in a manner that is synergistic, rather than conflictual. For this to happen, however, it is essential to be able to compare the effects of policies across such sectors. One place to look for the basis of that comparison is the results of formal appraisal, such as IA or SEA.

In the case of climate change, such comparison is exceedingly difficult. As RESPONSES work has highlighted, there is a lack of uniformity concerning how appraisals deal with possible future climate impacts. Some may stop at 2°C, while others concern themselves with impacts far greater. Because it is not always transparent when this is happening, it may be very difficult to draw conclusions concerning differential impacts of sectoral activities as a result of climate change.

5 Adaptation goals

In adaptation policy there is increasing demand for information about policy effectiveness. The development of adaptation indicators has been proposed by the European Environment Agency, and the European Commission in its Adaptation Strategy (to be published March 2013) is expected to propose mechanisms for reporting and evaluating adaptation in various policies at the EU level and at national level in EU Member States.

In order to say something about the effectiveness of policies, we need to start with their social, economic or political objectives. The main goal of adaptation will normally be to ensure that existing policy objectives can be secured, even under conditions of climate change. Therefore, in most cases, the goal of policies that promote adaptation will be to achieve current policy objectives, whether these relate to specific welfare, risk management or development goals. In this 'conservative' view, adaptation represents changes in policy, programmes and projects that allow current policy goals to be secured under conditions of climate change. Intermediate goals to achieve this successful policy may exist at various levels, such as making information available, provision of financial instruments, and development of legislation.

More recently, a debate has emerged about 'transformative' adaptation (Kates et al., 2012). In this case, prevailing policy goals or other social objectives may themselves be changed, voluntarily or involuntarily, opening up a different set of adaptation options. So, for instance, from a 'conservative' perspective, a rising coastal flood risk may lead to new investments in flood defence in order to maintain flood risk at current levels, while from a 'transformative' perspective a decision may be made to abandon a coastal area and plan for managed retreat instead. Under the conservative perspective, the goal of adaptation is to make new investments to maintain the *status quo*; under the transformative perspective an adjustment is made in the goal of adaptation, implying also a quite different strategy of adaptive actions.

We have earlier stated that adaptation or climate policy should be evaluated on a minimum set of criteria and that these should be included in appraisal approaches. These criteria are:

- Goal attainment (i.e. emissions reduction and vulnerability reduction)
- Cost-benefit
- Political feasibility

5.1 Defining adaptation goals for sectors: a risk management approach

In a risk management framework, risk is defined by the probability and the consequences of a threat. Strategies may be adopted to either modify the threat (here defined as proactive), or ameliorate consequences (reactive), or more broadly to improve adaptive capacity, without specifying particular measures. Adaptation policy can therefore anticipate specific threats or consequences, and a policymaker could decide to take action in order to secure existing policy objectives. A response to increasing risk is necessary, when consequences of the risk become unacceptably high (see Renn, 2008). There may also be cases in which a risk to a valued objective becomes intolerably high, because practicable or affordable adaptation options do not exist. In this case, it may be possible to speak of a 'limit' to adaptation, and preferences with respect to valued attributes will need to be adjusted. Under such transformative adaptation, new adaptation strategies and options come into consideration.

Adaptation goals addressing these risks cover a wide range of options, depending on the sector. Some examples are provided in Table 2. In principle, each of these adaptation goals can be linked to specific *adaptation strategies* which in turn can be supported by specific EU policies and measures. This is illustrated in Figure 8, which shows the relationships between climate change impacts on public health, the adaptation strategies available to manage these public health risks and the EU policy instruments that could contribute to facilitating these strategies. We therefore envisage a causal chain which links ultimate policy objectives through adaptation goals to adaptation strategies and on to EU policies and measures that support these strategies (see Figure 9). This also makes clear that policy support for adaptation will for the most part be integrated into existing policies and measures, rather than being a specific set of measures.

Table 2 EU policy objectives and adaptation goals.

Sector	**Policy objective**	**Adaptation goals**
Health	Low heat wave casualties toll	- Maintain cool urban spaces (proactive) - Install air conditioning in public buildings (reactive) - Adequate heat wave response measures (reactive)
Biodiversity	Maintain viable populations of species in designated conservation areas	- ensure ecosystem heterogeneity (proactive) - increase habitat connectivity (proactive) - manage impacts of extreme events (reactive)
Water	Protection of people and assets from floods	- Improving flood defences (proactive) - Improving upstream water storage (proactive) - Secure buildings from flood water (reactive) - Provide detailed information to public on risks (reactive)
Regional Policy	Robust infrastructures for economic development	- Reduce vulnerability of infrastructure projects to flood risk (proactive)
Energy	Develop new energy networks for low-carbon development	- Develop energy networks with low vulnerability to extreme climate events (proactive)

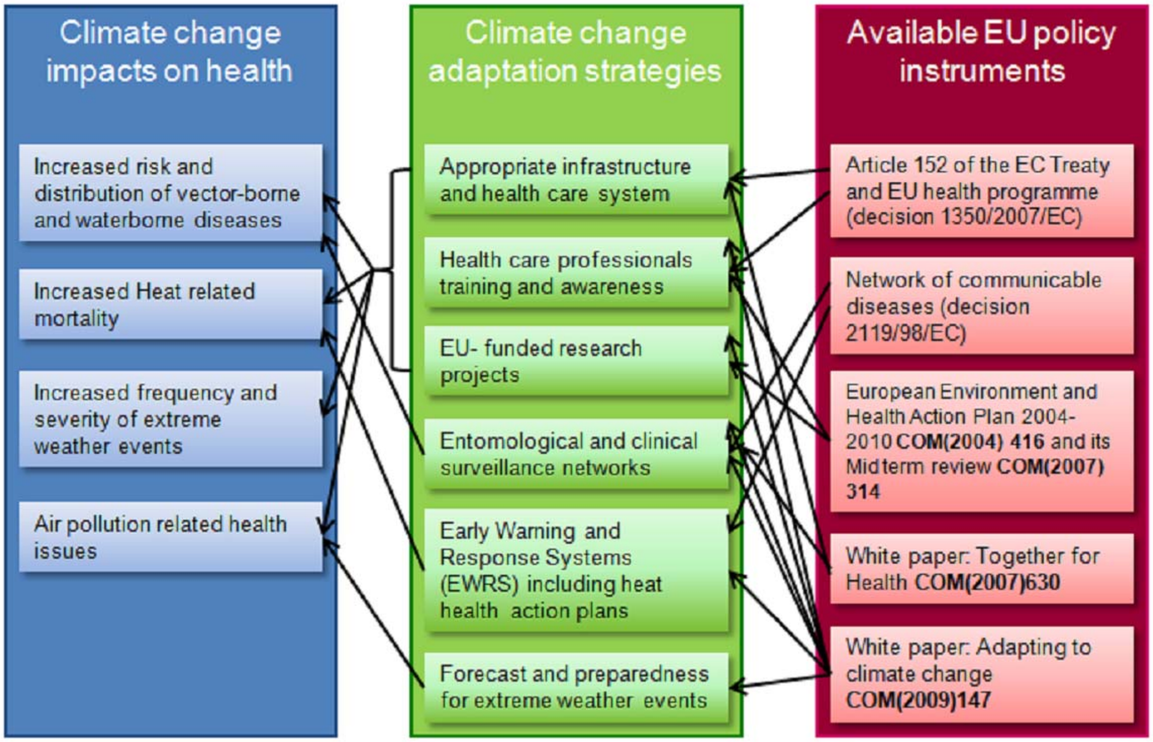


Figure 8 Relationships between climate impacts on public health, adaptation strategies and EU policy instruments.

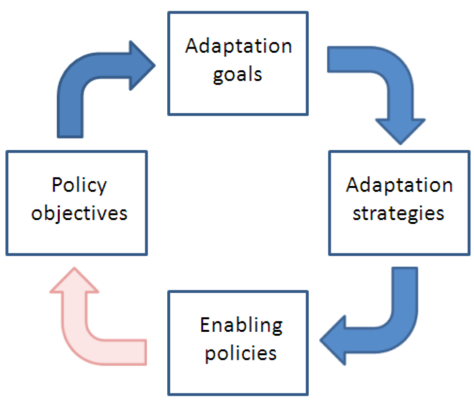


Figure 9 The causal chain between policy objectives, adaptation goals, adaptation strategies and enabling policies.

Note:

Enabling policies may include policies whose objectives are being secured by adaptation goals and strategies. Under conditions of transformative adaptation one of the adaptation options will be to adjust policy objectives. This is indicated by the pink arrow.

5.2 Uncertainty in climate change impacts and in policy effectiveness

A number of sources of uncertainty are at play, each with implications for defining adaptation goals. First, the hazard may be uncertain, as for many weather parameters (the hazard) the future rate and extent of change is uncertain or even unknown. This is because climate projections show wide spreads and because natural climate variability plays a dominant role in changes of extreme events distributions over time. More importantly, the relation between weather, or weather extremes and the impacts (consequences) is not always robustly established. Finally, other factors besides climate change determine changes in impacts or consequences. Socioeconomic development determines the exposure to weather hazards and therefore the extent of impacts, depending on a growing population of elderly people (in the case of heat wave risk), or the number of assets at risk in flood plain areas (in the case of flood risks). Also, the capacity to respond and adapt may increase, through wealth and technological innovation.

Given these uncertainties, it is hard to estimate the exact impact and timing of anthropogenically-forced climate change on existing policy objectives. Establishing whether a conservative adaptation strategy is appropriate or a transformative strategy is called for will therefore be difficult at the EU-level. Where a choice is made to adjust or relinquish prevailing goals, the problem of uncertainty will tend to grow. This is primarily because the social and technical system being considered is larger and the impacts being considered wider. Assessing the costs, benefits and feasibility of dyke-raising is less complex than assessing the costs, benefits and feasibility of a programme of managed retreat. Owing to this large, intrinsic and perhaps growing uncertainty, there would typically be a preference for allowing greater discretion at lower levels of governance.

When considering adaptation goals, the costs and benefits associated with the implementation of adaptation strategies need to be considered. While these strategies may reduce the burden of already existing and future weather and climate related impacts and losses, they are only justified when they are effective and efficient, that is, when the benefits outweigh the costs. A variety of well-established methods: cost benefit analysis, cost effectiveness analysis and multi-criteria analysis, are in principle available to assess costs and benefits (UNFCCC, 2011).

Adaptation goals may prove to be ineffective at securing a policy objective because existing or available methods are inadequate. For example, in European biodiversity policy, the Natura 2000 nature protection areas are designed to preserve target habitat types and species. With ongoing anthropogenic climate change, the habitat types and the distribution of species in these Natura 2000 areas will come under pressure. For instance, although national protected areas located in mountainous areas would preserve species better than unprotected areas, Natura 2000 areas in low-lying regions are less well-suited to species protection (Araújo et al., 2011). Certain designated Natura 2000 areas could therefore become ineffective over time, in the sense that the list of species an area is designed to protect can no longer be secured in that location.

Here the notion of effectiveness itself may need to be reframed. Narrowly-defined, a particular Natura 2000 area may no longer be effective as a ‘stage’ on which to protect a specific ‘actor’. But by ensuring greater connectivity between areas it may be possible to protect the species by allowing them to move around as their ranges change in response to climate change (Heller and Zavaleta, 2009). Under this scheme, effectiveness is judged across the whole network of nature protection areas, not simply one. An even more radical reframing would let go of the idea of conserving species one-by-one and look instead at species diversity as a whole by focusing on overall ‘species richness’ instead (Anderson and Ferree, 2010). Such an approach would represent a major change for EU biodiversity policy.

Given that adaptation will involve shifts in activities and resources, including the trade-off of policy objectives, the question of political feasibility will always play a role. The choice for a conservative or more transformative perspective to adaptation will also have a marked impact on the question of political feasibility. Under a conservative strategy broadly prevailing political and economic interests are preserved and there will be few winners and losers. Under a transformative strategy there are likely to be a far broader range of political and economic interests affected, some positively and others negatively. The distribution of risks among actors is also likely to be changed. Distributional issues arising from adaptation are therefore likely to come to the fore.

5.3 Key insights from the RESPONSES project

Insight 1: Adaptation goals may be conservative or transformative

The primary goal of adaptation strategies, enabled by EU sectoral policies, will be to secure existing policy objectives under conditions of climate change. This conservative notion of an adaptation goal will often involve minor adjustments in the design and implementation of policies. However, in some cases the costs of adaptation may not be justified by the benefits in terms of public welfare or risk management, or there may be trade-offs with other policy objectives that are deemed unacceptable. In extreme cases, practicable adaptation options may not be available, signifying an adaptation limit. Under all these conditions, when existing policy objectives can no longer be secured, a transformation of policy objectives and adaptation goals may be called for. Over the short term, examples of a need to consider transformative adaptation are in EU policy sectors such as biodiversity, agriculture and water.

The implications for policymakers are that they:

- Should define robust strategies and measures that help attain conditions under which policy objectives are likely to remain stable/improve under a wide range of climatic and socioeconomic conditions;
- Where appropriate, consider whether the economic, social, environmental or political costs of adapting to secure existing policy objectives may be disproportionate, and identify transformative options by reframing policy objectives and goals.

This is relevant for the purposes of policy appraisal, because explicit adaptation goals typically form the basis for the implicit assumptions within appraisals themselves. If, for example, a goal of adaptation planning is to maintain ecosystem services in a current location at their existing levels, then IA or SEA practitioners will assume this level of ecosystem services in the course of conducting cost benefit analysis. If, on the other hand, goals change, such that some ecosystem services will be enhanced as a result of climate change or climate policy (e.g. carbon storage, or water retention), and others degraded (e.g. irrigation supply), then policy appraisers need to be aware of these differences.

Insight 2: Given high uncertainty, adaptation goals and strategies may need to be devolved to lower levels of governance

The projected impacts of anthropogenic climate change on EU policy objectives in the areas of health, biodiversity, regional development and infrastructure, water, and energy, are highly uncertain. There are temporal and regional uncertainties about the projected changes in climate and weather parameters, as well as uncertainties in social systems that determine economic development and thus possible impacts, adaptive responses and residual impacts. Uncertainties may also arise through the transformation of policy objectives themselves, as the envelope of potential outcomes, effects and adaptation costs widens. Owing to this complexity and uncertainty, the potential for sound top-down governance of adaptation appears to be limited.

The implications for policymakers are that:

- In climate-vulnerable policy sectors, there will tend to be a stronger rationale for discretion and decision-making power at lower levels of governance as a result of climate and socio-economic uncertainties
- Even under conditions of high uncertainty, EU adaptive capacity and resilience may be enhanced through cross-European networks and interchange. Examples include the Natura2000 network and cross-border river basin agreements related to flooding and drought. EU sectoral policies should be reviewed to exploit these opportunities.

For the purposes of appraisal, this implies that there needs to be greater communication across levels of government, such that the revisions in adaptation goals that may be made at lower levels are apparent to those appraising policy proposals at higher levels.

6 Appraising uncertainty

A constant theme in the assessment of climate change and policy responses is the issue of uncertainty, and its twin brother, that of learning (ONeill et al. 2006). Countless articles have highlighted the role of uncertainty in climate policy making (e.g. Barnett 2001; Felgenhauer and De Bruin 2009; Tol 2003), suggesting aspects of climate uncertainty that need to be communicated (e.g. Risbey 2007; Webster et al. 2003) and how best to communicate them (e.g. Patt and Dessai 2005; Kloprogge et al. 2007; Webster 2003). Conventional wisdom in the climate change research and policy community holds that any perception by the public that there is uncertainty in the science behind climate change and its attribution to human actions has been and will continue to be the death knell for effective policy-making to combat it. At the same time, the climate change research and policy community has long recognized the importance of getting uncertainty communication "right," i.e., describing it accurately, completely, and free of value. There have been numerous guidance notes, written for the benefit of scientists, assessment team authors, and decision-makers, on how to measure, appraise, and respond to uncertainty; one set of examples is the series of guidance notes written by the Intergovernmental Panel on Climate Change (IPCC) (Moss and Schneider 2000; Manning et al. 2004; Mastrandrea et al. 2010).

One way of dealing with uncertainty is through the approach to governance. Ecologists developed the idea of "adaptive management" as a governance paradigm given high systems uncertainty (Holling 2001). The core idea of adaptive management is to design policy processes not only to take advantage of new information, but also to generate the information that may be useful in the future. A core aspect of this is to ensure that there is sufficient variance in the policies adopted at any given time; rather than all jurisdictions adopting a pre-supposed set of best practices, different jurisdictions should attempt to implement different practices, some of which might be better than others. There have been few real attempts to apply this concept at scale; in the only systematic analysis of such an attempt, Lee (1993) looked at the attempt to use adaptive management to restore salmon stocks in the Columbia River Basin, and found it to be a doomed quest, done in by political factors. A scaled back version of adaptive management, and often mistaken for it, is simply to ensure that policies can and will be updated over time. Rather than adopting a particular policy at one time, and assuming it will exist unchanged for decades into the future, it may be possible to ensure that it comes under periodic review. "Sunsetting" clauses, for example, can force this, requiring legislative or regulative action to sustain a policy past a particular date. It may be possible to evaluate, in the context of a policy approasial or assessment, the extent to which a particular option is adaptive over time, and hence could be responsive to new and improved information.

In the context of IA, SEA and EIA, however, the process for governance may already be pre-defined; there may be little flexibility with respect to whether a policy implemented now may be changed in the future. Hence, it is incumbent to incorporate uncertainty into the analysis of competing options. In this section, we cull the literature to offer guidance that is relevant for the purposes of mainstreaming climate change concerns into environmental, impact, and strategic environmental assessment practices. We take as a starting point the assumption that such assessments will cover far more than the climate mitigation and adaptation implications of a particular policy or project proposal. Given this, the time, attention, and resources available for addressing the uncertainties inherent in climate concerns may be limited. With these limits in mind, we arrive at three main practical insights. First, there are many uncertainties that are important for considering climate mitigation and adaptation implications of actions, and in many cases the most important ones are not those associated with climate science and prediction, but rather with the future development of economic, social, and technological systems. Second, most of the formalized methods for addressing uncertainty in policy appriasal and development require resources that go well beyond the scope of the typical environmental or impact assessment. It may be impossible to apply the methods quantitatively, and yet still possible to pay attention to some of the key insights. Third, qualitative decision tree mapping of the space of alternatives and information may be an excellent first step—and in some cases only step—in exploring the relative and absolute importance of key uncertainties within a strategic assessment process.

6.1 Guidelines for assessment, communication, and decision-making

There have been a number of articles and guidelines written on the subject of uncertainty management in the context of climate change and climate policy development. These have included sets of advice to scientists, to scientific assessment author teams, and to decision-makers. In particular the latter of these cover many of the formal methods that are potentially well suited to strategic assessment, the subject of this report. We cover the more well-known and most recent.

6.1.1 IPCC guidance notes

The IPCC's attention to the issue of uncertainty began with the Third Assessment Report (TAR), completed in 2001, with the preparation of a background paper and guidelines for author teams (Moss and Schneider 2000). Their intention was to provide a set of steps for the various assessment chapter team authors to follow. These were:

- For each of the major findings developed in the chapter, identify the most important factors and uncertainties that are likely to affect the conclusions.
- Document ranges and distributions in the literature, including sources of information on the key causes of uncertainty.
- Given the nature of the uncertainties and state of science, make an initial determination of the appropriate level of precision that is possible, such as qualitative versus quantitative.
- Quantitatively or qualitatively characterize the distribution of values that a parameter, variable, or outcome may take.
- Using two specific sets of terms, rate and describe the state of scientific information on which the conclusions and/or estimates depend. One set of terms encompasses qualitative judgment on the confidence the authors have in the basic knowledge: speculative, established but incomplete, competing explanations, and well established. The other set of terms matched particular words (e.g. very unlikely, unlikely, likely, very likely) to specific ranges of quantitatively assessed probability estimates.
- Prepare a "traceable account" of how the estimates were constructed.

Following inconsistent uptake of the guidelines by the different working groups, the IPCC organized an expert meeting to prepare for the Fourth Assessment Report (AR4), from which it drafted new guidelines. With 79 participants, the workshop featured a large number of presentations and breakout groups for each of the working groups to discuss. Following the workshop, the organizers drafted a report summarizing the proceedings (Manning et al., 2004), an Annex of which included a concept paper on the issue (Manning and Petit, 2004). A shortened version of the concept paper appeared as a guidance note for lead authors (IPCC, 2005). The new guidance notes built heavily on the earlier TAR recommendations, and indeed contained little in the way of new advice. The AR4 guidance saw more substantial, but still incomplete uptake by the author teams. Most recently, the IPCC revisited the issue of uncertainty in preparation for the Fifth Assessment Report (AR5). In July 2010, they organized a small meeting of the WG chairs and their close colleagues, which took place in Jasper Ridge, California (IPCC WGII, 2010). From this meeting, a core writing team prepared a new guidance note for lead authors (Mastrandrea et al., 2010), similar in form to the guidance note prepared for the AR4 lead authors. The primary new contribution was to go further in standardizing the language that IPCC authors were to use when describing uncertainty.

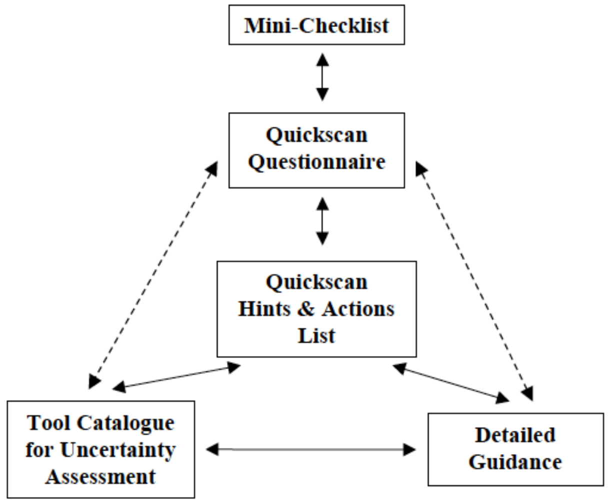
6.1.2 United States Government

The United States Government's Climate Change Science Program commissioned a set of reports to guide assessment, communication, and decision-making across the many agencies dealing with climate change. These reports took on the name Synthesis and Assessment Products, or SAP's. SAP 5.2 was one of these, and covered the issue of uncertainty. After initial drafting it went through extensive review, comment, and revision, before its final publication in 2009 (Morgan et al., 2009).

The guidance chapter in SAP 5.2 consisted of 16 bullet points, divided under two subheadings, *Reporting uncertainty* and *Characterizing and analyzing uncertainty*. Under the latter, the bullet points covered the value of undertaking expert elicitations in order to develop quantitative uncertainty estimates, the need to be careful in reporting (such as through separate distributions) when groups of experts disagree substantially, the need to apply care when using analytic tools such as Monte Carlo methods, to pay attention to sources of correlation between uncertain parameters, and to provide a traceable account as a form of information pedigree. The points continued with the suggestion that it is often effective to present the sensitivity of decisions to uncertainties, rather than simply the uncertainties themselves, and on the value of developing scenarios that are clear and transparent with respect to the critical variables. The advice concluded with the need to examine decisions strategies that are robust to uncertainty or ignorance, in cases where meaningful prediction is not possible.

6.1.3 Dutch Government

Perhaps the most ambitious set of formal guidance on decision-making under uncertainty was prepared by the Dutch government, for use in their administrative agencies, and drew off of the work and experience of a group of decision-theorists and empirical social scientists. A series of workshops, incorporating feedback from stakeholders, led to a suite of products to be used at different stages, and in different contexts, in an environmental assessment. Figure 10 shows the products.



a.

b.

Resources available ↓	Importance of uncertainty ↓ Small	Medium	Large
Few	MC	MC(+QS)	MC+QS
Medium	MC+QS	MC+QS	MC+QS(+DG)
Many	MC+QS	MC+QS(+DG)	MC+QS+DG

Abbreviations
MC **Mini-Checklist**
QS **Quickscan Questionnaire and Hints & Actions List**
DG **Detailed Guidance**

Figure 10 RIVM/MNP Guidance on uncertainty assessment. Part (a) is the suite of products. Part (b) shows the matrix for their application. Source: Petersen et al. (2003).

The starting point for consideration of uncertainty in an environmental assessment is the Mini-Checklist. This consists of a series of six questions, for each of which the assessment team has the option of answering “wholly,” “partly,” or “insufficiently,” and then providing additional elaboration if it is thought necessary. These questions are

1. Problem framing. A series of checkpoints cover whether the assessment authors have considered multiple problem framings and the connection with other policy processes.

2. Involvement of stakeholders. As series of checkpoints asks the assessment authors to consider whether they understand the range of stakeholder views.

3. Selection of indicators. The authors must identify whether the indicators they have chosen are unambiguous and well established.

4. Appraisal of knowledge base. The authors identify the state of the knowledge base upon which their conclusions are drawn.

5. Mapping and assessment of relevant uncertainties. The authors confirm that they understand the most important uncertainties relevant for their problem, and have identified the key sensitivities of the decision to those uncertainties.

6. Reporting of uncertainty information. The authors confirm that they have reported uncertainties in a manner that is fair and balanced.

From its face, the Mini-Checklist accomplishes two things. First, it provides a paper trail showing that assessment authors and researchers have paid attention to the issue of uncertainty and communication. Second, and more importantly substantively, it raises red flag when there are issues of uncertainty, or of communication to stakeholders, that may be problematic. In the case of such red flags, it then engages the Quickscan Questionnaire. That document consists of six groupings of questions, corresponding to the six items on the mini-checklist. The questions require the assessment team to identify, either through short written form (two sentence answers) or through checking multiple choice boxes, features of the assessment that have to do with its intended users, alternative framings, and associated uncertainties. The Quickscan Hints and Actions List is a 24 page document providing guidance to users on how to answer the various questions (Janssen et al., 2003). For further guidance, the Detailed Guidance is a 71 page document providing the theoretical foundation and background for all of the issues raised in the mini-checklist and quickscan questionnaire concerning assessment context and uncertainty communication (van der Sluijs et al., 2003). Finally, the Tool Catalogue is a 60-page document describing the analytic methods for developing and analyzing uncertainty, including issues such as uncertainty propagation, expert elicitation, and scenario analysis (van der Sluijs et al., 2004).

Wardekker et al. (2008) evaluated the success of the Dutch guidance system of documents. After the guidance was in place, they conducted a number of workshops and surveys with a variety of stakeholders, gathering data on what information people wanted and found useful, and on their specific reaction to an environmental assessment prepared using the guidance documents. Nearly across the board, they found that stakeholders did want uncertainties to be described, in quantified terms where possible, consistent with the Dutch system. They found substantial difficulties with the interpretation of the IPCC uncertainty scale on the one hand, echoing results from Patt and Schrag (2003) and Patt and Dessai (2005), and in interpreting the NUSAP kite diagram on the other. They did find that stakeholders were interested in information on the sources of uncertainty, and that all such detailed information be placed where people would actually read it, rather than buried in an appendix. Overall they were positive about the approach taken by the Dutch guidance system.

6.1.4 The European FP7 MEDIATION project

The most recent effort to provide guidance on decision-making under conditions of uncertainty, specifically addressing the issue of climate adaptation, has been the MEDIATION project. The goal of the MEDIATION project is to develop a uniform and comprehensive methodology for characterizing and acting on information about climate change, in order to assist adaptation decision-makers. Two particular deliverables of the project have addressed the tools for dealing with uncertainty.

The first deliverable was a guidance note on uncertainty and adaptation decision-making (A. Patt, Hinkel, and Swart 2011). It provided a background on models of human decision-making—economic, psychological, and sociological—and then covered methods of formal decision-analysis. For the latter, the document divided methods into those associated with deciding, and those associated with valuing outcomes. In the “deciding” methods were multi-criteria analysis, cost benefit analysis, cost effectiveness analysis, and robust decision-making. Of these only robust decision-making directly responds to the issue of uncertainty. Robust decision-making involves the use of computer models to examine the outcomes of a limited number of choice options under a wide range of possible future worlds, which in turn differ across several dimensions, including the sensitivity of the climate. The computer models identify those choice options that perform well under the widest range of future conditions. In the “valuation” methods were expected outcome valuation, expected utility and welfare analysis, general equilibrium analysis, inter-temporal discounting, real options analysis, and portfolio analysis. Of these, the first two treat uncertainty fairly simply, just taking the mean value of future outcomes, either in terms of their monetary valuation or in terms of the associated utility or welfare values. The latter two, by contrast, are quite sophisticated. Both real options analysis and portfolio valuation are most developed in financial markets, where data availability is high and the dimensions of decisions are few. In the area of climate adaptation, the MEDIATION guidance note points out, neither of these is typically the case, making both methods very difficult, and perhaps impossible, to apply.

The second deliverable is an inventory of methods and metrics that includes a set of policy briefs offering a critical review of particular decision-making methods. Three of these cover the methods real options analysis, robust decision making, and portfolio analysis, all of which specifically address the challenge of decision-making under uncertainty. They offer insights that are critical for their applicability for impact, environmental impact, and strategic environmental assessment.

With respect to Real Options Analysis (ROA), the critical insights from the MEDIATION project are that (a) its terms of applicability are quite narrow, and (b) the expense of conducting it in a full quantitative form is very high. ROA is applicable to one-time, irreversible investments, where there are both costs and benefits associated with making the investment now, compared to waiting until later to decide whether to make it. Typically the benefit of making an immediate investment is that the returns on that investment begin accruing sooner, rather than later. The benefits of waiting to make the decision—i.e., leaving the option open—are that more information will be known concerning exactly how the investment ought to be made, or whether it is even necessary in the first place. The MEDIATION project points to a single example of ROA analysis have been used in close to its full quantitative format, and that was for a study of adaptation in the Thames Estuary. There, the analysis cost over €1 million; in this case it appears worth it, given the magnitude of recommended investments being several billion euros. The report suggests that quantitative ROA is likely to be appropriate for adaptation decision-making only in exceedingly rare instances.

Portfolio analysis (PA) is a tool that developed in financial markets in order to maximize the expected return from an investment, subject to a fixed level of risk, or conversely minimized the risk from an investment, subject to a minimum expected return. The critical insight feeding it is the fact that a portfolio of two investments of equal expected return but uncorrelated (or negatively correlated) risks gives a combined risk level that is lower than each investment on its own. The MEDIATION report points to two examples of PA being used in a climate adaptation context; in these cases it was possible to put together a portfolio of adaptation options (in one case it involved planting multiple tree species; in the other it involved the combination of several flood management procedures), and to evaluate quantitatively their relative performance under a range of climate impact scenarios, each of which themselves could be quantified in terms of their livelihood. Compared to ROA the analysis was less expensive, but nevertheless involved the application of simulation modeling. The report was inconclusive concerning the overall usefulness of PA. Furthermore, the MEDIATION report suggested that in practice the application of PA is quite similar to that of robust decision making (RDM): the only practical difference between them is that PA requires the specification of probabilities for different scenarios, while RDM does not (Lempert and Schlesinger 2000; Dessai and Hulme 2007). In return, PA provides a set of portfolios lying at the frontier of the risk/return tradeoff space, while RDM does not provide estimates of risk, but rather qualitative insights into the set of future scenarios under which each choice option fares well or poorly. The MEDIATION report concluded that RDM offers a high potential for application to adaptation decision-support.

6.2 Key insights from the RESPONSES Project

Insight 1: Uncertainties in future climate impacts are unevenly distributed, implying a need for geographical and temporal specificity in the practice of policy appraisal.

Over the last decade, there has been a great deal of regional climate modeling for Europe, and that has revealed regional variation to be large; this in turn has important implications on sensitivities to uncertainty. Kjellström et al. (2011) presented results from regional modeling efforts, using 6 different climate models, each run numerous times with a variety of plausible input data. Figure 11 shows the results from averaging all model outputs, showing mean values for temperature and precipitation changes, summer and winter. Expected temperature changes vary seasonally and geographically from 1°C to exceeding 8°C. In the summer, it is primarily southern Europe that is expected to see the greatest temperature rise, while in winter it is primarily northern Europe. Expected precipitation changes vary seasonally and geographically from approximately a 60% decrease to a 60% increase. In both summer and winter, it is generally southern Europe that is expected to see a decrease in precipitation, while northern Europe is expected see an increase. What the figure does not show is that across the different models and model runs, there is a great deal of variance in the results for each geographical point, summer and winter, from which no clear picture emerges.

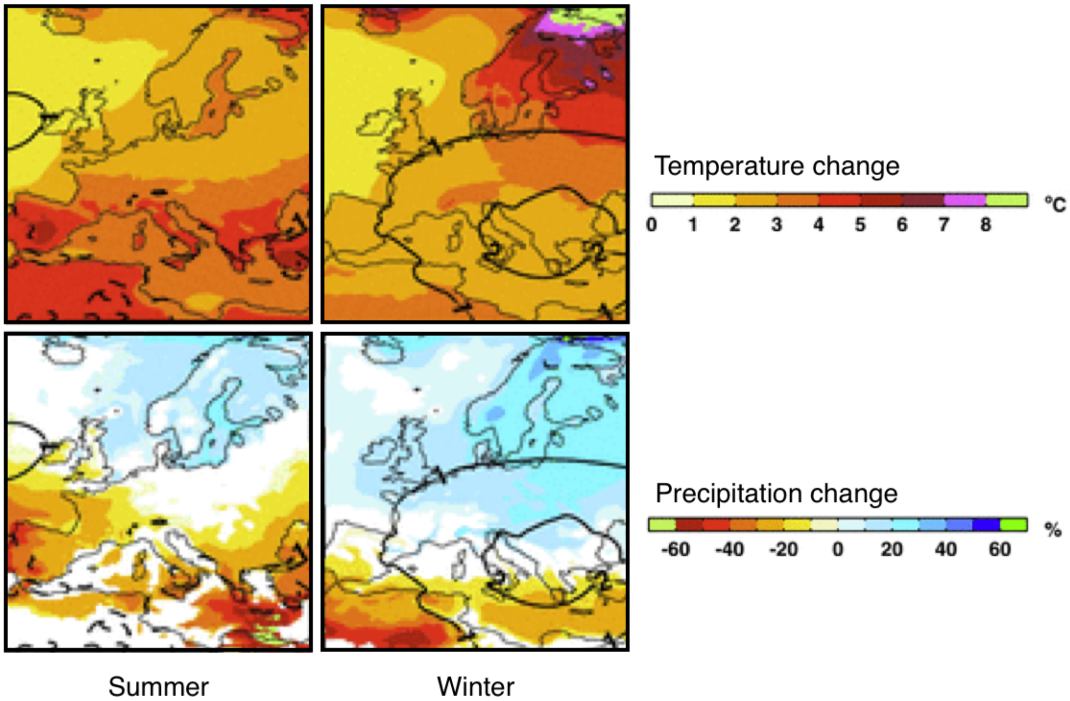


Figure 11 Changes from the period 1961 – 1990 to the period 2071 – 2100, from an ensemble of six regional climate models. The dark lines in each figure represent atmospheric pressure isobars. Expected temperature changes vary seasonally and geographically from 1°C to exceeding 8°C. Expected precipitation changes vary seasonally and geographically from approximately a 60% decrease to a 60% increase. Source: Kjellström et al. (2011).

Being able to ignore uncertainty can save a great deal of time and effort, and can make the politics of a given decision-task substantially easier. Many adaptation choice options are generated to respond to a particular climate parameter changing by at least some threshold value by a particular time in the future (such as summer precipitation rising by at least 20% by 2020), with a default option of staying with existing practices being appropriate if the threshold is not crossed by the relevant time. For regions expecting to see little change in a particular parameter, adaptations that address that parameter probably don't make sense now, while for those regions expecting to see a great deal of change, adaptations probably do make sense now. In between are those regions expecting to see moderate changes, and it is in those places that decisions are sensitive to particular uncertainties.

It is essential for policy makers to consider locally and seasonally specific climate impacts projections. While the need for adaptation may be greatest in those regions expected to see the greatest changes, the relevance of uncertainty—and the need to analyze it carefully—may be highest in those areas expecting more moderate change in the future.

Insight 2: Formalized tools for uncertainty analysis often require too much data to be practical

Coming out of research on governance and politics, there is evidence that the modern bureaucratic state derives a great deal of its legitimacy from the application of scientific methods to solving public problems (Ezrahi 1990). Consistent with this, there is often pressure to apply formalized, quantitative decision-analytic tools in order to backup difficult choices; at the very least, these tools can back up hard choices made at taxpayers' expense. In the burgeoning science and policy literature on decision-making under uncertainty, there have been multiple calls to base decisions on cost benefit analysis (A. Patt 1999), using complex mathematical methods and models to evaluate the expected values for different outcomes. Real options analysis and portfolio analysis are two of these tools.

Observation of practice, however, suggests that the more complicated the tool, the less value it may be in real-world situations. The one example of real options analysis being used to evaluate a climate adaptation decision, for example, required over €1 million for the collection and analysis of data; even then, the analysis did not manage to quantify all the elements of the problem that theory suggests ought to have been. That level of resources is one that is unavailable to decision-makers in most cases where an impact assessment, environmental impact assessment, and strategic environmental assessment is called for.

Deciding not to apply the more complicated decision-analytic methods may have the appearance of not taking the assessment task seriously. However, the opposite is the case. Taking the task seriously means allocating resources to those aspects of the assessment that can provide an answer that offer true insights. There have been many studies of how analysts can appraise situations involving significant risks and uncertainties that will produce information that is on the one hand normatively correct—identifying a strategy that will allow people to achieve their goals—and on the other hand enjoys the support of the people who must carry such a strategy out. A consistent finding is that analysts tend to miss important factors in such situations, such as the key values that stakeholders are trying to advance, the most important risks to those values, and even the data that can help to shed light on those risks (Irwin and Wynne 1996). Resolving this problem requires involving stakeholders, as partners, in the process of analysis (Fischhoff 1995). To make that analysis productive, however, it is important to focus attention on the issue of uncertainty.

One tool that can help to do so is the qualitative mapping of decisions and available information over time. This indeed was a strategy at the heart of the Thames Estuary study reported on in the MEDIATION project, as well as a wide variety of other context (e.g. Suarez and Patt 2004; Suarez et al. in press). The method involves diagramming, such as with decision trees, the decisions that need to be made, and some of the outcomes that will occur under different possible states of the world. In this context, stakeholders can offer their own opinions about which states of the world are more or less likely, and together with analysts they can explore whether it matters which state of the world will come to pass, and if it does matter, whether they can learn more about the states of the world before committing to an action. In essence, this method of analysis carries with it the key insights from real options analysis, but does so at a qualitative level.

Using assessment and appraisal as a vehicle for conducting such qualitative analysis of uncertainty can be very helpful, and indeed it falls within the scope of allowable practice. Of all the practical guidance for how to implement this, we see the Dutch strategy, described above, as the most transparent and the best developed. It starts at a very qualitative level in order to identify those uncertainties that appear important and potentially problematic. With those uncertainties, it identifies a sequence of analytic steps that can be undertaken to examine them. These start at a qualitative level, and only move on into the quantitative if such analysis is necessary.

Insight 3: Uncertainties in social systems, rather than the climate, may dominate the type of adaptation that is needed and possible; appraisals need to keep an open mind concerning what adaptation actions take place 'down the road'.

Uncertainties in future climate and climate impacts are large, but uncertainties in both socio-economic conditions and public attitudes concerning difficult tradeoffs are often even larger. Many—indeed most—of the uncertainties in social systems are ones for which it is impossible to assign precise probabilities for particular outcomes. In planning whether or not to construct a new ski lift, for example, it may be possible to quantify the uncertainty with respect to both natural snowfall and the potential for snowmaking (as a result of temperature) at that particular place, fifty years in the future. It would be exceedingly difficult, by contrast, to predict which of the two types of snow skiers of the future will prefer, which in turn will influence whether the lift in the place will be in demand. Combined, uncertainties in natural and social systems can preclude meaningful quantitative appraisal of long-term adaptation costs and benefits, and efforts to do so may be more misleading than reliable.

In almost every sector and region of Europe, however, there are major existing maladapatations that can be corrected, and it is not unreasonable to focus on these. Indeed, empirical observation of adaptation practices, in the RESPONSES project and elsewhere, has shown that adaptation primarily addresses existing maladaptations, rather than anticipated problems in the future. This is a sensible response to the uncertainties associated with projecting the future.

For the purposes of appraisal, this matters insofar as analysts assume particular adaptation goals and strategies. A cost benefit analysis may assume that people will prepare for an uncertain future climate across wide sections of society. But this assumption may be false, and indeed there is every reason to suspect that it will not be the case. What may be a more realistic assumption is that people will work harder and harder to correct the existing areas where climate is a threat.

7 Vulnerability and adaptive capacity

7.1 The basis of the problem

Starting about fifteen years ago, there began to be a sea change in thinking about climate change damages (Füssel and Klein 2006). Until that point, scientific research and assessment had primarily focused on the physical and ecological impacts of climate change as the key drivers of the damages that people would experience. As Patt et al. (2008) argue, this reflected a policy environment in which people viewed the critical question to appraise as the seriousness of climate change, and whether it would be worth investing society's resources to try to stop it. With the Third Assessment Report (TAR) of the IPCC, however, a new framing emerged for thinking about damages, namely that of vulnerability. The TAR defined the concept thus: "Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (McCarthy et al. 2001). The new framing may have grown out of recognition that a certain amount of climate change, causing damages, was inevitable; in such a case, one relevant policy question remained how much to invest to reduce climate change in the future, i.e. mitigation, but another was now how to reduce the damages from those changes that could not be prevented. (Patt et al. 2008).

The concept of vulnerability is closely linked with that of adaptation, and yet in a particular way. Adaptation can often take the form of measures that reduce either the exposure or the sensitivity of a system to climate change. Measures that reduce exposure include building dikes or sea walls, which prevent storm surges from touching human settlements. Measures that reduce sensitivity include a managed retreat of those settlements from the coast, or, addressing a different risk, developing drought-tolerant crop varieties for farmers. All of these measures directly address particular climate impacts and risks, and by addressing them, lower the corresponding damages and damage costs. The IPCC framing of vulnerability, however, suggests that there is a third approach to adaptation that might make sense: improving a system's adaptive capacity. An example of this would include making information about anticipated climate impacts, or adaptation best practices, available to stakeholders, such as with the planned European Climate-ADAPT Internet platform. Internet sites do nothing to stop floodwaters or help crops grow—they have no direct effect on the damages suffered from climate impacts—and yet they can help people better to help themselves. A focus on adaptive capacity is an indirect approach towards adaptation. The IPCC defines adaptive capacity in relation to climate change impacts as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences". It is determined by available technologies, economic resources and their distribution, the structure of critical institutions, human capital, social capital, information and skills, and public awareness (Smit et al. 2001). Most assessments define adaptive capacity as the capability for *planned* adaptation, as *autonomous* adaptation is hardly graspable with available data and methods (e.g. Metzger and Schröter 2006, Lung et al. 2011).

A great deal of literature in recent years has examined the drivers of adaptive capacity, and also the possible benefits of taking efforts to improve it. There have been numerous qualitative studies (e.g. Folke et al. 2002; Berry, Kiel, and Elliott 2002; Pelling and High 2005; Smit and Wandel 2006), and several quantitative ones (Brooks, Adger, and Kelly 2005; Yohe and Tol 2002; A. G. Patt et al. 2010). The results show that the elements of adaptive capacity are highly context specific, not only geographically but also in terms of what climate risks are being addressed, and what elements of a human environment system are to be protected from those risks. The results also suggest that in some cases the benefits of measures to improve adaptive capacity may far outweigh the more direct approach of responding to climate impacts. Lutz et al. (in review), for example, suggested that continuing efforts to improve secondary school enrolment rates of girls in sub-Saharan Africa could save over 100,000 lives per year from climate related hazards; this is a number of lives far greater than would be protected by the infrastructure measures looked at by the World Bank in a recent study, measures that would come at a cost of $70 - $100 billion per year through 2050 (World Bank 2010).

This report, however, is not intended to guide adaptation decision-making and appraisal in a developing country context such as sub-Saharan Africa, however, but in Europe, and that makes a difference. In sub-Saharan Africa, for example, there are a great number of school-age girls who are not enrolled, whereas in Europe the number is very small. Thus for Europe, two questions arise. First, is attention to vulnerability, as distinct from impacts, relevant for the purposes of IA, EIA, and SEA? More specifically, is there reason to believe that there exists in Europe a deficit of adaptive capacity, significant enough in magnitude that policies that cure this deficit will make a meaningful contribution towards reduced climate damages? Second, to the extent that there do exist deficits in adaptive capacity in Europe, where are they, and how can they be assessed?

7.2 Vulnerability in the European context

Although the vulnerability of people, communities and sectors in developing countries has been the primary concern, developed countries also show a growing interest in vulnerability and adaptive capacity assessments. At the EU level this manifests itself in intensified research efforts e.g. ATEAM, ADAM, ESPON Climate, RESPONSES, MOVE; it shows in increased awareness of regional disparities in climate vulnerability across Europe in regional and cohesion policy, (European Commission 2008, 2010a) and climate policy (European Commission 2009). DG Climate Action defines the role of the EU as being to "ensure that disadvantaged regions and those most affected by climate change are capable of taking the necessary measures to adapt" (European Commission 2010b).

The few pan-European vulnerability assessments use a refined version of the IPCC definition as their point of departure and conceptual framework, determining exposure and sensitivity based on comprehensive modelling results and adding a generic adaptive capacity indicator. Schröter et al. (2005, see also Metzger and Schröter 2006) conducted the first spatially explicit dynamic climate vulnerability assessment for Europe, focusing on human sectors at risk of ecosystem service loss. The purpose of this task was to provide decision support to stakeholders and decision-makers for the sustainable use of natural resources. The authors highlighted the importance of involving stakeholders throughout the assessment process to ensure the saliency and legitimacy of the results. This process rendered important insights on the usefulness of vulnerability assessment; most prominently the notion that stakeholders are more interested in impacts than in generic vulnerability assessments, and prefer to assess their own vulnerability/adaptive capacity (Metzger and Schröter 2006). The vulnerability maps which have been generated by the project may be helpful in anticipating vulnerability of sectors concerning different ecosystem services and thus serve as a basis for planning adaptation strategies. Ultimately, decisions require additional localized and context-specific information (Schröter et al. 2005).

Lung et al. (2011) developed a set of hazard-specific impact indicators for floods, droughts, heat waves and forest fires in Europe at NUTS II level. Based on the assessment the authors identified hotspots of vulnerability to natural disasters that were then compared to European infrastructure investment for adaptation across regions. The objectives of the assessment were mostly science driven, although the authors proposed implications for the development of the ongoing EU adaptation strategy and pan-European adaptation funding and mainstreaming. The results were presented to European and national-level stakeholders in a workshop. The participants found the results interesting on a general comparative level, but had reservations concerning: (1) the attribution of impacts to climate change, as well as (2) the additionality of measures that might have been taken anyway in the absence of explicit climate adaptation efforts and (3) the subjectivity of the choices made to define adaptive capacity and in turn vulnerability (Hanger et al. 2011).

Greiving et al. (2011), provide a general vulnerability assessment for European regions at the NUTS III level, to serve as a basis for a cohesive European territorial development policy, responsive to climate change. The special features of this analysis are the comparably high spatial resolution and the verification and validation of the pan-European results with in-depth case studies at regional and local levels. While the case studies largely confirmed the findings of the pan-European assessment, they highlighted the scale dependency of such endeavours and the fact that large-scale assessment blurs much of the regional and local specificity. Although the importance of stakeholder involvement was highlighted, no such process was consistently applied throughout the study.

More regional, local and or sector-specific studies lack comparability, but provide more context-specific, place-based and qualitative data, which is important for decision-making. Such examples also reflect the diversity of available vulnerability and adaptive capacity assessments in the context of climate change.

Holmann and Næss (2009) compare the effectiveness of vulnerability assessment approaches conducted in England and Norway. The authors emphasize differences based on the driving forces behind those assessments – stakeholders in the case of England and scientists in the case of Norway - and the level of awareness of adverse effects of climate change, which was much higher in England than in Norway. Indeed, Norway is generally considered to be among the least vulnerable and most resilient countries in the world. However, O'Brien et al. (2004a) conducting assessments on multiple scales, reveal climate vulnerability for certain regions, sectors and social groups across the country; highlighting thus the scale-dependency of vulnerability assessments. Also in a Nordic country, Glass et al. (2010) investigated how institutional determinants influence adaptive capacity in Sweden and what role vulnerability management plays in local political agendas. The authors conclude that vulnerability management involves mostly technological and reactive fixes, but missing are institutional knowledge, and local cooperation and coordination which could enhance institutional responses.

Kruse et al. (2011) assessed the vulnerability to climate change of the tourism sector in the Alps. The study was conducted to validate the pan-European vulnerability study by Greiving et al. (2011) and to explore aspects of adaptive capacity that may not be grasped at the European scale, such as cultural and institutional factors. This was achieved via a questionnaire that was designed according to the IPCC definition of vulnerability and adaptive capacity and distributed to relevant actors in the region, who answered based on their own opinion and judgment. The results showed significant disparities in awareness and available institutional knowledge across the region and is proposed to serve as a benchmark for local adaptation decision-making and improvement for adaptive capacity.

To date neither climate vulnerability nor adaptive capacity are explicitly included in any of the obligatory impact assessments prescribed by the EU (IA of EU policies, SEA and EIA for plans, programmes and projects). Furthermore, evidence that the inclusion of vulnerability and adaptive capacity assessments could be problematic shows in the discussion of scientific output with policy makers and stakeholders. Results from RESPONSES Work Package 6 suggest that integrating yet another aspect into obligatory environmental impact assessments might go beyond the capacities of those authorities who are required to implement them.

7.3 Key insights from the RESPONSES Project

Insight 1: Vulnerability reduction is less important in the European context than it is globally

Vulnerabilities of human-environment systems are much more salient in developing countries, where larger parts of the population rely on climate-sensitive sectors for their livelihoods and general adaptive capacity is significantly lower than in developed countries. Adaptive capacity cannot be seen exclusively in the context of climate change, but is a dynamic concept that may be depleted or enhanced by multiple stressors (O’Brien 2004a), and is thus inherently linked to wider issues of development.

Vulnerability and adaptive capacity are linked to immense inherent uncertainties and complexities (Patt et al. 2005a) and moreover are subject to extensive value judgments which in turn may be cause for conflict (O’Brien and Wolf 2010). These concepts should thus not be employed lightly. In the European context adaptive capacity, in all the ways in which it has been assessed, is much higher than in the developing world. Disparities exist across the continent but are significantly less pronounced. Given the reluctance of stakeholders to engage in assessments of vulnerability and adaptive capacity (Metzger and Schröter 2006) it seems these tools are of much less immediate importance than impact assessments, which are applied widely across countries and regions, for example to inform adaptation planning and the development of national adaptation strategies (Hanger et al. 2012).

Insight 2: Adaptive capacity and sensitivity vary across regions

In the light of the EU’s key objectives of economic, social and territorial cohesion, it is important to highlight disparities in vulnerability and adaptive capacity. Such pan-European assessments may guide EU policy development in general and adaptation and regional development in particular. Given uncertainties and value judgments in the selection of indicators it is important that not one single assessment, but multiple assessments from different sources, are used. Pan-European assessments, such as the assessment by Lung et al. (2011), help to identify vulnerability hotspots, which deserve extraordinary attention, especially at national and sub-national levels.

Recent work within the MEDIATION project, in particular, has identified some critical deficits of adaptive capacity at the national level, in terms of the capacities of decision-makers to make adaptation decisions informed by the best science, and to implement them to manage climate risks (Pfenninger et al. 2011). This is particularly the case in the newer EU member states, where government bureaucracies are still going through substantial growing pains. First, there is a tremendous degree of inequality among member states with respect to the amount of climate research that they fund domestically. Countries such as the UK and Germany have large research budgets, and a result of this a great deal of research, conducted at some of the leading research centres in the world, is focusing on the particular climate impacts and risks that their citizens face. Other member states, such as Romania, rely primarily on EU-funded research to find these things out. That research is less focused on the specific impacts facing citizens there, and is often conducted by foreign researchers, less familiar with the local contexts within which impacts are felt. Second, there is a high degree of inequality with respect to the degree of policy integration that has taken place (Jordan and Lenschow 2010). While the implementation of successful adaptation strategies often requires close communication across government ministries handling different policy sectors—from education to agriculture to disaster management—this is often lacking.

At the EU level, then, policy appraisal such as IA can take into account whether a given option has the effect of improving the state of specific climate knowledge for a particular member state, and also improving the level of policy integration in that country, especially for those countries where these aspects are problematic.

Insight 3: Local decision making capacities often matter

The third insight is that at the local level there may be pockets of low adaptive capacity that simply have not appeared in the literature to date. Many of the studies that have occurred have been at the national level, or have concentrated at the sub-national level on easily quantifiable indicators, such as income or education. But there have also been studies that have suggested locally-specific barriers to adaptation that may be particular important in some sectors. Several studies of the European wine industry, for example, have shown how the small-scale wine producers are often constrained in terms of the specific varieties that they can grow, whether because of rules prohibiting them from moving into new varieties, or because if they do so they will lose the benefits of varietal-specific certifications of origin (Battaglini, Barbeau, et al. 2009; Holland and Smit 2010). These are issues that would not be picked up by the studies that focus primarily on indicators.

In the context of SEA and EIA, both of which operate at the national or sub-national level, it may be worth considering whether there are particular factors constraining adaptation, either generally or in specific economic sectors, and whether the options under consideration would have the effect of augmenting or overcoming these barriers.

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