CARISMA

Innovation for Climate Change Mitigation

February 2018

A summary of results from the CARISMA project

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"Limiting global warming to 2 °C, or even 1.5 °C, requires behavioural change, stricter policy, and a drastic shift in investments, but also the accelerated deployment of a range of low-, zero- and even negative-carbon technologies and practices."
- The Paris Agreement goals and the EU's innovation policy

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"Scaling up for mitigation technologies will have implications beyond extrapolating single project impacts to larger scale implementation. The solution lies in contextualised policy approaches, considering technical and financial potentials, along with social structures."
- Assessment of climate change mitigation options: striving towards scaling up

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"Information and evaluation of climate change mitigation climate policies is crucial in a post-Paris world. While existing databases and evaluations offer useful insights, they are still skewed towards certain sectors (i.e. energy) at the expense of others."
- Climate change mitigation policies: interactions and evaluations

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"Policymakers' knowledge base can be further enhanced, making them better prepared to deal with unanticipated changes to the contexts or contextual factors that could shape the outcome of policies."
- Making context-sensitive climate policy for realising the mitigation potential

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"Moving R&I activities to emerging economies involves opportunities to reduce costs, adapt technologies to local markets and conditions, and take advantage of access to talent, knowledge, and new ideas."
- International cooperation on mitigation research and innovation

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"Knowledge exchange between researchers and policymakers is important, but challenging, as science and policy are communities with different cultures. How to move forward?"
- Learning from experiences in the science-policy interface

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Introduction

The goal of the Paris Agreement of 2015 is to limit the global mean temperature increase to well below 2°C above pre-industrial levels and aim for 1.5°C. Realising such goals requires substantial emission reductions, leading to low- or even zero-emission economies and societies over the course of this century, supported by options to extract greenhouse gases from the atmosphere. This would require a great variety of decision-makers to simultaneously overcome economic feasibility, technology availability and social acceptance issues of identified climate solutions, asking for significant coordination across governance levels.

The efforts through which countries address their mitigation challenges are communicated via national climate plans, the so-called nationally determined contributions to the global response to climate change (NDCs). Responding to its Paris commitments, the European Union requires Member States to submit Integrated National Energy and Climate Plans (INECPs), in accordance with the EU's Energy Union Strategy for 2030, and national long-term low emission strategies for 2050, by January 2019.

Scaling up mitigation options

The CARISMA project, funded by the EU's Horizon 2020 Programme, addresses a range of aspects related to successful implementation of technologies and policy for climate change mitigation. Earlier research and practice has already established a strong knowledge base on feasibility of mitigation options and pathways. Hence, CARISMA's efforts focussed on issues related to scaling up options within different country contexts. While decision-makers, both in the private and public sector, often have a good understanding of costs and potentials of options for mitigation, especially when implemented as a stand-alone project or small-scale programme, the consequences of large-scale implementation of options, in longer timeframes, in different social contexts, are often less clear.

For example, costs of a technology when implemented as a technology project may be mainly related to investment and operational costs. When scaling up the technology application within the sector or country, additional costs become relevant such as those related to grid system modifications (system level costs) and economy-wide costs. Moreover, people may not mind a single wind turbine or solar photovoltaic project, but may resist large-scale implementation of these technologies. It is in these areas where implementation problems often arise, and it is important that early in the policy cycle, at the stages of agenda setting, policy formulation and adoption of a policy package, the potential impacts of scaling up mitigation options are clearly understood and addressed.

Therefore, CARISMA has worked on improving the understanding of these aspects in terms of:

- The social, economic and environmental impacts of mitigation options in different country contexts when implemented on a scale required for realising climate and socio-economic goals;
- How effectiveness of national and European climate change policies can be influenced by developments in the policy and societal context;
- Positive or negative interactions with other climate or environmental policies, as well as innovation policies at the country or firm level;
- International cooperation in the field of technology and innovation, as well as on the 'transfer' of effective policies to other contexts.

This booklet highlights the main findings and insights from CARISMA's work to date.

Interface between policy and science

An important goal of CARISMA has been to bridge knowledge gaps, where they exist, between policymaking and scientific research, for example: how can policy issues be translated into research questions and how can findings from research be used by policymakers and private sector decision makers? In order to explore this policy-science 'interface', at several stages of the project, CARISMA actively engaged with stakeholders in different Member States. We expected that this would impact the project outcomes positively for two reasons: first, stakeholders from private and public sectors form an important target audience for CARISMA results, and second, stakeholders, as technology or policy practitioners, have experience and knowledge that is key to assessing the policy, economic and social aspects of scaling up mitigation options in specific regional or country contexts.

Therefore, the CARISMA team invited stakeholders to participate in, among other topics: analysing political, economic and social contexts in a range of EU case study countries; reviewing CARISMA's inventory of existing national and European policies related to climate change; identifying areas where climate-related policy instruments may interact with other environmental policy instruments and how such interaction may affect policy effectiveness; and exploring ways for international collaboration to strengthen research, innovation and transfer of technology options for mitigation.

While doing this, CARISMA's participatory steps and stakeholder engagement activities, were evaluated, which formed the basis for a reflection workshop on the policy-science interface in which also other EU-funded projects were involved. The lessons learned from that evaluation are presented in the next chapter.

Online portal for highlighting results of EU-funded research and innovation projects

Finally, CARISMA initiated a collaboration with other EU-funded research and coordination and support projects in the field of climate change mitigation. The goal of the collaboration is to increase visibility and accessibility of project results by the target audience (policy and decision makers) as well as greater continuity of access of a wider public interested in climate change mitigation. Usually, projects have their own websites, but these are generally no longer maintained once a project has ended. Together with the other projects (see also Box 1 on page 5), CARISMA created an online portal called ClimateChangeMitigation.eu, for posting articles with highlights from projects' research and analysis activities.

Each project has access to the back-end of the portal for uploading own articles and tagging these to the sections on the portal for easier search by visitors. The portal will continue to exist beyond the project duration of CARISMA, as the newly funded EU coordination and support action on climate change mitigation, DialoguE on European Decarbonisation Strategies (DEEDS), will continue the management and maintenance of the portal after CARISMA finishes its work.

Project details

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I4CE	France – www.i4ce.org
Wegener Center / Uni Graz	Austria – wegcenter.uni-graz.at
SEI Stockholm Environment Institute	Sweden/United Kingdom – www.sei-international.org
ZEW	Germany – www.zew.de
CEPS Centre for European Policy Studies	Belgium – www.ceps.eu
ENVIROS	Czech Republic – www.enviros.cz
UNEP DTU Partnership	Denmark – www.unepdtu.org

The Paris Agreement goals and the EU's innovation policy

As the 2015 Paris Agreement stipulates that global warming needs to be limited to well below 2°C, or even 1.5°C, emissions in the European Union and elsewhere need to be reduced rapidly. Aside from behavioural change, stricter policy and governance arrangements and a drastic shift in investments, this requires the accelerated deployment of a range of low-, zero- and even negative-carbon technologies and practices. In the CARISMA project, we have tried to investigate what the consequences of such renewed, deeper ambition would be for the EU's innovation policy.

We started with an evaluation of the current expenditure on different climate mitigation technologies. This was a challenging task as the mitigation technologies or practices are not necessarily listed as topics of research projects. It proved even more challenging to investigate the same for national research, development and innovation programmes. Figure 1 is the result of the assessment of EU funding based on a limited search on climate mitigation-related search terms in the European Commission's database. It can be concluded that R&D on a large number of technologies in the mitigation portfolio are funded over the years. Some emphasis can be seen on carbon capture and storage (CCS), biofuels, and transportation options.

The next step is to investigate whether there is reason to modify such a funding portfolio as a result of the Paris Agreement goals. Those goals roughly require a net zero emission of greenhouse gases in the European Union by 2050 or 2060. We have, for now, assumed that the higher end of the EU's Energy Roadmap indicative target of 80 to 95% emission reduction in 2050 compared to 1990 would suffice. For one, this would mean that several of the technologies supported in Figure 1 are not fully 2050-proof. If energy efficiency in industry, for instance, would achieve an admirable 30% emission reductions, but emissions have to drop by over 90%, we could conclude that we are wasting public R&D funding.

In the CARISMA project, we make suggestions for prioritisation of R&D on technologies based on whether they have a high mitigation potential, meaning that a) their possibility for application is wide, and b) they reduce emissions to near-zero, zero or below zero. The EUTL (European Union Transaction Log) and EEA (European Environment Agency) data reveal that for ETS (Emissions Trading System) covered sectors in 2016, emissions are for 874 Mt covered by power, 750 Mt by industry, and 151 Mt by other sources in the power and energy sector, such as CHP. For the non-ETS sector in 2015 (latest available), the numbers are transport 890 Mt, Buildings 630 Mt, Agriculture 436 Mt, non-ETS industry 423 Mt and waste 141 Mt.

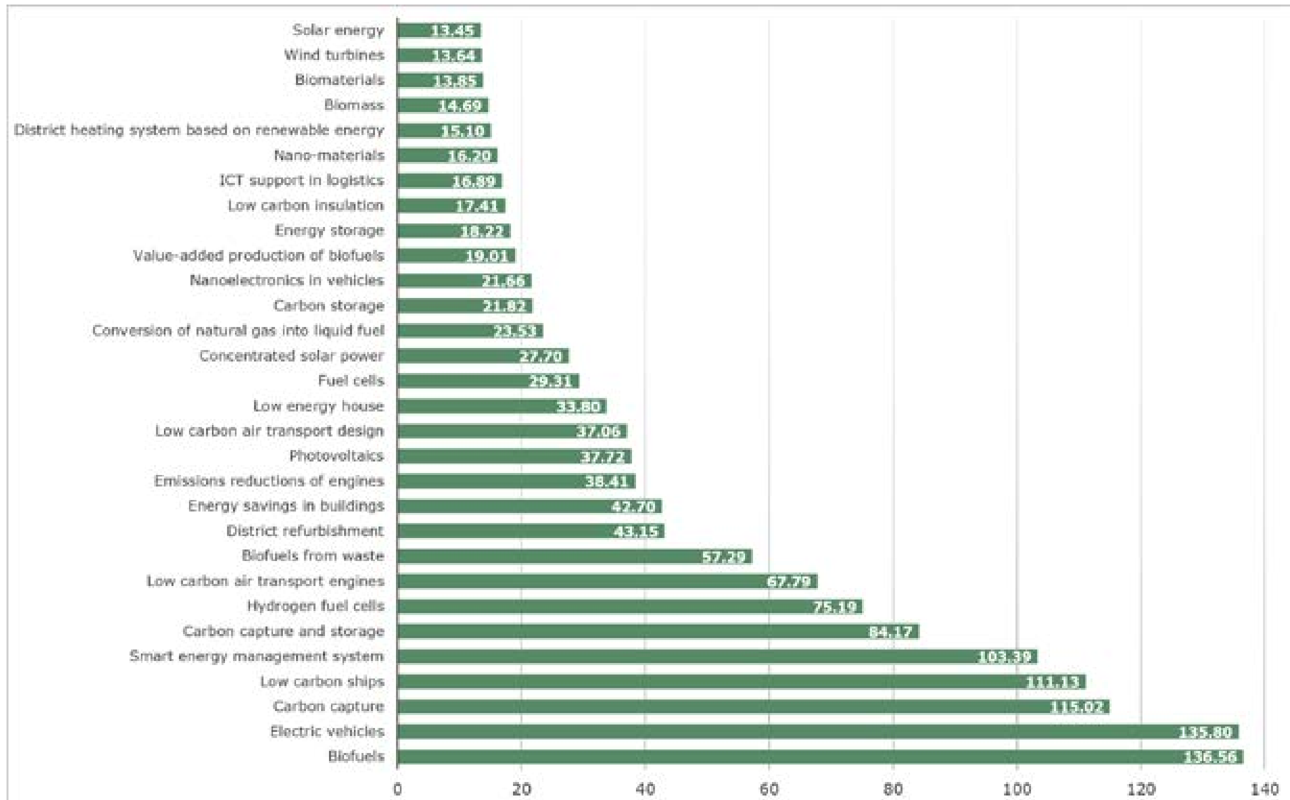

Figure 1. Spending by the European Commission Framework Programmes from 2008 to 2015 on various climate mitigation technologies.

The spending on R&D in technologies in different sectors is roughly proportional to their contributions, with the exception of the industry sector. It is therefore recommended that R&D is prioritised for technologies that could help industry to decarbonise quickly. These options have the advantage that they may be applicable to multiple sectors. They include:

- Scaling up and enabling renewable electricity: Renewable electricity options are a success story as innovation has led to sharp declines in costs and deployment is picking up quickly. Their applicability is wide: from heat pumps and transportation to electrification of industry. However, this leads to new challenges: to achieve the greater scale, grids and storage systems need to become much better and cheaper.
- Hydrogen: Most known for its application in transport, it may actually be industry that benefits most from renewable electricity-based hydrogen production, for instance in steel-making.
- CCS/CCU: CCS on coal-fired power has limited applicability after 2050 as it still leads to significant emissions, but on gas-fired power plants and in the longer run on bioenergy it is needed. Its application in industry is also a short-term option that enables deep emission reductions, also potentially in combination with biomass. Although CCU (carbon capture and utilisation) has limited potential on the short term, it may be interesting if options such as solar fuels can be realised in the longer term.

In this overview, we have focussed on expenditures on climate-related R&D. It should be noted that R&D in other fields could also increase or decrease emissions. A fuller overview of climate-related R&D would have to include R&D spending in other fields, by Member States and by businesses. However, such transparency and insight is, at the moment, beyond our reach.

Box 1

EU-funded research projects on mitigation

As introduced on page 3, the CARISMA project has taken the initiative to launch the ClimateChangeMitigation.eu portal for collecting and sharing highlights from EU-funded research and coordination projects on climate change mitigation. Until now, apart from CARISMA (2015-2018), twelve projects have joined this knowledge exchange platform initiative, and this range of projects shows the wide variety of EU-funded research being undertaken on mitigation.

Several projects focus on the assessment of **'transition pathways'** for climate change mitigation. The PATHWAYS project (2013-2016) analysed European 'transitions-in-the-making' on local and regional level with regard to for example the power system, transport, and household energy use. TRANSrisk (2015-2018) carries out an assessment of costs, benefits, and risks of transition pathways based on an integrated approach of modelling and interdisciplinary methods including stakeholder engagement. The INNOPATHS project (2016-2020) will describe a number of possible low-carbon pathways for the EU based on a co-design process with stakeholders, along with online tools to explain the pathways. Related is also the REINVENT project (2016-2020), that provides a new evidence-based framework to assess the viability, challenges, and governance implications of decarbonisation pathways, specifically focusing on important, emissions-intensive sectors.

Other projects focus on the combination of climate change mitigation actions with other **sustainable development** considerations. In CD-LINKS (2015-2019) provides information for designing complementary climate-development policies, by linking climate change policies (mitigation and adaptation) to multiple sustainable development objectives. GREEN-WIN (2015-2018) applies a solution-oriented approach to increase the understanding of links between climate action and sustainability, leading to win-win strategies for green growth. Just as the abovementioned TRANSrisk project, also the ADVANCE project (2013-2016) focused on **modelling**. This project aimed to evaluate and to improve the suitability of models for climate policy impact assessments.

With regard to climate change mitigation **policies**, the POLIMP project (2013-2016) facilitated a process to identify knowledge gaps about implications of possible directions of international climate policies, and cover these gaps. Related to this, the COP21 RIPPLES project (2016-2019) analyses the implications of the Paris Agreement and assesses the adequacy of nationally determined contributions (NDCs). The Carbon-CAP project (2013-2016) focused very specifically on consumption-based greenhouse gas emissions accounting and demand-side oriented climate policies, in order to realise a more effective climate policy mix.

Many EU-funded project focus on policies and measures for **energy efficiency**. This includes ENSPOL (2014-2016) that carried out research on the implementation of Article 7 of the EU Energy Efficiency Directive, and PUBLENEF (2016-2019) that aims at assisting government agencies in EU Member States, at national, regional, and local level, in the implementation of effective energy efficiency policies.

Assessment of climate change mitigation options: Striving towards deployment on a larger scale

The challenge of scaling up mitigation options

Developing Integrated National Energy and Climate Plans (INECPs), in accordance with the EU's Energy Union Strategy for 2030, and national long-term low emission strategies for 2050, implies that in many cases EU Member States will have to make fundamental decisions about restructuring their economies and societies. Such decisions require knowledge of how mitigation options 'behave' when implemented on a larger scale on the medium to longer term. As explained elsewhere in this brochure, when selecting and scaling up mitigation options, several aspects need to be considered, such as where to locate a technology for effective contributions to mitigation, what are system and macro level costs of scaling up, what are social implications of scaled up mitigation options and what does that mean for public acceptance of these? CARISMA addressed these aspects as follows.

How much do location-specific carbon payback times of mitigation options affect their climate benefits?

With carbon payback time (CPT) it is measured how much time it takes before a technology's contribution to emission reduction outweighs its own life-cycle emissions (e.g. emissions related to design, production, construction, operation and dismantling of a technology). CPT is very technology-specific, and its value is influenced by geographical, climatic and spatial factors, resource availability, and the local energy mix in the grid. For example, a wind turbine will have a relatively short CPT in a region with large wind resources and a relatively carbon-intensive energy mix, leading to high levels of wind energy production and replacement of technologies with high GHG emissions.

CPT is thus a helpful indicator for selecting locations for effective mitigation contributions by options. However, it also implies that, once these optimal locations have been used for a technology option, further scaling up means that the technology will be implemented in regions that are less effective from a mitigation point of view. In these regions, the same technology (e.g. a wind turbine) need more time before its contribution to GHG emission reduction outweighs its life-cycle emissions.

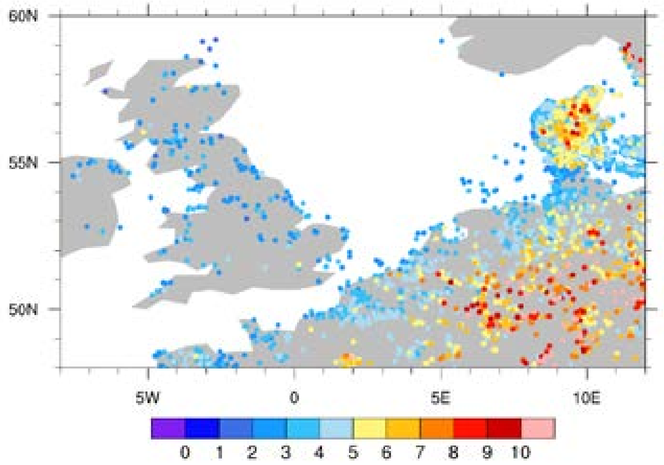

Figure 2: Example of location-specific carbon payback times (CPT) for wind power in North-West Europe as determined by CARISMA – the figure shows, e.g., that wind power in the UK and along the shore of the North Sea has a relatively low CPT (blue dots).

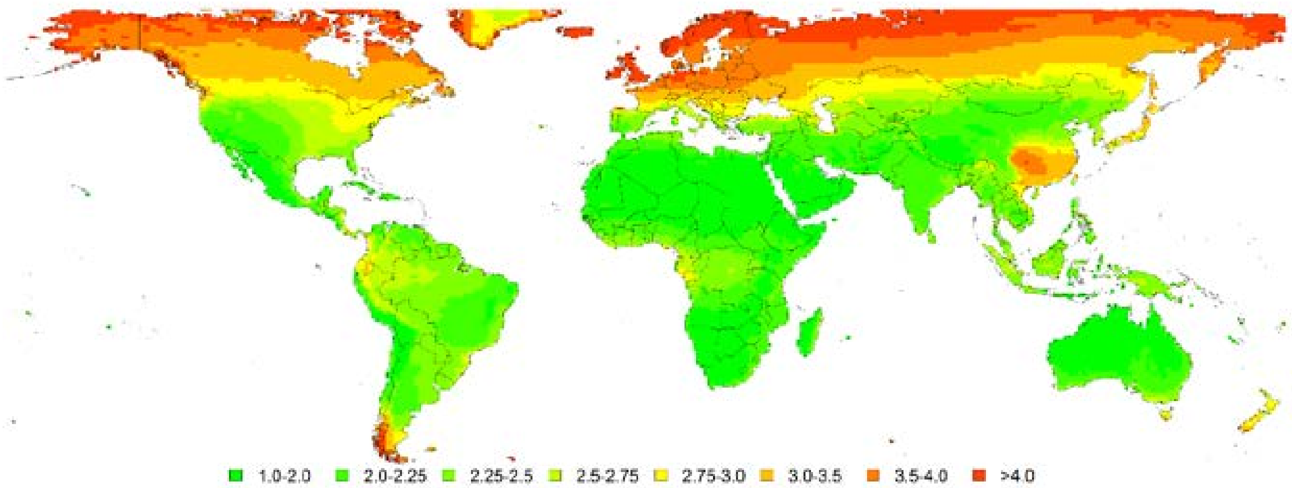

Figure 3: Example of location-specific carbon payback times (CPTs) for solar PV based on country-specific energy production mix carbon footprints (i.e. what are solar energy resources and what energy sources are replaced by it) – the figure shows, e.g., that in regions with low solar radiation the CPT is relatively low (towards red), but that the CPTs differ depending on whether or not a country has a carbon-intensive energy mix.

How can system and macro-economic costs of scaled-up mitigation options affect the scaling-up potential?

Next to identifying locations for climate-effective contributions by mitigation options, it is important for policymakers to understand cost implications of scaling up. These cost implications are related to technology investment and operational costs (these are so-called levelised cost of energy or LCOE), but also to the wider system (such as a power grid, which may need balancing adjustments and to which the project must connect) and in terms of economy-wide cost implications. With these insights an indication can be obtained of what is economically feasible, affordable, or acceptable given the country context.

In CARISMA, system- and macro-level cost impacts have been calculated with help of macroeconomic modelling for case studies in Austria and Greece. Both cases have illustrated the critical importance of moving beyond classical LCOE assessments of renewable energy expansion and incorporating macroeconomic effects and feedbacks in policy evaluation and design. For example, since wind and solar power are relatively capital intensive, scaling up these renewable energy options in Greece led to negative welfare impacts due to the relatively high costs of capital in this country.

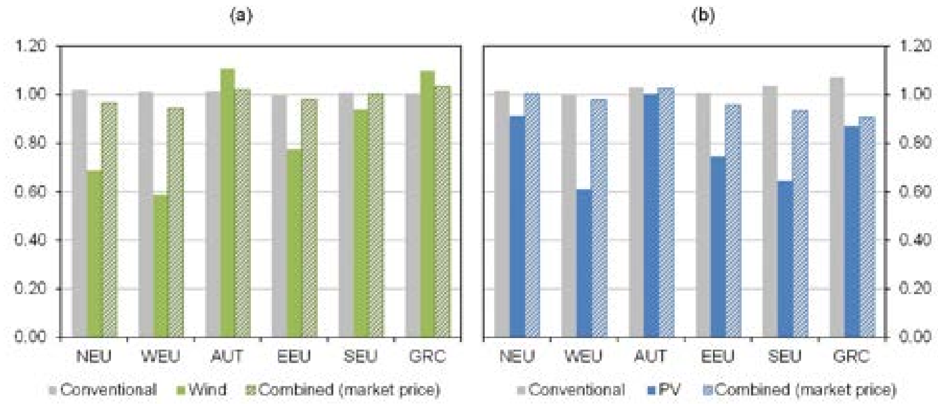

Figure 4: Relative electricity prices after the scaling up of wind (a) and PV (b) in different regions/countries, including integration costs (after economy-wide feedback effects). Prices are indexed to 1 for the case without expanding wind or PV (i.e. benchmark equilibrium). The "combined" price is the eventual market price that emerges, when combining conventional and wind/PV and supplying it to the market. (NEU: Northern Europe, WEU: Western Europe, AUT: Austria, EEU: Eastern Europe, SEU: Southern Europe, GRC: Greece).

What are viable approaches to opening up public discussions that would be needed for wider adoption and social acceptance of mitigation options?

Even if a mitigation option in a country is attractive from a CPT and/or wider cost perspective, this does not necessarily mean successful large-scale application of the option in the country. In fact, there are several examples of potentially promising mitigation technologies (even in pilots) that met with public resistance due to the social implications they were expected to have. The extent to which a mitigation option is publicly acceptable is an important determinant of its realistic potential within a country. The public may respond positively to small-scale projects but resist their scaling up ("not-in-my-backyard" or NIMBY).

As local contexts and priorities are of key importance for social impacts of technology options and since these can strongly differ, even within countries, 'one-size-fits-all' policy approaches should be avoided. Contextualised approaches to enhance people's awareness of a technology option, to include people in the process, and to provide clarity about costs and benefits and accompanying risks, are recommended for greater public acceptance of mitigation options, and unlocking their physically possible and economically feasible GHG emission reduction contribution within a country.

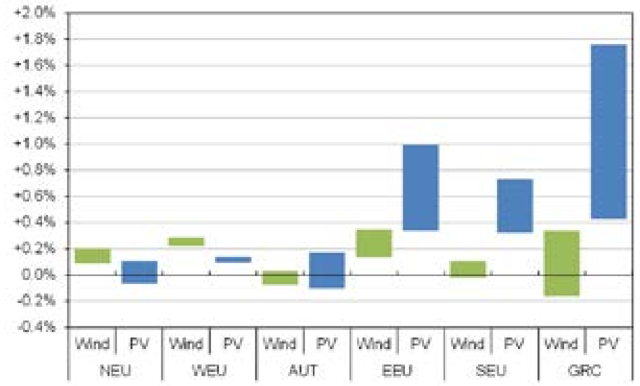

Figure 5: Ranges of possible economy-wide welfare effects (due to expansion of either wind (green) or PV (blue) electricity generation for European regions) (NEU: Northern Europe, WEU: Western Europe, AUT: Austria, EEU: Eastern Europe, SEU: Southern Europe, GRC: Greece).

These welfare effects result from combinations of high/low Weighted Average Costs of Capital (WACC) and boom or recession economy assumptions. Lower bounds show the effects of a boom + high WACC combination, and upper bounds the effects of a recession + low WACC combination.

CARISMA publications on this topic

The following publications by the CARISMA project can be downloaded via www.carisma-project.eu

- Report on identifying research needs for climate change mitigation technology options (Deliverable 4.1).
- Economic costs and benefits of renewables deployment in the EU (Deliverable 4.2.)
- Life-cycle assessments of climate mitigation technologies (Deliverable 4.3).
- Social implications of climate change mitigation technologies (Deliverable 4.4).
- Challenges and Solutions for Scaling up Mitigation Technologies (Deliverable 4.5).

Climate change mitigation policies in Europe: What do we (and what don't we) know?

Information on climate change mitigation policies

The Paris Agreement underscored the crucial importance of climate policy information. Robust information can help build trust that countries are taking climate action, offer greater certainty to investors, and allow civil society to exert pressure on governments. In recent years, various databases have emerged, compiling information about climate change mitigation policies in many countries. However, it is unclear whether this large variety of data sources and the available information match the expectations and needs of the various stakeholders.

To answer this question, we analysed 24 climate policy databases. Our analysis showed that data on climate change mitigation policies is increasingly available, a positive development in terms of climate policy transparency. However, available information is concentrated largely on the energy sector, with an emphasis on energy efficiency. Moreover, data availability is unevenly distributed, with information on policies in developing countries (particularly in sub-Saharan Africa) still being scarce (Figure 6). The databases also generally avoid comparisons of policies and offer little information about the costs of, and actual emissions savings attributed to, specific policies. We also found that the databases analysed are insufficiently linked to each other, thus forgoing potential synergies, and potentially leading to an information overload. However, this situation is changing as can be observed by the merger of two databases in our analysis into the "Climate Change Laws of the World" database.

We further carried out a survey and conducted interviews, to help understand what kind of databases are already used by stakeholders, what kind of information is sought, and where there are gaps between this desired information and the available information. What emerged was that what was needed – evaluations of specific policies – was often not included in databases. While this can be explained by the challenge of policy evaluation, resource limitations, and methodological difficulties, it points to the importance of making available information from evaluations (see below).

Climate change mitigation policy interactions

Interactions between climate and energy policies can occur if they target the same stakeholders. Interactions can be positive or negative and can cause climate policy results to deviate from expected results. We analysed how and to what extent policy interactions can occur, focusing on four case studies (in Austria, France, Greece, and the EU).

The study showed that policy interaction can take place through policies' overarching objectives, policy instruments, and their design characteristics (target, scope, technologies, and target groups). Policy coexistence can be justified if the policies are aimed at different targets, such as different policies for achieving short- or long-term targets. However, in some cases a specific policy interaction is assumed to lead to synergistic effects (e.g. with both policies leading to emission reductions), but with attendant undesirable effects (e.g. low carbon price). It is important to have provisions in place should effects of policy interactions be unanticipated or stronger than anticipated (e.g. the Market Stability Reserve). Policy interactions can further take place within one policy area within the same country but also between different policy levels, as shown in the case of Austrian energy efficiency policies. The French case study illustrated how renewable energy targets were automatically met as a result of achieving energy efficiency goals. An unintended side-effect was that the need to increase investments in renewable energy technologies was reduced, which may slow down their development. Similarly, short-term interactions between EU ETS and renewable energy policies may result in negative impacts on renewable energy technology deployment in the longer term.

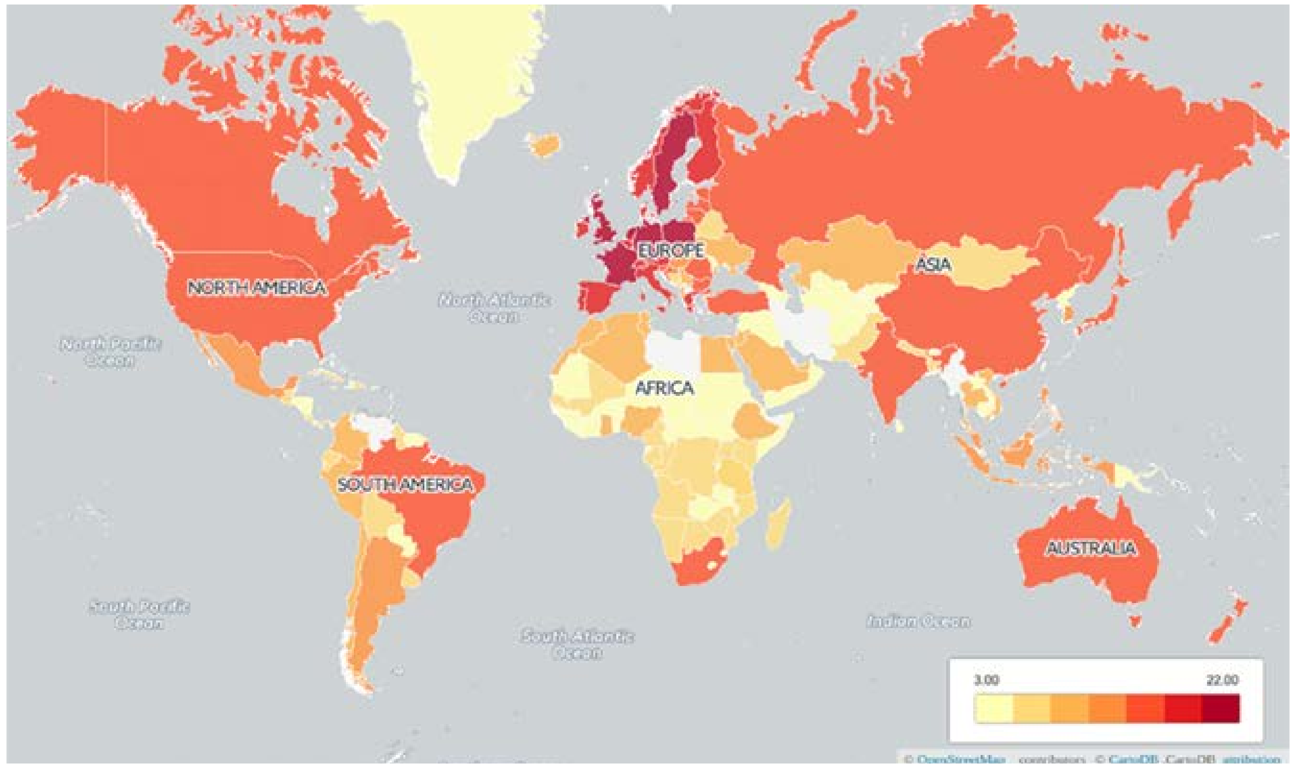

Figure 6. Country coverage of climate change mitigation policy databases.

Evaluating climate change mitigation policies

The evaluation of climate change mitigation policy is crucial for knowing how well policies work. But how are climate policies in the EU being evaluated? To answer this question, we conducted a meta-analysis of a total of 236 ex-post climate change mitigation policy evaluations in the EU and six Member States (Austria, Czech Republic, France, Germany, Greece, and the UK). By doing so, we aimed to provide insights into how evaluation practices might be improved and responds to information and knowledge needs about the state of European climate change mitigation policies, which are expected to become ever more important in the context of the Paris Agreement and the forthcoming Regulation on the Governance of the Energy Union.

Compared with the results of a previous meta-analysis carried out in 2008-2009, formal evaluations commissioned by government bodies have been on the rise in 2010-2016. Most evaluations focus on the effectiveness and goal achievement and usually forgo a deeper level of reflexivity and/or public participation in the evaluation process. The analysis also revealed the dominance of the energy sector in the sampled evaluations (Figure 7). We found that while the EU and the six Member States have made some progress in reducing emissions and increasing the share of renewable energy sources in the energy mix, other sectors such as transport and buildings for energy efficiency lag behind those efforts. The low number or indeed the absence of any policy evaluations in the agriculture, waste or land-use sectors is an area for further investigation.

CARISMA publications on this topic

The following publications by the CARISMA project can be downloaded via www.carisma-project.eu

- Report on climate change mitigation policy mapping and interaction (deliverable 5.1)
- Meta-analysis of climate change policy evaluations in the EU and Member States (deliverable 5.2)
- Climate change policy evaluations in the EU and Member States:
- Results from a meta-analysis (CARISMA Discussion Paper No. 4, January 2018)

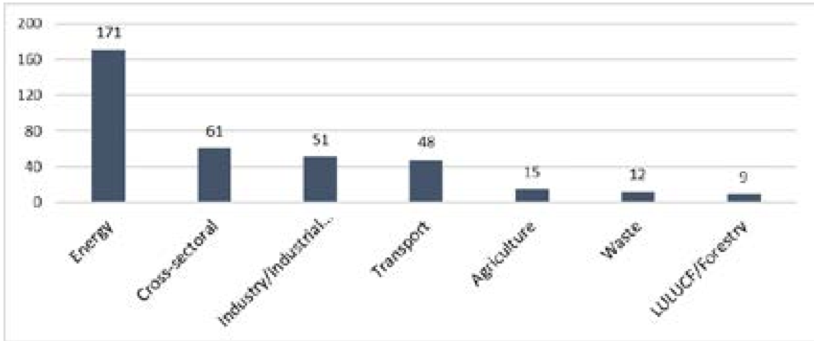

Figure 7. Sectors covered by evaluations in our meta-analysis.

Making climate policy sensitive to the contexts to realise the mitigation potential

Policymaking is complex: the institutional, economic and social policy contexts are difficult to control; and sometimes policy and policy instruments cannot deliver what was expected when they were designed. In practice, contextual factors could positively or negatively affect the implementation of policy instruments, and unforeseen changes to these contextual factors may influence the outcome of a policy instrument. The better policymakers understand these factors, and how they support or hinder the outcome of the policy instrument introduced, the better they could be prepared to deal with the unforeseen changes to the contexts that would shape the policy outcome.

In response to the above questions and for reality check, CARISMA carried out case studies on measures to support climate change mitigation in a number of EU Member States. CARISMA first undertook a literature review to group contextual factors in categories with common features. This has resulted in three categories of contextual factors: institutions and governance; innovation and investment; and attitudes and lifestyle. Within each category, four to seven individual factors have been identified (Table 1 contains an overview of the contextual factors). Identification of each factor was supported by a few examples reported from EU Member States in the literature.

Table 1. Overview of contextual factors as defined based on literature review

Institutions and governance	Innovation and investment	Attitudes and lifestyle
• Institutional coordination • Regulatory alignment with non-climate policies • Administrative feasibility • Constellation of stakeholders	• Presence of a technological innovation system • Market and regulatory framework • Policy continuity • Macroeconomic environment • Corporate and investment culture	• Collective environmental beliefs and norms • Demographic attitudes and other parameters • Public perceptions • Behavioural disposition at the individual level • Knowledge and experience • Financial resources • Social capital

The contextual factors thus identified from the literature review have subsequently been validated through country-based case studies within the EU. Case studies were selected to cover six countries and two timely policy topics for climate change mitigation: measures to support renewable energy, and smart technologies for energy efficiency improvement including smart grids (Table 2 contains an overview of the selected case studies.) The aims of these case studies were to identify the key contextual factors and discuss how they affect the outcome of the selected policies by interviewing national stakeholders (and if necessary by literature review as a background study).

Table 2. Selection of case study locations and policy measures for assessment

Country case	Policy measures assessed	Rationale for case study selection
Netherlands	Evolution of smart grid policies	Early adopter of smart-grid policies
Croatia	Renewable energy support scheme from 2008 to the present	Renewable energy policies spurred by EU accession, little initial capacity, significant obstacles
UK	Wind support scheme	Long-running renewable energy policies with substantial changes with a focus on wind power
Spain	Feed-in-tariffs and the evolution of policies that altered support measures for renewables	Long-running renewable energy policies in a region with high solar potential
Greece	Policies encouraging energy efficiency in buildings	Assessing factors for energy efficiency policies in early stages of development
Thailand	Renewable energy support instruments	Extension of the assessment of contextual factors beyond an EU focus

Note: The Thai case study is included to present a discussion on the first results of initial observations emerging from research efforts, and to serve as an illustrative example.

CARISMA publications on this topic

The following publications by the CARISMA project can be downloaded via www.carisma-project.eu

- Contextual factors affecting EU climate policies and their outcomes (CARISMA Discussion Paper No. 1)
- Report on the knowledge gaps about key contextual factors (Deliverable 6.3).

Despite the diversity of national circumstances in the case study countries and backgrounds of the stakeholders, a small set of contextual factors was observed in multiple case studies and acknowledged to affect adoption or/and implementation of policy instruments. This provided feedback on the mapping and categorisation of contextual factors based on the literature review.

Most of the factors selected by stakeholders are concentrated in the category of innovation and investment and to a limited degree in attitudes and lifestyle. In innovation and investment, more weight needs to be given to the presence of technological innovation systems and their adaptability to a changing environment. On the other hand, policy continuity is important for many stakeholders, which means that there is a balance to be struck between adaptability and continuity. Contextual changes can have beneficial effects on reaching policy goals, and policies designed with future corrections as a possibility have been seen as successful. On the other hand, tipping the balance too far towards radical or retroactive changes may hinder overall policy success. In response to the profound effects of the macro-economic environment, it is recommended that policymakers place more emphasis on assessing a range of scenarios, both best and worst-case, when designing and implementing policies. Electricity market and EU regulatory frameworks are found to have a large and varied effect on policy success (either helping or hindering) and warrant serious consideration during policy design. In attitudes and lifestyle, the need for increased and direct participation of citizens is stressed. A more focused consideration of the behaviour of households, moving beyond provision of information and training schemes, and a better understanding of behaviour is also highlighted as a factor in policy success.

Consequently, CARISMA adapted the overview of contextual factors to the feedback from the case studies (Table 3). With those insights, policymakers' knowledge base can be further enhanced, making them better prepared to deal with unanticipated changes to the contexts or contextual factors that could shape the outcome of policies.

Table 3. Overview of contextual factors as updated by CARISMA

Institutions and governance	Innovation and investment	Attitudes and lifestyle
• Institutional coordination • Constellation of stakeholders	• Presence of a technological innovation system • Market and regulatory framework • Policy continuity • Macroeconomic environment	• Public perceptions • Demographic attitudes and other parameters • Behavioural disposition at the individual level • Knowledge and experience

Note: Sub-factors are identified under each factor in Table 4 of the CARISMA report on the knowledge gaps about key contextual factors (Deliverable 6.3).

Box 2

Case study: Contextual factors affecting development of smart grids in the Netherlands

As case study, for several Member States the CARISMA project analysed how implementation of a technology of mitigation has been influenced by contextual factors. The table below presents the case of smart grids in the Netherlands, how contextual factor influenced deployment of the technology and what can be learned from that.

Contextual factor	Main contextual considerations	Summary of suggested options
Low fossil fuel prices	The Dutch government is exploring the optimal pathway to phase-out fossil fuels by considering growth of renewables, financial aspects, potential carbon leakage to other countries, security of supply and innovation.	Further investigation of the costs and benefits of a CPF (carbon price floor, i.e. minimum price for carbon emissions) introduction. Consider the option of linking revenues for the CPF to funds utilised for investments in innovative low-carbon options. Close monitoring of the CPF for distributional effects – timely consideration of cost-containment measures. Stronger political support for a more robust reform of the coal sector.
Presence of EU regulatory framework	Evolution of the Energy Data Service Netherlands (EDSN) from a bilateral communication facilitator to a central agency promoting synergies of the various parties.	Close monitoring of the "Experiementeerregeling's" data, examining the regional unbundling regulation suspension. Examination of the potential of the Energy Data Service for the Netherlands (EDSN) to provide instant metering and active consumer load control.
Market reaction to variability	Day-ahead and intraday price balancing, taking into account international energy trading with coupled markets.	Effort to increase collaboration with other Member States' markets to promote regulatory harmonisation towards a single European energy market, more flexible in negative price management. Assessment of the option to introduce a zero-electricity price limit after a certain period of negative prices.
Investment framework for DSOs/ESCOs to invest in smart grids	Efficient operation incentives given to DSOs. Pilot projects run to test new tariff structures and increase consumer willingness to change consumption patterns.	Investigation of incentive-based regulations applied in other EU countries promoting innovation. Consideration of introducing a separate innovation budget in line with (and not affected by) efficiency operation targets. Exploration of the costs and benefits of national dynamic/time-based electricity pricing mechanisms.

International cooperation on research and innovation for development and diffusion of mitigation technologies

Background
Reaching near-zero emission societies requires large-scale application of a wide range of technologies and measures for climate change mitigation. Several of these options have become commercially available, but many others are still at stages of research, demonstration in pilot projects, or deployment into markets. Research is an important driver for developing new options for climate change mitigation, but innovation is a key driver for successfully lifting the options to large-scale application as needed for reaching the goals of the Paris Agreement.

Research and innovation (R&I) in relation to technologies for mitigation is increasingly taking place at a global scale, across a geographically dispersed set of interlinked actors, units and activities. In particular, over the past decade a number of emerging economies, such as China, India and Brazil, have become prominent actors in global innovation activities. The global R&I landscape has therefore changed significantly from mainly being undertaken within and across the classic Triad of Europe, Japan and the United States to increasingly involving emerging economies.

With a focus on particular mitigation technology options, work conducted in the CARISMA project has focussed on gaining an improved understanding of this shift in the global R&I landscape. The insights generated have been aimed at informing key (international) stakeholders and decision makers on how international R&I cooperation could help to accelerate the development and transfer of climate technologies.

The work has been divided into three main areas of analysis: (1) International R&I initiatives; (2) R&I offshoring to emerging economies; and (3) transfer of climate change mitigation policies to developing countries.

1. Analysis of international R&I initiatives in mitigation technologies
The first area analysed by the CARISMA project involves analysis on specific R&I collaboration initiatives between various developed and developing countries focused on a number of climate change mitigation technologies. This work has clearly highlighted that there are different dynamics at play across various types of initiatives, which should be considered in relation to their design and implementation.

Generally, there is no single factor ensuring the achievement of desired objectives in international R&I collaboration initiatives. Indeed, the analyses conducted have revealed significant variation across various initiatives in terms of the involved actors, the scale and size, the specific sector in question, and the type of activities undertaken. Nevertheless, while the optimal structures consequently varies, some overall recommendations may be extracted in order for implementing agencies to ensure effective cooperation and outcomes:

1. A well-defined strategy and implementation plan is needed to ensure that the involved stakeholders can see the benefit and added value of their participation.
2. The specific objectives and targets to be realised should be clearly and explicitly defined to enable a shared understanding and alignment of expectations.
3. It is crucial to establish a monitoring system in the project in order to continuously evaluate progress and adopt measures to adapt to changing circumstances if needed.
4. Mechanisms should be put in place to enable effective coordination and communication across the involved actors and agencies.

2. Analysis on R&I offshoring to emerging economies in relation to mitigation technologies
The second area of analyses focused on the increasing displacement of R&I activities to emerging economies, as undertaken by multinational companies (MNC) based in Europe, and how that affects research and development of mitigation technologies. This work has identified a range of barriers and challenges related to R&I offshoring, as well as drivers and benefits for the companies and countries involved (see Table 4).

In terms of opportunities, the analysis shows that moving R&I activities to emerging economies involves an opportunity for the MNCs involved to reduce costs of R&I, as activities can be shifted to locations with lower salary levels compared to their European counterparts. Further, the establishment of local R&I units allows the MNCs involved to adapt existing technologies to local markets (and climate conditions) effectively in order to accelerate their deployment in local markets and diffusion to wider-scale applications. Thirdly, given the shortage of qualified engineers in Europe and the availability of a well-educated and skilled workforce in many emerging economies, MNCs benefit from offshoring R&I in terms of securing continued access to talent, knowledge and new ideas. Finally, European MNCs offshore R&I to emerging economies in order to tap into the knowledge available in local innovation systems and specialised clusters in the countries concerned.

Table 4. Key drivers and barriers of R&I offshoring to emerging economies.

Drivers and benefits of R&I offshoring	Barriers to and challenges of R&I offshoring
• Costs of conducting R&I • Effective adaptation of existing products to local markets • The global race for talent and new ideas • Tapping into specialised local clusters and innovation systems	• Cultural and organisational differences • Management and coordination of globally dispersed R&I activities • Intellectual property rights and spill-overs of knowledge and technology

However, the analysis has also identified a number of barriers and challenges related to R&I offshoring for the involved MNCs. A first challenge relates to cultural and organisational differences between the offshored R&I units and other parts of the MNC, including the MNC's own headquarters. Second, the management and coordination of a globally dispersed set of interlinked R&I activities constitutes a substantial challenge in terms of organisation and effective communication. Finally, the analysis has pointed out that MNCs devote significant efforts to protecting their intellectual property rights and preventing the spilling over of knowledge and technology from the offshored R&I units to the local economy.

In order for the MNCs to reap the benefits of R&I offshoring, and for R&I offshoring to contribute to accelerated development and diffusion of climate technologies, it is critical that the above challenges are addressed and overcome. National policies and measures could play an active role in supporting MNCs to reap the benefits, for example by developing and adopting supportive policies and by providing extension services for MNCs in the specific emerging economies.

3. Analysis of transfer of climate mitigation policies to developing countries
Finally, the CARISMA project has analysed how the understanding of transferring climate change mitigation policies from Europe to various developing countries can be improved. This work has pointed out that the policy transfer process is not a question of adopting a set of ready-made, one-size-fits-all incentive structures. Rather, a more complex picture emerges in which the involved actors actively interpret and modify policies according to the specific local conditions.

For such policy transfer processes to be successful, the CARISMA analysis recommends that a local champion is in charge of driving the process with a clear mandate, vision and leadership. This helps secure political commitment and coordinate activities aimed at designing a viable framework for investment. Furthermore, the process of learning from other countries typically proceeds through various phases from policy inspiration, through emulation and hybridisation. Since this process involves a number of actors, such as foreign donors, national policymakers, government agencies, interest groups and private sector actors, it is vital to ensure that activities and interests are regularly coordinated, monitored and evaluated to ensure a common direction.

CARISMA publications on this topic
The following publications by the CARISMA project can be downloaded via www.carisma-project.eu

- How should international institutions promote research and innovation technologies collaboration for climate change mitigation (CARISMA Policy Brief D7.1)
- Government-led international research and innovation collaboration in climate mitigation: Practical guidance for policymakers (CARISMA Policy Brief D7.2)
- International Collaborations in Industry on Climate Change Mitigation R&I Initiatives (CARISMA Policy Brief D7.3)
- R&D offshoring in climate technologies to emerging economies: opportunities and challenges for Europe (CARISMA Working Document No. 6)

Box 3

Workshop on international R&I cooperation

As part of the CARISMA project, a workshop was hosted in Amsterdam, 20 February 2017, to discuss international R&I initiatives taking into account the main actors and organisations involved in: (i) regional-level R&I initiatives; (ii) government-to-government R&I initiatives; and (iii) industry-specific R&I initiatives. Representatives from academia, government, international institutions, industry associations, and the private sector were present to share experiences and insights. Speakers included researchers from the CARISMA team, as well as Lisanne Groen (United Nations University), Ludovic Lacrosse (Full Advantage), Roland Keil (CLIENT II programme), and Yvonne Leung (Cement Sustainability Initiative).

The research done by the partners of the CARISMA project revealed that mapping R&I initiatives is a challenge. Feedback from the participants at the workshop indicated that a case study approach would provide more detailed insights. A suggestion was made by the research team to establish a common database for all Member States to register their initiatives. A take-home message from the workshop was that technology cooperation cannot be put into a replicable, optimal framework, as it requires flexibility, improvisation and endurance and will need to have heterogeneous key performance indicators. Moreover, technology cooperation should not be seen as stand-alone, but rather seen as integrated with other important policy aspects. All PowerPoint presentations from the workshop can be downloaded from the CARISMA website.

Learning from experiences in the science-policy interface

Scientific knowledge is key to climate change mitigation governance. However, effective exchange of knowledge between science and policy is challenging. Translating policymakers' knowledge needs into research questions and presenting scientific results into concrete policy advice is difficult. How did CARISMA address those issues in its original project design? What problems did it encounter? To help other projects learn from CARISMA's experiences, the project team engaged in active reflection on its project design and the roles it played, through independent observation of activities, a reflection essay, and a workshop.

Science-policy theory suggests collaboration between scientists and policymakers, stakeholder participation and iterative communication as key principles for improving the science-policy interface. Confronting observations during informal talks, formal interviews, workshops, and document reading with the scientific theory on these matters, the reflection essay – Organising effective exchange in the science-policy interface: Lessons from the Horizon 2020 CARISMA project – critically discusses how the CARISMA project applied such principles. Examples of activities for strengthening the science-policy interface initiated by CARISMA include stakeholder engagement through feedback loops, interviews with the project's Advisory Board members, and an information platform. The essay functioned as a starting point for a workshop on Building Productive Relations at the Science-Policy Interface, held in Nijmegen (the Netherlands) on 30 October 2017, involving also other EU Horizon 2020 projects.

Challenges at the science-policy interface

Key issues regarding CARISMA's activities include, for instance, that realising iterative and two-directional communication between policymakers and CARISMA researchers via feedback loops during the project proved difficult in practice. In addition, active mediation in conflicting interests about knowledge was necessary. Further, CARISMA aimed at commensurate assessment and research, but such activities provided tensions in allocation of resources, as well as in the roles played by the CARISMA researchers in advising policymakers.

Two more structural issues were identified based on these observations. The first concerns the roles of researchers in applied knowledge projects. While the role of providing actionable knowledge that is directly applicable for decisions is important, a deeper reflection shows that more roles are valuable and necessary for a sound science-policy interface and interaction. An important conclusion for CARISMA and follow-up projects is to acknowledge that there are many types of knowledge use and that there are multiple valuable roles researchers can play. The second structural issue is the incentive structures for ongoing collaboration. Researchers and policymakers are communities with different cultures, and their performance is measured against different criteria. Collaboration via several iterative cycles is time-consuming but not necessarily rewarded in their environments.

To work effectively in the science and policy interface, CARISMA needs to balance flexibility and stability. The possibility to adapt the original project plan was key for CARISMA's impact. For example, while initially not foreseen, the joint decision was taken by the EC project officer and the project team to develop an information platform integrating and engaging results of multiple EU projects rather than creating a forum for exchange. Another example was the opportunity for flexibility in both content and deadlines of deliverables which enabled the project team to push for more salient outcomes.

Seven directions to move forward

Effective work at the science-policy interface needs a significant effort of all actors involved, as well as an institutional environment that incentivises commitment of researchers and policymakers. Such a commitment would facilitate cross-boundary cooperation, rather than dissolving the productive differences between the two communities altogether. The workshop in Nijmegen with practitioners of the science-policy interface resulted in the following seven directions forward to make knowledge exchange between science and policy more effective:

1) Reflect and act on the role of project researchers. Multiple roles in a project are useful to cover the multiple aspects of the science-policy interface. Examples of roles are information provider, knowledge broker, science arbiter, consultant, and facilitator. While hard to combine in a single person, a project team can contain multiple roles. Especially in domains characterized by scientific uncertainties, clear communication of the roles taken is important to maintain credibility and trust.
2) Beware of the dynamics of the policy process. In the agenda-setting phase of policymaking knowledge needs are different from those in the decision phase. Agenda-setting may allow or call for novel ideas while the latter is about substantiating or amending a decision at hand. The criteria and timing to which knowledge should respond varies with the phase.
3) Explore and try alternatives in communication. The target audiences are diverse and often lack time for detailed reports. Involving science journalists and influential societal actors can help translating research findings in salient messages. Influential societal actors can also act as ambassadors. Using alternative communication means requires a clear understanding of the different audiences of the project, the type of information that they need, and the routes via which knowledge reaches them.
4) Incorporate and appreciate flexibility in projects. The system of ex-ante scheduled deliverables, while helpful for keeping a project on track and ensuring that outputs from one project phase are available as inputs in other project phases, does not offer much flexibility in terms of scheduling delivery of a research output when it is most timely from a policy perspective. Solutions to address this are: offer flexibility to project coordinators to reschedule a deliverable, without jeopardising the overall project progress, or prepare intermediate spin-offs from deliverables-in-progress, such as policy briefs.
5) Be realistic about and prepared for stakeholder involvement. Involving stakeholders is vital for both relevance and robustness of research. Different rationales for involvement are legitimate, but it is important to be realistic about how often and at what level of detail stakeholders will be able to collaborate with a research team. Such expectation management is also important in communication with the funding agency or client. After all, involvement requires substantial investment of time and resources of all actors involved. This points at two conditions: 1. researchers and stakeholders need to clearly communicate the purpose and structure of the participatory dialogue; 2. for stakeholders, the time spent on cooperation must be rewarding, such as opportunities to co-design a decision process or obtain additional knowledge from the cooperation
6) Reconsider funding criteria to include collaboration between researchers and policymakers. Demonstrating how collaboration between research and policymakers is guaranteed should be an eligibility criterion for funding. Successful collaboration could be rewarded by funding small joint projects between researchers and policymakers that address follow-up questions from the project's assessments. The latter can be handled in two ways: either by reserving an amount of money within a project's budget for future, yet-to-be-defined follow-up questions, or extending a running project with an additional budget for addressing the follow-up questions. The latter may be preferred less as it requires amendments of an existing contract.
7) Invest in stable knowledge infrastructures. Ad hoc funding is problematic for knowledge infrastructures that require ongoing maintenance, such as online platforms. Invested human capital in the form of relationships between people at the science-policy interface is crucial, but risks discontinuation when projects end without direct follow-up. This needs rethinking how and with what criteria to fund Coordination and Support Actions, such as, for instance, transition periods between completed and incoming EU-funded projects in the same areas.

The seven directions address both the direct actors involved as well as the institutional environment in which the operate. The seven recommendations should not be understood in isolation but are highly interrelated. Investing in a skillset of participating researchers, stakeholders and project coordinators is of no avail if the operating environment is not enabling. Also, a favourable science-policy environment remains just that if not navigated adequately.

CARISMA publication on this topic

This is a shortened version of the essay 'Organising effective exchange in the science-policy interface: Lessons from the Horizon 2020 CARISMA project' by Daan Boezeman and Heleen de Coninck. Daan Boezeman previously worked for Radboud University, and is now a researcher for PBL Netherlands Environmental Assessment Agency. The essay will be available to download shortly via www.carisma-project.eu

Box 4

EU climate leadership after Paris

EU climate governance has both internal and external dimensions. A key question regarding the external dimension concerns the EU's international climate leadership. While the EU has long been viewed as a climate leader, the failed climate conference in Copenhagen and the secondary role played in Paris cast some doubt on this claim. Moreover, recent developments, including Brexit and the rise of populist parties, pose significant challenges to its climate leadership. With the US federal government turning away from multilateral climate action, EU climate leadership is needed more than ever. In a CARISMA discussion paper, we show how the EU has led on climate change in the past, and analyse the current challenges faced by EU climate and energy policy. The brief offers suggestions to improve internal climate and energy governance, including strengthening ties between EU institutions and subnational and transnational actors, creatively employing side-payments and policy linkages, ramping up support for mitigation technologies, strengthening the monitoring of climate policies, and communicating the results of the EU's efforts to a wide audience. Externally, the EU could reclaim its international leadership role by strengthening existing partnerships with non-EU countries, and orchestrating new climate initiatives.

Box 5

Strengthening coherence in global climate governance

Global climate governance is not confined to the UNFCCC and Paris Agreement. Climate action is taking place in other multilateral forums, including the Montreal Protocol on ozone-depleting substances and international regimes governing international shipping and aviation, and new climate coalitions involving a limited number of countries. Moreover, a groundswell of non-state and subnational action complements the actions by nation states. However, ensuring coherence in this broader system of climate governance will be key to meet the Paris goals. This CARISMA discussion paper examines the broader architecture for global climate governance after Paris and offers suggestions for improving coherence. It begins with an overview of three significant areas of climate action initiated outside of the UNFCCC – focusing on other international legal regimes, minilateral climate coalitions, and actions by non-state actors – and offers some indications of how such action may evolve in light of the Paris outcome. It analyses how the United Nations climate regime is linked to action taken in other venues, focusing on the Paris Agreement. The discussion paper ends with three suggestions on how those relationships could be strengthened, namely: (1) enhancing the visibility of non-UNFCCC climate action; (2) developing operational linkages; and (3) monitoring and review.

carisma-project.eu: *On the CARISMA project website, all publications by the project can be downloaded, including deliverables, discussion papers, and policy briefs. The website also includes background information on the project and its partners.*

Climate Change Mitigation Monitor: *The Monitor is CARISMA's periodical on climate change mitigation research. Highlights are shared from the CARISMA project, other EU-funded mitigation projects, and the general mitigation research world.*

ClimateChangeMitigation.eu: *CARISMA has launched the Climate Change Mitigation portal, where all EU-funded projects on climate change mitigation can share highlights of their research on reducing emissions. Currently 13 projects are involved in the portal.*

@CarismaEU on Twitter: *Follow the CARISMA project via Twitter! After finalisation of the project, the Twitter handle will continue to share high-lights of EU-funded climate change mitigation research. Join the discus-sion or share your highlights by using the hashtag #mitigationEU.*

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