Research for meeting the challenges of climate change

Strategic Agenda for the National Research Programme for Climate

FORMAS | ETT FORSKNINGSRÅD FÖR HÅLLBAR UTVECKLING
A SWEDISH RESEARCH COUNCIL FOR SUSTAINABLE DEVELOPMENT

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Contents

Foreword

We at Formas would like to thank everyone who has contributed in various ways to our work on this strategic research agenda for the national research programme on climate.

This includes the programme committee participants, the Swedish Energy Agency, Forte, the Swedish Agency for Marine and Water Management, Mistra, the Swedish Environmental Protection Agency, the Swedish Polar Research Secretariat, the Swedish National Space Agency, Sida, the Swedish Research Council, Vinnova and, of course, the programme's working group and their representatives from these organisations.

We also wish to extend our gratitude to the committee's independent chair, Anders Wijkman.

And last but not least, we thank all the universities, research institutes, government agencies, industry associations, companies, municipalities, non-profit organisations and others who have contributed by participating in workshops and stakeholder dialogues and who have provided valuable input via our referral procedure.

We look forward to our continued collaboration!

Summary

The National Research Programme for Climate stems from a government commission received by Formas and spans the period 2017–2026. This research programme has several purposes, the main one being to promote research and innovation that support climate mitigation and adaptation efforts and help to achieve relevant goals at the national and the global level. The present strategic research agenda has been developed in 2018 as a starting point for the research programme's content and activities, including calls for research funding and other initiatives for increasing the societal impact of research findings. The research agenda also aims to coordinate the efforts of Swedish research funders in the field of climate through common priorities and objectives.

The national research programme is also expected to create synergies between actors that complement each other in terms of knowledge, expertise and projects. Therefore, a programme committee and a working group consisting of research funders in this field will support Formas in its work with the National Research Programme for Climate. In addition to this collaboration, the entire process of developing the agenda has involved valuable dialogue with a wide range of societal stakeholders.

This strategic research agenda identifies a number of key themes and perspectives that together create a framework of priority areas to explore within the research programme. These areas are based on analyses of the diversity of aspects influencing the climate challenge, the context of goals the programme should contribute to achieving as well as on analyses of society's need for knowledge related to climate mitigation and adaptation efforts. These starting points have then been correlated to current and future investments in climate research and innovation, so that the national programme can complement current climate research.

Among the identified themes is **sustainable solutions for climate initiatives**, which concerns the need for next-generation solutions that can significantly contribute both to mitigation and adaptation activities, in Sweden and globally, while also taking into account other global sustainability goals. The theme **systems-integrated knowledge about climate, climate impact and society** highlights the need for increased knowledge about advanced systems perspectives and multidisciplinary analysis resulting from the complexities of the climate system and climate challenge and the many links between sectors, levels and stakeholders, as well as between the climategoal and other sustainability goals. The theme **sustainable lifestyles** focuses on the need for new knowledge about how we can create sustainable, responsible consumption patterns that consider entire value chains. The theme **policies, implementation and follow-up of climate efforts** highlights the need for a way forward that steers society's different actors in a more sustainable direction, one that helps to achieve the set goals. The climate challenge demands clear political governance and a leadership that helps to bring about societal structures and developments that recognize climate as an undisputable input value. The theme **economic system for a fossil-free society** covers questions about how we can envision a climate-neutral, sustainable economic system and how this system affect climate change efforts. The theme **justice and democracy in climate efforts** raises questions about how people, organisations and countries can become involved in and influence the development of society in order to shape future climate efforts.

In addition, each of these themes should be highlighted using the key perspectives of **globalisation, digitisation, sustainable development** and **gender equality**.

The content of the strategic research agenda will be put into practice based on a logical framework approach that includes implementation plans. The programme will be monitored and evaluated during the course of the programme period.

1. About the programme and agenda

This introductory chapter briefly describes the government's commission to Formas and how the agenda has been developed. It also describes the relationship to other national research programmes.

1.1 A national climate research programme – commission and organisation

In 2017, the government tasked Formas with developing a ten-year national climate research programme in collaboration with other funders (Appendix 6).

The purpose of the programme is to create a strong foundation that enables research and innovation to support work on climate issues. The programme is expected to support interdisciplinary and cross-sectoral collaboration. Activities associated with the programme's implementation can include all aspects of the research and innovation system, such as research, innovation, technology development, demonstrations, market introduction and dissemination. The programme should include collaboration as well as the practical application and communication of the research results. The programme should also aim to:

- Ensure that innovation and research results have an impact in society.
- Promote the interplay between research and higher education.
- Achieve gender equality by integrating a gender perspective into the programme's activities.
- Promote practical application and communication of the research results.
- Increase its global reach.
- Make existing research infrastructure available and more widely used.

National research programmes are expected to create synergies between stakeholders that complement each other in terms of knowledge, expertise and projects. Therefore, Formas is supported by a programme committee in each national research programme. This includes the programme committee participants, the Swedish Energy Agency, Formas, Forte, the Swedish Agency for Marine and Water Management, Mistra, the Swedish Environmental Protection Agency, the Swedish Polar Research Secretariat, the Swedish National Space Agency, Sida, the Swedish Research Council and Vinnova. The programme committee is headed by an independent chairperson, Anders Wijkman. The committee also has a working group with representatives from the above organisations.

The research agenda also aims to coordinate the efforts of Swedish research funders in the field of climate change through common priorities and objectives. The agenda describes knowledge needs in society and how Swedish research

capacity in the field can be strengthened. The agenda presents the funders' relevant existing and future investments and programmes in order to

facilitate assessment of possible synergies and effective use of funds. The national climate research agenda should therefore also be able to inform and foster other collaborative efforts, nationally, within Europe and globally.

The research programme and the strategic research agenda run during the period 2017-2026. The agenda constitutes a strategic framework and tool that supports dialogue between funders, research practitioners and other stakeholders, such as civil society organisations, the public sector and the private sector.

1.2 Developing the agenda

Formas developed the agenda in consultation with the funders from the programme committee. However, the process of identifying the agenda's strategic content has been broader and has included dialogue with both societal stakeholders and research practitioners.

On the initiative of Formas, in 2017 the Growth Analysis agency conducted a global analysis of international experiences from challenge-driven research programmes. This analysis describes the processes and experiences from research programmes in Canada, the UK, Finland and Denmark as well as on a European level. The purpose of the analysis was to identify key factors to consider when designing research programmes that focus on societal challenges. An important conclusion of the report is that ten-year research programmes are relatively rare and require flexibility to maintain relevance and impact over time. The report also emphasises the complexity of designing research programmes to help solve such challenges. Cross-sectoral, multidisciplinary and interdisciplinary approaches are needed, and affected stakeholders must be included early in the process. The conclusions of the study have been important input values both in the development of the strategic direction of the agenda and its design.

To ensure the relevance of the research programme, Formas conducted a workshop in October 2017 with representatives from civil society organisations, the public sector and the private sector. During the workshop, the knowledge needs of these stakeholders were discussed and inventoried (Appendix 5). These knowledge needs, together with the conclusions of a number of key reports and publications, form the basis for the strategic direction of the agenda.

To map the current state of research funding within the area of climate, Formas has consulted background material from the largest state funders.

A first version of the agenda was sent out for referral to research practitioners at universities and institutes and to the stakeholders who participated in the workshop (Appendix 7). Formas received about fifty responses containing many valuable comments and suggestions for improvement, which testifies to a commitment to the programme.

Representatives from academia and institutes were invited to continue the dialogue to further ensure that the programme's actions and activities during the programme period create added value and synergies for the sector's development.

Based on an inventory of knowledge needs and a situation analysis, we have identified several themes for future actions within the programme. The agenda

describes the strategic direction for the National Research Programme for Climate over the entire ten-year period up to 2026. The agenda also describes how comprehensive programme logic will be developed to support achievement of the programme objectives. The programme logic will be implemented through three-year implementation plans. Frameworks for monitoring and evaluating the programme are also described. The overall approach will provide the programme with a clear focus, while creating the necessary flexibility to maintain the programme's relevance and impact throughout the entire programme period.

1.3 Relation to other national research programmes

In addition to the National Research Programme for Climate, the government has tasked the research councils Formas and Forte, as well as the Swedish Academy of Sciences, with establishing six additional national research programmes. Formas is responsible for two additional programmes that address sustainable spatial planning and food. Forte is in charge of two research programmes focused on applied welfare research and workplace research. The Swedish Research Council is responsible for two research programmes, one on migration and integration and one on antimicrobial resistance.

All the programmes address significant national and global challenges facing society. They deal with complex issues that are not well-defined or clearly delimited. The drivers, consequences and solutions regarding one particular societal challenge also relate to other challenges, so there are many interactions, synergies and conflicts of interest between the challenges. For the climate research programme, there are obvious touchpoints with:

- The programme for sustainable spatial planning, on issues of urbanisation and climate adaptation, green spaces and water in urban and rural areas, as well as sustainable transport and energy solutions in spatial planning, consumption, policy instruments, the circular economy, and more.
- The migration and integration programme, on issues such as climate-driven migration and sustainable urban planning.
- The food programme, on issues of health, climate and food (including drinking water), both nationally and globally.

There are also touchpoints with the national research programmes for applied welfare and for workplace research.


2

2. Target context for climate actions

This chapter describes the objectives that the program will help to achieve.

The climate issue poses a twofold challenge to society: reduce human climate impact and adapt communities to the climate changes that are taking place. This is about the realignment of society, together with and in line with all the dimensions of sustainable development. The complexity of the challenge – and the fact that we have no time to lose – requires dynamic knowledge development through research and research-related initiatives that can help to ensure that new knowledge and sustainable solutions benefit society and support its positions when decisions are made and actions are taken.

The global sustainable development goals, the EU's goals and national objectives for climate action also guide the National Research Programme for Climate.[1]

2.1 Goals to be achieved by the programme

The National Research Programme for Climate will contribute to the achievement of the global climate agreement (the Paris Agreement), Agenda 2030 and its global goals for sustainable development, the EU's climate change goals and Sweden's national climate goals. The government research and innovation bill, "Collaborating for knowledge – for society's challenges and strengthened competitiveness" (Bill 2016/17:50) also acts as guidance in this context.

International goals

In December 2015, virtually all the countries of the world agreed on a new global climate agreement: the Paris Agreement. The goal of the agreement is to keep the global temperature increase at well below 2 degrees and to make efforts to limit the increase even further to 1.5 degrees, compared to pre-industrial levels. The agreement states the need for all countries to have a climate plan with their own goals. Less affluent countries should get help from other countries to take climate change action, including adapting their communities to a changing climate. This assistance can take the form of financing, technology transfer or capacity expansion. Every five years, the work will be evaluated with a view to increasing ambitions. The first review will take place in 2023.

In 2015, the UN also adopted Agenda 2030. The agenda consists of 17 global goals for sustainable development. Several of the goals have links, synergies and conflicts among them. See also goal 13 calling for urgent action to combat climate change and its consequences.

The ability to adapt, and the resilience of countries and communities to manage the consequences of climate change, touches upon the following goals in particular: Tackling climate impact on agriculture and food production (goal 2), water resources (goal 6), cities, communities and health (goals 2, 3, 11), land-based

1. At the same time, it is still important to contribute to minimising climate impact even in areas without set targets (for example, international transport and consumption).

ecosystems (goal 15), ocean and marine resources (goal 14), and biodiversity and ecosystem services (goal 15).

Climate mitigation is intended to reduce our climate impact and the risks of climate change society will face. There is a need to mitigate climate impacts in virtually all sectors of society, and this need involves all stakeholders. The success of sustainable climate mitigation also requires consideration of questions concerning health, justice and gender equality (goals 3, 4, 5, 10). There are many synergies with the other sustainability goals, such as the conversion to fossil-fuel independence in various sectors including energy (goal 7), sustainable industry and infrastructure (goal 9), sustainable cities and communities (goal 11), sustainable consumption and production (goals 1, 2, 12), policy, governance and management objectives (goals 12, 16, 17) and a sustainable economic system (goals 8, 12, 15, 17). For more information about how the programme links to the targets of the global sustainability goals, see Appendix 3.

As part of the EU, Sweden has undertaken a quantitative target for emission reductions, jointly with all other member states, both under the UNFCCC and the Kyoto Protocol, for the period 2013-2020.

In October 2014, the EU Council of Ministers agreed on the following climate and energy targets for 2030:

- 40 percent lower greenhouse gas emissions than 1990.
- 27 percent renewable energy.[2]
- 7 percent better energy efficiency.[3]

Negotiations are currently underway between the Council of Ministers and the European Parliament on the final details of the climate and energy objectives for 2030. In addition, the EU has previously set the target of reducing its emissions by 80-95 percent by 2050 compared with 1990 levels.

2.1.1. Sweden's national climate objectives

The climate challenge is global, national, regional and local. The government's ambition is for Sweden to be an international model and a leading country in the achievement of the objectives of the Paris Agreement and Agenda 2030. Sweden aims to show that it is possible to reconcile climate mitigation and adaptation with social welfare, good economic and social development, and competitiveness. Sweden intends to become a fossil-free welfare society.

In June 2017, Parliament decided on a national climate policy framework for Sweden. It takes effect 1 January 2018 and consists of a climate act, new national climate targets and a climate policy council. Under the long-term climate act that was passed, Sweden is aiming for net-zero carbon emissions by 2045, and thereafter negative emissions.[4]

2. The European Commission, the Council of Ministers and the European Parliament agreed on 14 June 2018 that the percentage of renewable energy should reach 32% by 2030.
3. The European Commission, the Council of Ministers and the European Parliament agreed on 14 June 2018 on an energy efficiency target of 32.5% by 2030.
4. Sweden has a previous national interim target for the climate, which provides for a 40% reduction in emissions by 2020 compared with 1990 (Bill 2008/09:162).

Together with the climate target, the introduction of new interim targets for 2030 (-63 percent) and 2040 (-75 percent) compared with 1990[5] emissions levels was also decided on for emissions outside the EU Emissions Trading Scheme (ETS). The remaining emissions from operations in Sweden should be at least 85 percent lower than 1990 emissions levels. Supplementary measures may count towards achieving net-zero emissions, such as increased uptake of carbon dioxide in forests and land as well as investments in emission reductions in other countries. Negative emissions means: "A situation of net negative emissions is achieved when, as result of human activities, more greenhouse gases (GHGs) are sequestered or larger than are released into the atmosphere." (IPCC, ARS 5: SYR) (Swedish Environmental Protection Agency, 2017b).

5. Similarly, as for the long-term objective, it is also possible to achieve parts of these objectives through supplementary measures. Such measures may be used to achieve a maximum of 8 and 2 percentage points of the emission reduction targets by 2030 and 2040, respectively..

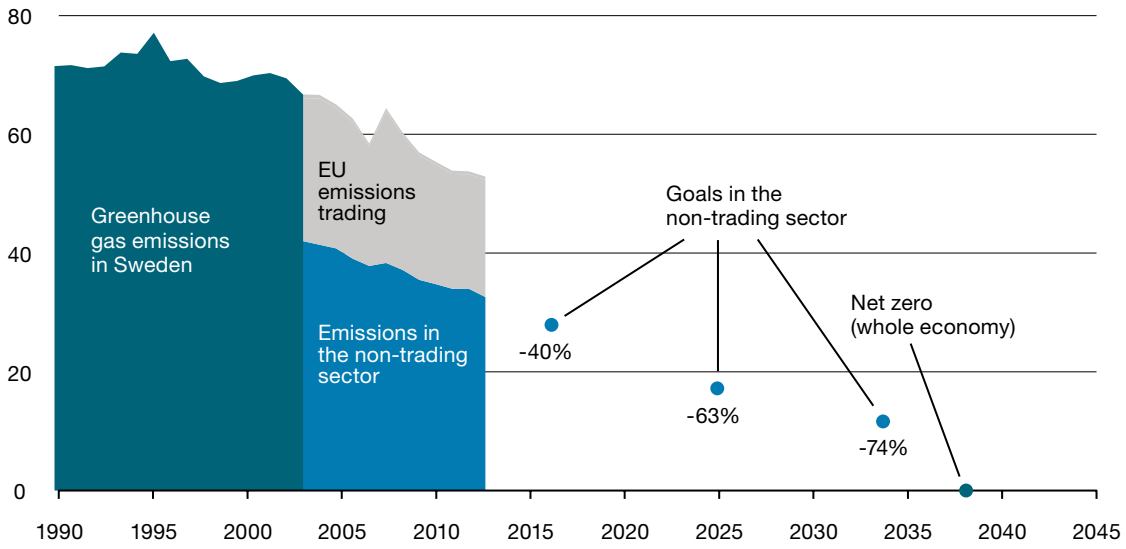


Figure 1. Sweden's greenhouse gas emissions in 1990-2005 and in 2005-2016, divided into emissions in the EU Emissions Trading Scheme (ETS) and in the non-trading sector. The figure also shows Sweden's climate goals for the non-trading sector for 2020, 2030 and 2040 as well as the indication that net emissions should be zero by 2045. Supplementary measures can be used to achieve the different goals, but this is not considered in the figure (Swedish EPA, 2017a).

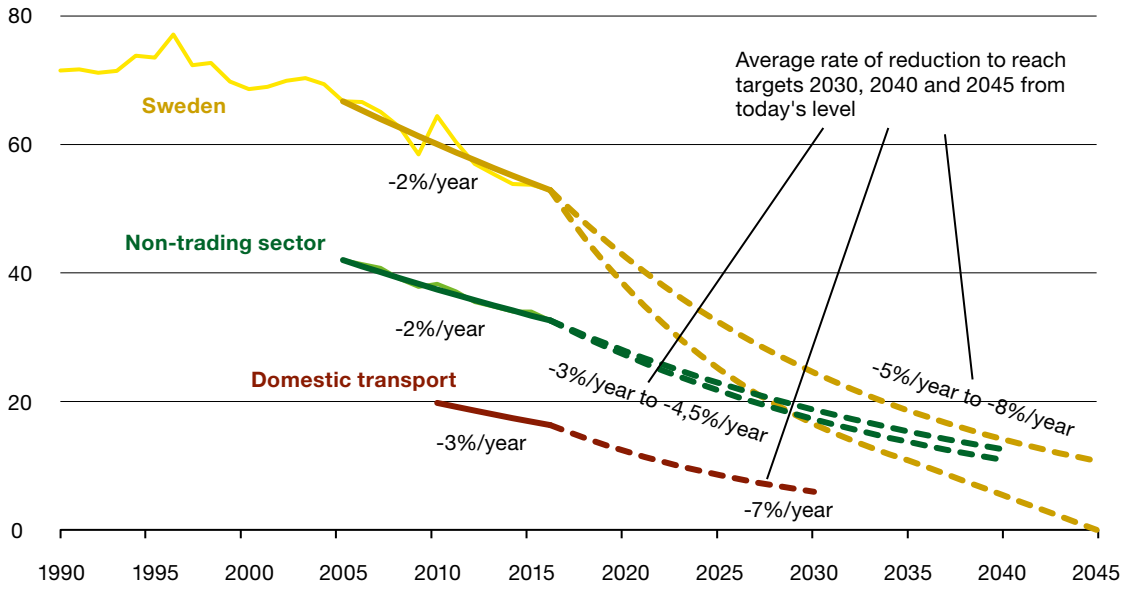


Figure 2. Rate of reduction expressed in a range since additional measures such as international climate action, increased forest and land uptake, and uptake and storage of carbon may count towards the goal achievement. (Swedish EPA, 2017a)

Emissions from domestic transport (except domestic flights) are to be reduced by at least 70 percent by 2030 compared with 2010. Domestic flights are covered by the EU Emissions Trading Scheme (ETS) (Swedish Environmental Protection Agency, 2017). Planned instruments can contribute significantly to speeding up the rate of reduction, but further measures are necessary to achieve the climate goals.

A complementary method for measuring Sweden's emissions is to use Sweden's consumption of goods and services regardless of the country of production.[6] Measurements of consumption-based emissions are currently uncertain, but they are important because they expose emissions from our consumption regardless of country of production. Consumption-based emissions from Swedish consumption were approximately 11 tonnes per capita in 2015, compared with 5.3 tonnes per capita in terms of territorial emissions. Achieving the goals of the Paris Agreement requires a reduction in global emissions to a maximum of 2 tonnes per capita/year by 2050 (Swedish Environmental Protection Agency, 2017a).

2.1.2. Sweden's research policy objectives

The government's goal for Swedish research policy[7] is for Sweden to be one of the world's foremost research and innovation countries and a leading knowledge economy. In addition, research and innovation should contribute to the welfare of society and help respond to the challenges society faces both in Sweden and abroad. To achieve this, the government points to the need for both scientific and interdisciplinary research, where science and technology are linked with research and knowledge in other sciences.

The National Research Programme for Climate will contribute to achieving the objectives of Swedish research policy while laying the foundation for achieving the national, European and global climate goals which Sweden has committed to.

The government highlights the contribution the national research programmes will make towards increasing research in higher education, boosting the impact of research on society and promoting gender equality. The programme will also support long-term planning for the effective use of infrastructure, create the conditions for interdisciplinary and cross-sectoral collaboration, and provide a natural link to international research programmes while strengthening Swedish participation in them.

The programme should be in continuous dialogue with research practitioners about the need for infrastructure[8] in this field, as well as how to better utilise and make available existing infrastructure.

Gender equality must be taken into account when designing all the initiatives in the programme, in particular those affecting career advancement. The programme must contribute both to increased gender equality in academia and to equal development potential in society as a whole.

6. The size of consumption-based emissions in other countries depends on how much we import, how emissions-intensive the goods or services are, and how large the emissions intensity is in the country of production. Total consumption-based emissions can be divided into (1) household consumption, (2) public consumption and investment, and (3) export companies. Emissions from exports do not count towards consumption-based emissions. Two-thirds of total emissions come from households, and the remaining third from public consumption and investment. Public consumption corresponds to the goods and services that organisations like schools, hospitals and government authorities buy to conduct their operations. The increase in emissions abroad is linked to Swedish economic growth, increased import volumes and increased international travel (Swedish Environmental Protection Agency, 2017a)..
7. Government Bill 2016/2017:50 on collaborating for knowledge.
8. Infrastructure refers to facilities as well as infrastructure for data and other collected materials.

Sweden's commitment to Agenda 2030 is central to its global development policy. As our point of departure, all policies should make use of the government's ability to contribute to fair and sustainable development throughout the world. To achieve sustainable development globally – and to strengthen Sweden's competitiveness – five areas have been given priority in the research and innovation bill 2016/17:50 on collaborating for knowledge. The climate challenge is a challenge of global and national relevance, and the need for new knowledge and solutions has been given top priority by the government.

2.1.3. Overarching objective for the National Research Programme for Climate

To summarise, the National Research Programme for Climate aims to do the following:

- Contribute to renewal and innovation through high-quality, excellent climate research and innovations (both in terms of adaptation and mitigation).
- Contribute new knowledge and solutions to achieve the national climate objectives and help to fulfil the Paris Agreement and the global sustainability goals.
- Strengthen the communication, practical application and impact of research both nationally and globally.
- Contribute to a greater use of infrastructure as relates to the climate issue and encourage a greater focus on research in higher education.
- Make climate research more available to a global audience through existing and new partnerships.
- Strengthen interdisciplinary and cross-sectoral collaboration in the field.
- Contribute to strengthening synergies and collaboration between funders, research practitioners and end users of climate research.
- Strengthen gender equality both within universities and in society.


3

3. The climate challenge: One of humanity's greatest challenges

This chapter provides an overview of the complexity of the climate challenge and how society's various stakeholders are seeking to tackle the issue together. The chapter is based on analyses from current background material, strategies and roadmaps and on dialogue with various key stakeholders and sectors.[9]

3.1 A comprehensive transition to climate neutrality

Global greenhouse gas emissions (GHG) have risen gradually since the mid-1900s and today amount to approximately 50 gigatons CO2 equivalent per year (IPCC, 2014). Emissions originate from many different areas of society and are affected by factors like population size, economic activity, human lifestyles, fossil energy use, land use patterns, technology and climate policies (IPCC, 2014).

A large percentage of emissions are generated when humans produce, distribute and use fossil-fuel-based energy. Fossil fuels represent just over 81 percent of the global energy supply.[10] In 2014, the total world energy use was barely 100,000 TWh. Energy use rose globally by slightly under 50 percent from 1990 to 2014 (Swedish Energy Agency, ET 2017:12).[11]

Sweden's GHG emissions were 52.9 million tonnes in 2016. Emissions were reduced by 26 percent between 1990 and 2016 (Swedish Environmental Protection Agency, 2017a). In Sweden, a major challenge is the transition of the transport sector, the sector that relies most on fossil fuels.[12] Emissions from domestic transport account for one-third of Sweden's total GHG emissions.[13] Industry, with just under one-third of Sweden's total GHG emissions and fossil-fuel-based energy use of 19 percent (2015), is also facing challenges in its transition to meet the climate goals (Swedish Energy Agency, ET 2017:12; Swedish Environmental Protection Agency, 2017a).

Our daily lives and practically all the products and services we use at some point or other result in emissions that impact climate. Emissions arise not only in connection with energy use during production and transport, but are also linked to how products are manufactured as well as how and which raw materials are used to produce the product. Only the industrial production of base materials such as steel, cement, aluminium, textiles and plastics accounts for almost 25 percent of CO2

9. See appendices 5 and 7 for the dialogue with stakeholders.
10. Oil dominates at 31 percent, followed by coal at 29 percent and natural gas at 21 percent. Renewable energy including hydropower has increased over the past ten years to 14 percent (Energiläget, ET 2017:12).
11. During 2000 to 2010, the average increase was 2.1 percent annually, while the increase during 2010 to 2014 corresponded to 1.6 percent annually (Energiläget, ET 2017:12).
12. The transport sector has the highest percentage of fossil fuels, but it is also the sector that has seen the most rapid transition from fossil fuels to other alternatives over the past 10 years. The sector still predominantly uses fossil fuels such as gasoline, diesel and kerosene (82 percent in 2015) (Energiläget, ET 2017:12).
13. In 2016, domestic transport emissions totalled 17 million tonnes of CO2 equivalent, which is 15 percent lower than 1990 levels..

emissions globally today, and the use is not least in developing countries where infrastructure expansion is rapid (IPCC, 2014). There is therefore a great need for industry to replace not only fossil fuels but also fossil-fuel-based materials with renewable ones, and to transition its systems of production. Food production also results in significant emissions that cannot be linked to energy use and transport. Emissions also occur in connection with the exploitation of new land, land use, livestock farming and the degradation of by-products. In Sweden, the agricultural sector accounts for 13 percent of Sweden's total GHG emissions, of which less than 2 percent is carbon dioxide emissions[14] (Swedish Environmental Protection Agency, 2017a).

At the same time as we in Sweden have succeeded in reducing our emissions across several sectors, our consumption patterns have led to increased GHG emissions at a global level. Consumption (eating, living, travelling, shopping) is strongly linked to emissions in several sectors and processes. It is an important consideration to discuss in relation to climate impact, while consumption is a driving force for economic development, welfare and fighting poverty. This means that questions about how sustainable consumption patterns and sustainable economic development can co-exist remain critical.

The questions here revolve around how we can achieve sustainable production systems, material flows and consumption patterns – meaning that we need to have global access to modern and renewable energy, increase reuse and recycling (a development from linear to circular processes), use renewable raw materials, and examine our view of quality of life and what a good life can entail in a climate transition. The scale and pace of the transition also pose a challenge, especially in view of existing social structures and investment patterns.

3.2 From words to action

Through the Paris Agreement, the climate challenge has a defined goal that nearly all countries and states throughout the world have supported. This goal is underpinned by research showing that although climate impacts cannot be completely avoided, increasingly widespread and dangerous climate impacts can probably be avoided by keeping global temperature changes in line with the goals of the Paris Agreement. Yet the path to achieving the goal is complex and involves many different stakeholders, perspectives and processes that need to interact in the same direction.

The climate challenge is global and must be addressed at a variety of levels – globally, at EU and other intergovernmental levels, as well as at national and local levels – in all countries of the world. The correlation between the globally agreed temperature target and national emission targets is neither direct nor absolute. We must continue to analyse the types of emission reduction efforts needed to meet the global target based on new research findings and changed risk assessments on how the global average temperature is affected by emission levels and other factors.

Furthermore, the gap is great between the Paris Agreement goals and existing decisions on policies and actions. It is a much greater challenge to reach net-zero emissions (and thereafter negative emissions) compared to reducing GHG emissions by 20 percent.

14. Approximately 51% of the emissions consisted of nitrous oxide, just over 47% of methane, and less than 2% of carbon dioxide.

Clear governance and powerful policy instruments are needed to pave the way to the goals. Measures must be geared more towards a radical shift rather than incremental improvements. This requires strong leadership at several levels and a solid grasp of the context-dependent barriers to implementing the transition. For example, the question of funding a green transition must be addressed. And as for financial market players, how can they take a more long-term view of the climate issue? How should we envision the transition to a sustainable economy?

Developing sustainable solutions and putting them into practice requires innovation as well as the preconditions for enabling them. For example, what do effective policies for innovation look like? What are effective management models that support a holistic approach? Solutions for adapting society to a changing climate are also needed to create resilient societies, for example through infrastructure planning. And innovative processes are needed that can help to clarify the goals and translate them into practical action at the local level.

3.3 Collaboration, practical application and participation

The climate challenge is both difficult to imagine and to explain in a clear, understandable way. In many cases, there is quite a wide gap between the climate scenarios described by scientists and individuals' own perception of their surroundings and daily lives. To achieve the climate goals, we must reach out to people and get their reactions to the visions and goals for a fossil-free welfare society. Questions on how we as human beings can address the changes we face – and how to communicate these questions – are central to climate actions since the effects of the decisions and measures introduced are concrete. Knowledge about climate change and its impacts must be disseminated successfully. Research on relevant issues remains important, as does knowledge-building using research as a point of departure.

Collaboration between different sectors of society (academia, industry, the public sector and civil society organisations) is a key ingredient in successful research programmes that aim to promote awareness and an increased use of research results. The intended users of new knowledge and sustainable solutions can also help to assess complex and uncertain issues. Several Swedish industries have underscored the need for collaboration, leadership, insight and long-term ground rules in order to align with the Climate Act's goal of net-zero GHG emissions by 2045. These industries have also expressed the need for continued research and innovation support, as well as support in highlighting risks when they invest in radical innovation (Fossil-Free Sweden, 2018).

3.4 Fair and inclusive climate action

International climate change action is underpinned by the assumption that all countries have a common yet diversified responsibility. The people who are most vulnerable to climate change impacts live in developing countries that often lack the resources to adapt their communities. The countries that have historically been responsible for most of the emissions are assumed to shoulder their responsibilities regarding adaptation and mitigation, where they are most needed.

Equal and inclusive climate action requires positive interaction between many sectors and levels of society as well as a nuanced understanding of differences in access to power and resources. Local stakeholders and civil society organisations are an important resource in these efforts, and evidence-based knowledge plays a central role in the success of these efforts. Climate action must address and focus attention on the issues and challenges related to sociocultural sustainability (such as issues of democracy, vulnerable groups, gender equality and justice).

The fairness aspects of climate action, common learning opportunities and capacity building that includes all groups in society are fundamental, whether in global or national climate action.

3.5 Adaptation to a changing climate

Climate change is already making an impact around the world today. Continued climate change will most likely increase the scale of the impact. The more the temperature rises, the more the risks of climate impact increase and thus become less manageable. In addition, social development as a whole is also an important factor for considering how exposed and vulnerable individuals face climate change. The risks are often greater for those who are already living under vulnerable conditions.

The effects of climate change have consequences for all different communities, from cities to rural areas. Knowledge and sustainable solutions are needed to adapt spatial planning and urban development to climate change. Heatwaves increase the risk of mortality among vulnerable groups. Moreover, climate emissions are often closely linked to air pollution and related health issues. Heavy rains increase the risk of flooding, which can have major consequences for infrastructure, buildings and drinking water quality. The question of coordinated management of both the quantity and quality of water is becoming increasingly important, at national and global levels. Rising sea levels present another major challenge for all coastal communities worldwide – many of which also have high population levels and vulnerable infrastructures.

In rural areas, climate change can have a major impact on agriculture and forestry in the form of droughts, fires, heavy rainfall or storms. This affects people's income and the supply of food and raw materials throughout society.

The impacts of climate change also pose a threat to the richness of ecosystems, both on land and at sea, and to the ecosystem services that people depend on.

3.6 A holistic approach to climate

In addition to research and innovation, which make an obvious contribution to climate actions, interdisciplinary perspectives and a systems mindset are also highlighted as important foundations for addressing challenge-driven issues (Growth Analysis, 2018).

The programme needs to support investments in climate adaptation measures as well as climate impact reduction. These two investment areas are interdependent and should be coordinated as much as possible. In addition, climate adaptation measures should not counteract measures to reduce GHG emissions and vice versa (Bill 17/18:163).

A key point of departure for the programme's efforts will be to tackle the climate challenge by relating climate actions to other global sustainability goals. As we try to adapt society to the changing climate we are already experiencing and to shift to a society where we can reduce our climate impact to achieve a temperature increase well below 2 degrees, we need to consider both the common touchpoints and the points of contention with the other global sustainability goals. For example, we can consider different systems perspectives for planetary boundaries as well as the socio-economic and cultural aspects of climate actions.

3.7 Understanding, monitoring and anticipating climate change

Today we understand the serious challenges we face thanks to research that measures, monitors and anticipates climate developments and their effects, and maps the dynamics and processes of the climate system. This research must continue to evolve, as there is much we do not yet understand and are probably not even aware of. For example, we need to learn more about feedback mechanisms – that is, how different climate system processes reinforce or mitigate ongoing climate change. A better understanding of these mechanisms will make climate change models and scenarios more precise.

We also need more knowledge about the carbon cycle in nature: What processes and circumstances contribute to carbon sequestration and release? What is the magnitude of carbon sequestration and release associated with these processes and environments? We need this knowledge to understand questions like which ecosystem services we can use to combat climate change, or how we can leverage different natural resources to avoid a negative climate impact. Forests play a potentially key role in managing climate change. So, how should we use forests in different parts of the world and what should they be used for? We also need to keep monitoring and measuring climate developments to know whether or not climate action is working and to what extent. Society's climate adaptation efforts depend on empirical climate data and climate scenarios to develop evidence-based documentation and services.

3.8 Summary

The following key climate-related needs were identified from the needs assessment conducted during the preparation of the agenda.

- A better understanding of how we can translate knowledge into practical benefits (an educational challenge, since climate actions take place at many different levels of society, from local to global).
- Leadership on climate issues and targets in all climate efforts.
- Increased cooperation between different sectors (academia, private companies, the public sector, civil society) to produce relevant evidence-based solutions.
- Sustainable and innovative solutions for achieving emission reductions and fossil-fuel independence in sectors like energy, transport, food and water systems, spatial planning, agriculture, forestry, production and consumption, and more.
- More knowledge of system considerations, uncertainties and linkages between the climate challenge and other global sustainability goals in order to develop new knowledge that can be used in evidence-based documentation.
- A better understanding of people's lifestyles, consumption patterns, welfare issues and health concerns linked to our climate footprint, and how we can bring about behavioural changes in individuals and organisations.
- A better understanding of objectives, implementation, governance and ground rules that can contribute to a robust, long-term and inclusive transition to fossil-fuel independence and to the adaptation of our societies to a changed climate. Follow-up of initiatives and policies for increased learning.
- A better understanding of financial game rules and systems that can promote green investment and economic models. Business models are needed that can bring in more private capital to step up efforts.
- A greater focus on the impacts and uncertainties of climate change, in order to strengthen the knowledge base and help society adapt to climate change.


4

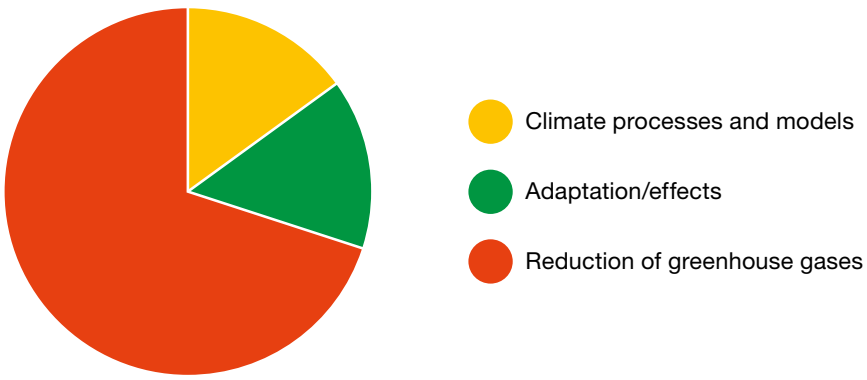
4. A review of Swedish climate research

In 2012, the Swedish National Audit Office published a review of Sweden's climate research (National Audit Office, 2012). Although the report was written several years ago, it is nonetheless a relevant starting point for discussing the scope and quality of climate research and providing a first overview.

The background to this review was the fact that some of the government's biggest investments in climate research take the form of research and innovation grants. The Audit Office wanted to determine how much public money was spent on funding climate research, as well as the focus and results of the research. The purpose of the review was therefore to assess whether research grants, as an important climate policy instrument, reduce emissions in line with the climate goals and if done at a reasonable cost.

Climate research is a broad area. It spans the climate system and climate changes, climate impacts and adaptation issues, and the reduction of climate emissions. The Audit Office's review covered the period 1994-2010 and compiled information on research funds, number of scientific publications and citations, and patent applications. However, the scope of state aid for climate research for the entire period proved to be difficult to calculate. So, for this parameter data for the year 2010 was used instead. This does not include funding from sources like the EU, municipalities and county councils, foundations or other private financiers.

The data showed that close to 2 billion kronor in government funding was allocated to climate research in 2010, or roughly 7 percent of the government's total research budget. Of the 2 billion, about 70 percent was allocated to research on reducing GHG emissions, which consisted largely of energy research. The remaining 30 percent was evenly distributed between research on climate processes and models and research on climate effects and adaptation.



National Audit Office, review of Swedish climate research (2012). Impacts in 2020.

At higher education institutions, about 55 percent of climate research focused on GHG reduction. Companies that received public research funds almost exclusively conducted climate research that focused directly or indirectly on reducing GHG emissions. In total, 90 percent of climate-related research was conducted in 2010 within science and technology.

The National Audit Office's review also showed that Swedish climate research produced comparatively many scientific articles and patent applications, and that the number of articles increased sharply between 1994 and 2010. Research on GHG reduction was judged to have the greatest potential to contribute to achieving the climate goals. The review shows that articles in this specific field were cited more than the world average and that Sweden ranked fourth in the world. As for patents, the review found that research on GHG reduction mainly resulted in patent applications. According to the Audit Office's review, the number of patents in the field increased an entire 140 percent between 1994 and 2009. In an international comparison with 16 other countries, Sweden ranked near the middle and highest of the Nordic countries. This means that as government grants for climate research have increased, the number of publications and patents based on research in that field has also increased. Despite this, the link is ambiguous because publications and patents from climate research have also risen in many other countries without having increased appropriations there.

One way to utilise the results of climate research is through commercialisation. However, the Audit Office believes that there has been a lack of follow-up on the extent to which results in the field of climate research have led to commercialisation. Their analysis shows that factors other than research funding – such as other policy instruments, state investment aid and access to risk capital – are often vital for commercialisation of climate-friendly products. They also underscore that Swedish companies in the climate technology sector have increased their sales and exports, but in international comparisons Sweden still ranks lower than several of the other Nordic countries, for example.

In terms of practical application, we should stress that not all research is targeted to – or leads to – commercialisation. Research results can also be useful in higher education, for example, or as a basis for international negotiations or policy instrument decisions. However, this type of practical application was not examined in the national review.

In conclusion, the National Audit Office found that Swedish climate research is of high quality. But it also revealed uncertainties about the extent to which the research has been used. It is therefore not clear that research contributes to the societal transition needed to achieve the long-term climate goals.

4.1 Strengths and weaknesses in Swedish climate research

In 2015, Formas conducted its own survey and analysis of Swedish climate research following a government commission (Formas, 2015). The survey was based on Formas' eleven largest grant recipients: Chalmers, University of Gothenburg, Karolinska Institutet, Royal Institute of Technology, Linköping University, Luleå University of Technology, Lund University, the Swedish University of Agricultural Sciences, Stockholm University, Umeå University and Uppsala University. As input to the survey, both quantitative and qualitative data was

collected on climate research funded by all sources (basic appropriations, other state funders, private financiers and international funding sources). The data requested consisted of publications from 2008-2013, funding during 2008-2013 (scope and funding source) and case studies, with a special emphasis on the impact of research results in society. The material was compiled and then evaluated by a panel of four experts.

According to the expert panel's opinion, Sweden funds climate research of high quality. Many high-quality articles are published that have a global reach and frequent citations. Swedish climate research also features a high degree of international collaboration compared with many other fields of research. Another strength is that the results have the potential to be directly relevant to decision-makers and society at large, since the climate issue is one of the most pressing societal challenges we face. This means that there is also great potential for closer cooperation between researchers and people who use the research results.

The panel highlighted the importance of strengthening knowledge of all the different dimensions around the climate issue. This includes everything from measuring and monitoring the changes that are taking place, understanding the dynamics and mechanisms of the climate system and its consequences for different communities and natural environments to understanding our human impact and what we need to do to slow or halt the impact. This requires knowledge and solutions from many different disciplines and cooperation among researchers through the use of more interdisciplinary approaches.

The panel also pointed out that climate research is clearly prioritised by the government. This should provide good opportunities for state research funders to support the area's development and take a new strategic approach to funding climate research. The research area should also show good potential for contributing to innovation and market growth in terms of near-to-market development of solutions and services.

At the same time, the panel described today's funding system as fragmented; several different funding sources support the research yet no one has coordinating responsibility for the different actions. The panel also believed that much of the world of higher education, as well as the funding system, are still designed to reward traditional divisions in research disciplines and that it is difficult to recruit reviewers with the necessary skills for assessing applications containing interdisciplinary and cross-sectoral research. These factors have a major impact on the climate sector's ability to progress in a more interdisciplinary, cross-sectoral direction. The panel also pointed out that scientific and technical research have long had good funding opportunities. We now need knowledge from the humanities and social sciences. These disciplines need to access more paths of entry and funding opportunities than before.

4.2 Ongoing research efforts in the field

As part of developing this strategic research agenda for the national research programme, in the spring of 2018 Formas conducted a survey of ongoing research efforts in the field of climate change. The eleven funders that are part of the programme committee include the Swedish Energy Agency, Formas, Forte, the Swedish Agency for Marine and Water Management, Mistra, the Swedish Environmental

Protection Agency, Swedish Polar Research Secretariat, the Swedish National Space Agency, Sida, the Swedish Research Council and Vinnova. Formas' survey shows that the size of funders' investments in climate research varies. The field of climate research is difficult to define, and the survey of current funding is based both on bottom-up analyses from the participating funders and top-down analyses from various relevant supporting documents. In addition, we have included information on research funding from the Wallenberg Foundations and the Riksbank's Jubilee Fund. The survey does not, however, include funding that universities, colleges and other research practitioners use for climate research using their own appropriations. The description of the current situation we present here reflects the investments and funds that have been allocated for climate research since 2012 and planned future investments. A listing of all investments is provided in Appendix 4. Figure 4 summarises the focus areas for external funding provided to research and innovation practitioners by government funders and some private foundations.

Our survey (Figure 4) shows that approximately 12.5 billion kronor from state funders, the Wallenberg Foundations, Mistra and the Riksbank's Jubilee Fund have been supporting climate research and innovation since 2012. An estimated 70 percent of the funding has been used to develop new knowledge and new solutions for reducing our carbon footprint. The remaining funds are evenly distributed between increased knowledge of the climate system and the consequences of ongoing and anticipated climate change and adaptation. Funding from state funders and foundations over the last six years has thus had the same relative distribution between the three main approaches (climate processes and models, adaptation and effects, and reduction of greenhouse gases) that were reported in the National Audit Office's 2010 data on state funding (Figure 3). Approximately 85 percent of the funding was allocated to research and innovation with a science and technology focus. This estimate is also of the same magnitude as the National Audit Office's data on state resources for climate research for the year 2010.

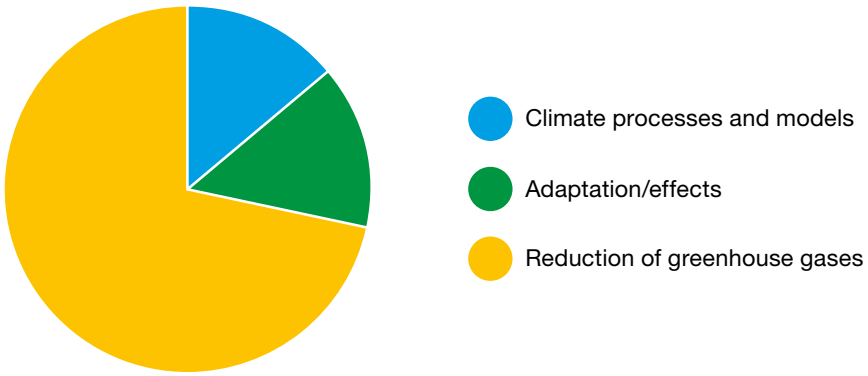


Figure 4. The relative distribution of funds from government funders, Mistra, the Wallenberg Foundations and the Riksbank's Jubilee Fund for research and innovation focusing on climate processes and models, adaptation and impacts, and greenhouse gas reduction.

As previously mentioned, our survey (Figure 4) of funding for climate research and innovation is not exhaustive; it does not include, for example, the universities' basic appropriations or funds from other private sources and international funding sources. The Audit Office's review estimated that approximately 25 percent of state grants for climate research in 2010 consisted of basic appropriations from universities (Figure 3). If a similar percentage of funds were to be added to the funds surveyed here, the research picture would probably be consistent with the investments identified. One reason for this is that internally funded research at universities is often not entirely independent from the research conducted using external funding.

4.3 Funders' investments

Vinnova estimates that about half a billion kronor of their funding since 2012 relates to various aspects of the climate issue. The investments are characterised by a large number of relatively broad innovation programmes, such as innovations for a sustainable society, open innovation, mobility for growth and challenge-driven innovation, which includes projects with fairly different focuses. More strategically oriented programmes include national innovation programmes for building innovation, the Centre of Excellence programme, strategic vehicle research and innovation, and the strategic innovation programmes InfraSweden2030, BioInnovation, PiiA, Strim, Lightweight and Re:Source. Other important features of the Vinnova programme portfolio are test beds, demonstration projects and different types of collaboration programmes. Most of their investments relate largely to technical and natural science topics, but a small percentage focus more on social innovation and innovation in management, organisations and services.

The Swedish Energy Agency's total research and innovation portfolio has approximately 90 percent of its investments in renewable energy and transport solutions, resource-efficient materials and the development of new sustainable energy technologies. All investments can be said to contribute to the transition of the energy system. Although the emphasis is on technology, there are elements of interdisciplinary science. The portfolio is dominated by investments that focus on applied research and industrial development or demonstration projects, often co-funded by private businesses. However, most investments also include elements of basic research. In addition to this, the Swedish Energy Agency targets investments for basic renewable energy research, largely in collaboration with the Swedish Research Council (scientific, technical, social sciences or humanities research). The programme Humans, Energy Systems and Society is a multidisciplinary social science and humanistic initiative from the Swedish Energy Agency. The programme aims to provide new insights into the complex interactions and contradictions of energy and climate issues.

Initiatives that have emphasised research activities in science and technology mainly come from the Swedish Research Council, the Swedish Space Agency, the Swedish Environmental Protection Agency and the Knut and Alice Wallenberg Foundation. Much of the funding is offered for research projects through the aforementioned funders (except for the Swedish EPA, which does not fund basic research).

A large part of the Swedish Research Council's and Swedish National Space Agency's programme portfolios also consists of funding for infrastructure that provides data, tools and materials for scientific research. For example, the Swedish Research Council funds infrastructures for measuring greenhouse gas flows and atmospheric composition, climate modelling, field stations, databases, and drilling in climate proxies on land and in the world's oceans. The Space Agency funds infrastructures for various types of earth observations from space, both at national level and within the framework of the European Space Agency's programme for earth observation. The Space Agency also invests in small, innovative Swedish research satellites with the aim of studying the atmosphere and atmospheric processes. The Swedish Polar Research Secretariat funds infrastructure for research in the Arctic and Antarctica through marine research expeditions with the icebreaker Oden and through terrestrial infrastructure at the Abisko Scientific Research Station and Wasa and Svea stations at Queen Maud Land in Antarctica.

Research that emphasises humanistic and social science issues is mainly funded by the Swedish Energy Agency, Formas, the Swedish Environmental Protection Agency, the Riksbank's Jubilee Fund, the Marianne and Marcus Wallenberg Foundation, and the Marcus and Amalia Wallenberg Foundation. This includes both thematic initiatives and research project grants. The investments have specialisations that address issues like consumption, policy and governance.

A certain percentage of the funding goes towards research with a multidisciplinary or interdisciplinary focus. Formas, the Swedish Research Council and Sida offer several grants that are geared towards this type of research. Mistra is, however, the only funder that solely funds research with an interdisciplinary approach. Mistra believes that their research programmes should be designed jointly by researchers and by people who will use the research results.

Our survey of the state research funders (Swedish Energy Agency, Formas, Swedish Agency for Marine and Water Management, Swedish Environmental Protection Agency, Swedish National Space Agency, Sida, Swedish Research Council and Vinnova) and the foundations (Mistra, the Riksbank's Jubilee Fund and Wallenberg Foundations) shows that their climate funding since 2012 can be summarised as follows:

- Most of these grants fund basic and applied research and innovation related to science and technology (85 percent).
- A much smaller number of grants thus fund research with social, humanistic or interdisciplinary approaches.
- Funding initiatives that target social innovations for reduced climate impact are very few.

4.4 International funding

Internationally, the European framework programme for research and innovation, Horizon 2020, represents the major source of funding[15]. Climate action is highly prioritised by the European Commission, which believes that research and innovation are crucial to bringing about change. As a result, the European Commission has set a budget target for Horizon 2020 of 35 percent towards

15. See Appendix 1 for a selection of other international investments.

funding climate change research. This objective has recently been followed up for the period 2014-2017 to determine the percentage of the budget that the Commission and the Member States have thus far allocated to climate action projects. The follow-up reveals that at the half-point of the Horizon 2020 programme period, only 29.8 percent of funding was related to climate action (Tzatzanis, M., 2018). The largest portion of this funding has been earmarked for the areas of the framework programme that focus on societal challenges. In particular, these areas include: food security; sustainable agriculture and forestry; marine, maritime and inland water research; bioeconomy (called "food security and bioeconomy"), safe, clean and efficient energy (called "energy"); smart, green and integrated transport systems (called "transport"); and climate action, environment, resource efficiency and raw materials (called "climate").

The largest percentage of projects that are funded focus on emission reductions and adaptation largely related to energy and transport. Research that examines the impact of climate change on communities and the environment receives significantly less funding. Research on humanities and social science issues linked to transition and interdisciplinary research questions are only funded to a limited extent.

When looking at Swedish participation in Horizon 2020, we see that Swedish organisations are generally granted 3.5 percent of available funds. However, the grant award rate is higher than this average within the areas of societal challenges of food security and bioeconomy (3.7 percent), energy (3.9 percent), transport (4.1 percent) and climate (4.3 percent). This means that Sweden has a strong participation rate in those parts of Horizon 2020 that fund the largest proportion of research and innovation related to climate. In total, Swedish organisations have received nearly SEK 3 billion from these areas of Horizon 2020. The full amount cannot be directly linked to climate research and innovation because the societal challenge for climate also includes areas that fund raw material research without a direct link to climate action. Nor does the challenge of food security and bioeconomy exclusively fund projects related to climate action. However, the entire portfolio for the societal challenges of transport and energy can in one way or another be considered related to the climate issue.

4.5 Summary

- Funding for climate research has been fragmented.
- The research area has maintained high scientific quality and demonstrated a high number of patents.
- The vast majority of current research and innovation efforts in the field of emission reductions is within technical energy and transport initiatives. They are found mainly in applied research and industrial development and demonstration, and are therefore often co-funded by businesses.
- Touchpoints between academia and other sectors in this area are obvious as seen in the co-funding in areas that interface technological research and innovation with business players.
- The vast majority of climate research that focuses on adaptation and impact lies within the natural sciences and primarily consists of basic research.
- The vast majority of climate research that focuses on climate change and models lies within technology or science and primarily consists of basic research.
- International research funded by the EU's Horizon 2020 programme shows similar patterns, with research primarily being funded within the natural and technological sciences
- There is an expressed need for more interdisciplinary science and the involvement of humanistic and social science research in the current climate research – both for mitigation and adaptation.
- There are currently very few initiatives that are being implemented with a focus on social innovation in the field of climate research.

The national programme on climate should be seen as an important complement to the research and innovation already underway in the field through the investments of state funders (Appendix 4). The point of departure for the agenda is that the other existing investments will continue beyond the agenda's timeframe. This is why we propose that the national programme complements the other initiatives with the themes and perspectives presented in Chapter 5.


5

5. The programme's central themes and perspectives

During the preparation of the agenda, six central themes and four recurring perspectives were identified for the national climate research programme. They were created based on previous descriptions of the target context for the programme, knowledge needs identified by societal stakeholders, identification of ongoing climate funding research and conclusions from other relevant reports. The programme's investments will complement the previously funded research and innovation activities in this field (see Appendix 4).

The themes should be viewed as components of a whole, with more or less strong synergies and internal linkages. This means, for example, that the theme Sustainable Solutions may include considerations based, for example, on the theme Justice and Democracy.

Noteworthy is that some themes contain elements that have strong linkages to other national research programmes (such as urbanisation and climate adaptation). These linkages are jointly managed within the national research programmes on climate, on food and on sustainable spatial planning. As Figure 1 illustrates, the programme's themes relate to established climate objectives and to the global sustainability goals set out in Agenda 2030.

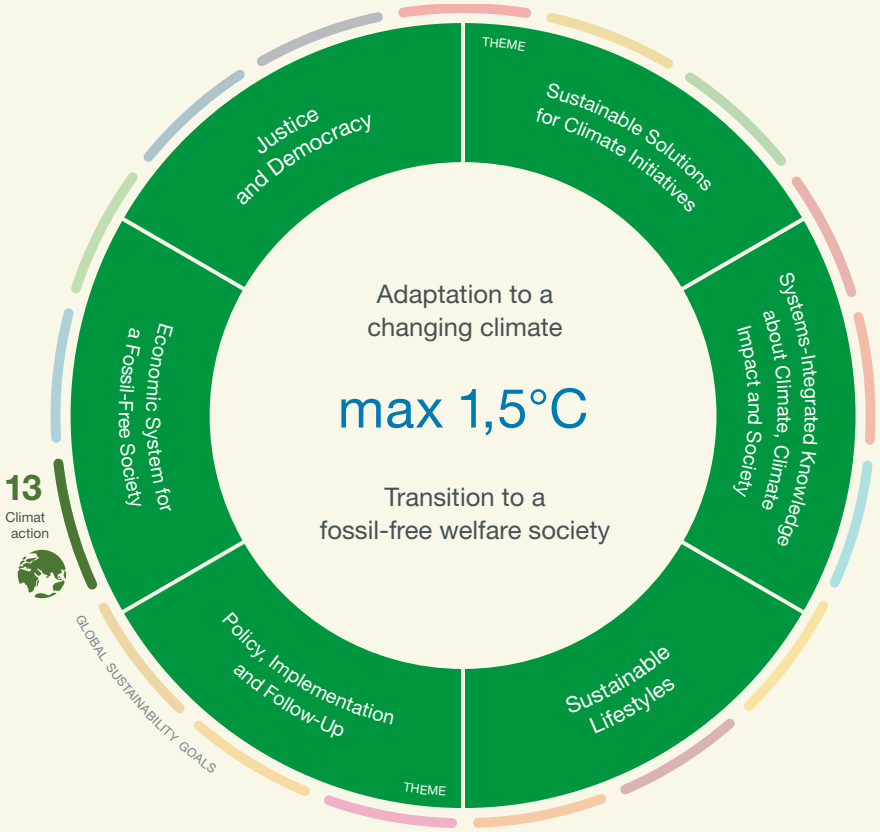


Figure 1. The programme's six selected themes, with a focus on climate adaptation as well as transition to a fossil-free welfare society, will contribute to achieving climate goals and Agenda 2030.

5.1 Theme: Sustainable Solutions for Climate Initiatives

There's no time to wait for the next generation of solutions. These solutions need to make a major contribution both to the transition process and to helping communities adapt to climate change, both in Sweden and globally. But they also need to take into account other global sustainability goals.

This theme highlights the need to develop next-generation solutions (innovations in the broad sense, such as social, organisational, policy-driven and technological) in our efforts to achieve climate neutrality. For a sustainable transition, next-generation solutions in climate change must also consider, and create synergies with, other global sustainability goals. Radical solutions are needed, especially in areas with relatively high GHG emissions across all sectors of society. For example, what kind of actions do we need in different industries in order to transition society to climate neutrality, and how can we support the production of fossil-free materials? How can circular material flows contribute to sustainable development in different sectors? What kind of effective transition processes can be applied in, for example, municipal practices, and how can we leverage lessons learned? The theme also addresses the need to find sustainable climate-adaptation solutions through, for example, more efficient spatial planning (including urban design and architecture). This includes sustainable technological and ecosystem solutions in society as well as organisational and policy-driven solutions, but also resilient, adapted infrastructure and adaptation measures related to altered precipitation patterns, for example.

The theme highlights initiatives that involve intended users early in the processes of developing, testing and learning from the different activities.

This includes collaboration with users in the public sector, civil society and private-sector businesses. For example, the public sector requires investments in digital tools, methods/models, processes and work approaches to work effectively with climate issues. New business models, digital services and work approaches must also be developed and tested in both the public and private sectors.

5.2 Theme: Systems-Integrated Knowledge about Climate, Climate Impact and Society

Increased knowledge is needed of advanced systems perspectives and multidisciplinary analysis. The climate system and climate challenge are complex, with many linkages between sectors, levels and stakeholders, as well as between climate goals and other sustainability objectives.

This theme highlights the need to develop new knowledge around questions that have no clear answers. Where there are models and methods that attempt to describe how the climate functions and its effects on climate change both in natural environments and in our social systems. How does regional change caused by global warming link back to the climate system? How do these effects drive or dampen further change? How is natural carbon uptake and release impacted by a warmer climate? What options exist for tackling interconnected problems such as air and climate change? What impact does climate change have on different ecosystems in terms of our built environment and critical infrastructure (electricity, telephony, internet, transport, water, sewage etc.), in combination

with social, cultural and economic processes? And what impact do these effects have on a future welfare society? Within the theme, questions can be explored concerning the interplay between climate and forests, for example, from different system boundaries and the many uses of forest raw materials. Questions about the interplay between climate and land use (food production in particular) can also be further explored. Food production affects the climate in terms of health considerations, for example, where communicable diseases (mainly those transmitted via insects, water or the environment in other ways) are expected to increase in abundance and/or to emerge in new contexts as a result of a changed climate. This linkage also includes questions concerning the possibilities for increasing soil carbon sequestration.

In addition, risk and vulnerability research is needed on natural and cultural environments in relation to the effects of climate change linked to planning processes, for example. This can include research on disaster preparedness and risk analysis management.

Researching these issues requires both disciplinary and new interdisciplinary approaches in systems research, where researchers from different scientific, technical, social-science and humanist disciplines work together.

In terms of methodological and scenario development, transparent and innovative models are needed to explore complex systems perspectives, alternative scenarios and development paths, taking into account the behaviour of stakeholders, new goals and other influencing factors. Critical analyses and the humanities can also contribute to new methods and models in our climate efforts. In addition, an understanding is needed of how modelling results are used and how they function (both benefits and drawbacks) as a basis for policy decisions.

5.3 Theme: Sustainable Lifestyles

Swedish consumers' GHG emissions have become increasingly global. Some even say that we are now "exporting" our emissions to other countries. Today, Swedish consumption is highly dependent on production and value chains outside Sweden's borders. One central issue is how Sweden contributes to creating far more transparent, sustainable and responsible consumption patterns, with value chains included.

Sustainable Lifestyles is a theme that addresses the key challenge of adapting to sustainable production and consumption chains globally. The theme also includes sustainable distribution, logistics and communication for promoting sustainable alternatives when we eat, travel, live and shop, whether at work or at home.

The theme calls for increased knowledge about the natural resources used in production, their origins, how the use of nature's resources affects people and our surrounding environment, and potential scenarios for increased sustainable reuse or recovery (circular economy).

New knowledge is needed about a sustainable food supply, including clean water, for the earth's population. This is something that relies on functioning trading systems and markets, as well as on viable infrastructure for sustainable transport and storage. Linkages need to be investigated between things like food production, which is both impacted by and impacts climate change (through cultivation systems and animal husbandry), and its consequences.

In addition, we must address issues related to changing consumption habits, as well as links to health and well-being and the potential to reduce negative environmental and climate impacts. An understanding of issues relating to consumption patterns and the overall level of consumption are central to this theme. Economic growth is strongly linked to consumption and therefore also to the emissions generated by consumption. Can an enhanced sharing economy represent a successful path towards a more sustainable use of resources?

We need to explore our patterns of behaviour more and understand beliefs about what a good lifestyle can mean. How do we define well-being, health and beliefs about quality of life? How are such beliefs and values linked to different types of consumption?

Such research can highlight the gap between an ethical climate mindset and action, and can help to bridge this gap. Can a good lifestyle embrace other values and a different form of consumption?

5.4 Theme: Policies, Implementation and Follow-Up

The theme Policies, Implementation and Follow-Up highlights the need for a way forward that steers society's different stakeholders in a more sustainable direction, one that helps to achieve the set goals. Our climate challenge demands clear political governance and a leadership that helps to bring about societal structures and developments that recognise climate as an undisputable input value.

Policy decisions and processes on climate are implemented in society at the global, intergovernmental, national, regional and local levels. Policy needs to be designed in close collaboration between different sectors of society, such as academia, industry, the public sector and civil society. Synergies and conflicts of objectives in different policy areas, as well as policies related to them, must be analysed, followed up and assessed in order to achieve effective, comprehensive and sustainable societal change through evidence-based decisions.

The theme focuses on the need for better knowledge of both climate-related decision-making processes and of different policy measures (individual or in combination) in order to increase the rate of research used in decision-making and measures that reduce climate impact and help us adapt and readjust our societies. For example, how can different types of instruments, individually or in combination (both mandatory and voluntary), contribute to a rapid societal transition to a fossil-free welfare society and to the 2045 target of zero-net GHG emissions in the atmosphere, followed by negative emissions? What are effective climate adaptation measures that interplay with other sustainability objectives? How can effective management be achieved that manages increased climate risks and contributes to adaptation in a changing world? Climate scenarios developed on an ongoing basis are needed to understand the impacts of climate change as aligned with new policies.

Other issues that require research are: How can we contribute to important international policy areas for transformative climate change that currently lack powerful instruments, such as shipping and aviation? What are the prerequisites for international cooperation around climate adaptation policies, for example regarding urban climate adaptation solutions and solutions for addressing the effects of flooding, heavy rainfall and fires?

For continued analysis and a better understanding of effective policy instruments, we also need to follow up and evaluate different measures for further learning. Can economic instruments be complemented by other efforts to correct market failures and other barriers that curb climate mitigation? Addressing and analysing combinations of, for example, economic instruments and their consequences is vital in terms of climate change through more radical technology shifts (such as combining technology policy and climate policy). How can important industries be supported through research and innovation funding for the transition we are facing?

Further analyses of the costs of different instruments, as well as their benefits and value add, are captured in this theme. This also includes analyses of distribution effects and other consequences of potential choices and policy instrument measures for limiting CO2 emissions from human activity.

Further knowledge is needed on the various forms of aid and mechanisms that are voluntary and can operate from the ground up to bring about change. This could take place through dialogue and information to households and companies encouraging sustainable behaviour, or through education on climate-smart urban planning and climate-smart public procurement processes. How can people translate climate knowledge to different contexts, and what opportunities and challenges are there today? Climate issues also have a bearing on purely existential questions about what it means to be human and what competencies must be developed in order to survive under altered circumstances.

Educational solutions should also focus on how to understand and explain the climate challenge in different contexts. Critical perspectives on how different interests can translate into climate knowledge and oppose climate knowledge must also contribute under the theme.

5.5 Theme: Economic System for a Fossil-Free Society

This theme includes questions around a neutral, sustainable economic system and how the game rules of the economy affect climate actions.

Issues relating to sustainable financial systems can be highlighted within the theme. For example, how can private and public investments increasingly interplay with society's climate efforts and thus be leveraged in global climate funding? How can green investments contribute to a sustainable society through employment, innovation and technology dissemination in a way that simultaneously creates synergies with other global sustainability goals?

Within the theme, questions can be explored that relate to financial conditions and instruments and how these can be linked to real climate impact and climate benefits. What could a financial system look like that addresses the long-term impacts on natural and cultural resources, over several generations? And how can we develop models that place both a monetary and non-monetary value on green infrastructure and ecosystem services to strengthen our capacity for recovery and resilience in the face of climate change?

5.6 Theme: Justice and Democracy

People, organisations and countries need to be involved in climate actions and get the chance to influence social development and shape the future of fossil-free spatial planning.

This theme revolves around climate justice and the democratic aspects of climate adaptation and climate change. Analyses are needed on how different individuals, groups and countries create different climate problems, how people in different contexts are affected and what opportunities they have to make a difference. How can the countries that have so far been emitting the most carbon dioxide (historical emissions, but also actual emissions and impacts today) support other countries that are already severely impacted by climate change? How can industrialised countries and even several emerging economies take responsibility for and reduce their own emissions?

Questions about the underlying causes of conflict and migration need to be highlighted based on considerations like the unequal distribution of resources and goods and the consequences of climate change. For example, what is the relationship between sustainable development and women's access to sustainable energy and transport solutions, and access to functioning markets?

How can a new understanding of climate-related natural disasters, ones that have different effects on different social groups due to political and economic inequalities among these groups, contribute to greater justice?

The theme covers research on social movements, processes, ideologies and power factors that can contribute to a better understanding of what promotes and what counteracts society's climate adaptation efforts.

Sweden faces different challenges in urban versus rural areas in terms of climate adaptation and climate change actions. Issues of justice and equality between groups in society must be addressed in climate actions locally, nationally and globally, through solutions that maximise sustainability and fairness for all groups.

Scientific climate research should be made openly accessible by developing and making available data, information and research findings. Users should be able to access and take part of the scientific knowledge base, regardless of where they live. Policymakers, academics and civil society globally should be able to gain access to research on climate adaptation and the transition to climate neutrality. Strengthened research networks and global collaboration remain important for strengthening the role of science in decision-making. The theme includes methods for increasing points of contact between different sectors of society so that, for example, citizens can participate and influence content and solutions.

5.7 Perspectives in the central themes

In addition to the six themes already presented, four perspectives have been identified as particularly relevant within each theme of the national climate research programme:

- Globalisation. The process of adapting society and transitioning to fossil-fuel independence must be researched using global, intergovernmental (e.g. EU), national, regional and local perspectives. Comparative studies and collaborative international projects should therefore be welcomed in all aspects of the programme's activities. The programme should also be actively linked to current international collaborative initiatives for climate change research.
- Digitalisation. Society's climate adaptation and transition to fossil-fuel independence – and the foundations of climate policy – will be strongly influenced by digitalisation and the rapid development of the digital economy. Digitalisation offers a variety of solutions that address how to reduce climate emissions, including: sustainable accessibility (the ability to minimise and bridge geographical distances to create touchpoints and proximity to benefits and features), travel-free meetings, sustainable solutions for leaving and picking up children at day-care, grocery delivery and so on. Digitalisation also offers solutions related to hiring or sharing resources instead of ownership, smart houses, a more efficient use of energy and materials, and more. Digitalisation also entails the management of large data sets, which creates challenges as well as opportunities for the further development of complex climate and socio-economic models and scenarios that can contribute to evidence-based policy. At the same time, a variety of new IT-based services and products are being developed that are causing a surge in energy and resource use. We must therefore better understand the potential of digitalisation to facilitate the climate transition in different parts of society. The government has also indicated the need for increased digital capacity in public agencies in order to leverage digitalisation to meet the requirements of climate adaptation and mitigation (2018:3).
- Sustainable development. Climate adaptation and the transition to a fossil-free welfare society must take place in interaction with the social and economic dimensions of sustainable development, and with the environmental dimensions that do not directly concern the release of greenhouse gases. This perspective permeates all the priority themes so that the contributions to climate efforts are put into context in relation to the other sustainability objectives and in relation to the Swedish action plan for Agenda 2030.
- Gender equality. Gender equality is an important issue for poverty reduction, development and increased awareness of the world around us. Representation and participation in democratic processes have been highlighted as important aspects of a sustainable transition. Diversity and gender equality help to raise the voices of different people and interests in our climate adaptation and transition efforts. Gender equality is also a designated interdisciplinary area within Agenda 2030, in addition to being a separate goal.

6

6. Implementation of the agenda

The agenda has identified central themes and key perspectives for future activities in the national research programme. These themes and perspectives address challenges and knowledge needs for climate action that can help to achieve national and global goals, EU goals and the goals of Agenda 2030.

This chapter describes how the agenda's themes, perspectives and objectives guide the planning of activities within the framework of the national climate research programme. It also describes how the agenda's priorities are driven forward by implementation plans, and how programme logic will be used as a tool when planning activities in order to achieve the objectives and contribute to the desired outcomes of the programme. The chapter concludes with an account of the follow-up and evaluation work that forms an important basis for developing the programme.

The strategic research agenda is a living document and will be regularly updated during the programme period.

6.1 Programme logic and implementation plan

Chapter 2 describes the global and national objectives that the programme uses as its starting point and defines the objectives specific to the national programme.

To achieve the objectives, so-called programme logic will be used. Programme logic is a description of how the programme intends to achieve its goals and is based on an analysis of the expected outcomes and effects to be pursued to achieve the goals.

The programme will be implemented using three-year implementation plans that describe the activities to be carried out during the programme. This can include new investments in research funding, or activities for coordinating, communicating and utilising ongoing research. The planned activities will help to meet the specific needs of the area as well as the overall objectives of the national research programmes.

When designing the implementation plan, the programme committee is expected to shed light on how different funders' activities are planned in time, in scope and in relation to each other to achieve the greatest possible effect. The programme committee is also expected to take into account synergies that can be achieved in relation to other national and international activities. The programme's first implementation plan will be created in 2018, after the agenda is determined, and will be valid until 2020.

6.2 Follow-up and evaluation guide future choices

Follow-up and evaluation are essential support tools in the programme committee's work on implementing and, as necessary, revising the strategic research agenda.

In accordance with the commission, Formas will follow up on the national research programme each year to monitor its progress. For follow-up purposes, Formas is developing several indicators that will be used to:

- Monitor the activities of the funders who participate in the programme.
- Monitor the projects and activities of the programme's research practitioners and others who are being funded or otherwise take part in the programme's implementation.

Because the programme is long-term, a number of evaluations will also be conducted during the programme period. An initial evaluation of the programme is scheduled to take place after two years, and will focus on the programme's organisation and logic. A second evaluation is scheduled to take place at the halfway point, and will provide information on how the programme is evolving in relation to its objectives. At the end of the programme, a final evaluation is planned that will focus on the programme's impact on society's ability to meet the challenges and impact on the research system. Formas' evaluations will also inform the overall evaluation of investments in national research programmes that the government intends to initiate.

The programme is long-term and has built-in flexibility to take account of changes taking place in the world and the results of the evaluations. Following each evaluation, the programme committee will consider whether the agenda needs to be revised. Major changes in the world that may affect the programme, whether domestic or international, can also lead to a reprioritisation of programme objectives and activities. The revised agenda should be anchored with research practitioners and societal stakeholders.

Formas' Scientific Council will approve the revised agenda after consulting the programme committee.

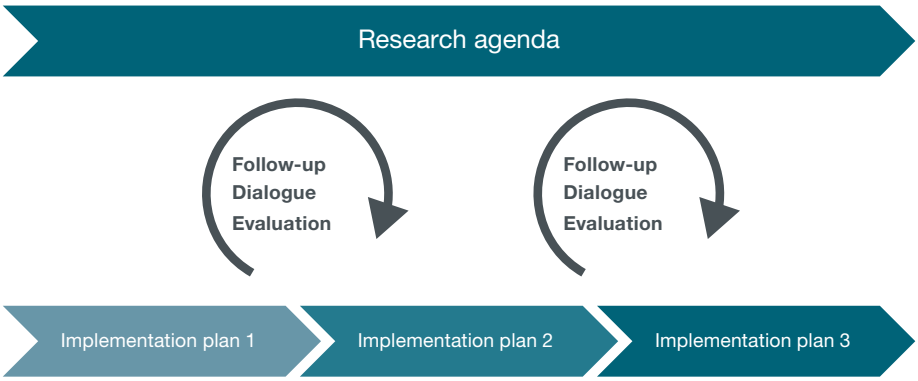


Figure 5 The research agenda outlines the overarching objectives and priorities of the programme over a ten-year period. The implementation plans set out the activities to be conducted over a three-year period and how they relate to the agenda and the programme logic.

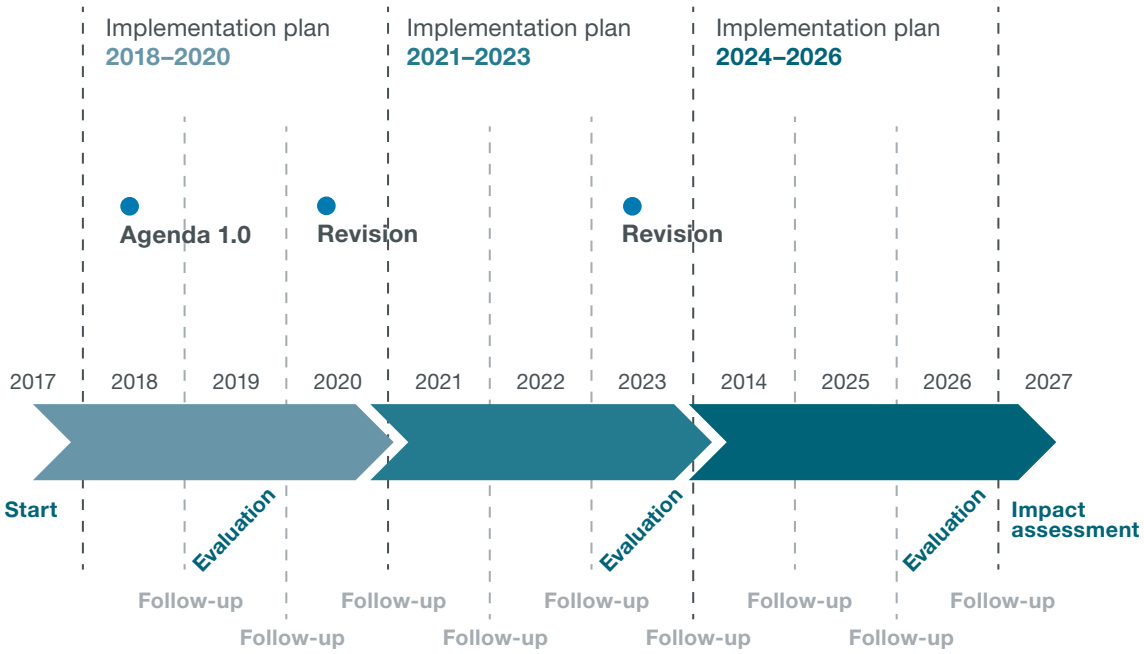


Figure 6. Overall timetable for follow-up, evaluation and revision of the research agenda.

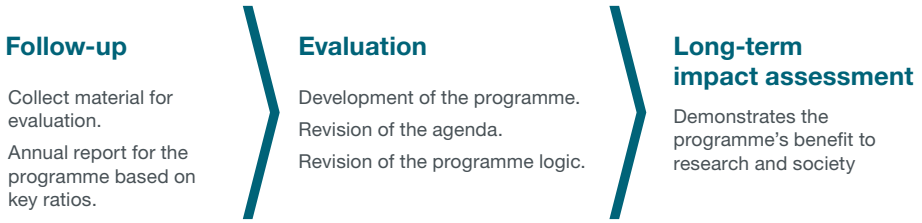


Figure 7. The relationship between follow-up, evaluation and impact assessment of the national research programme.

7. Appendices

Appendix 1 Other programmes and strategies

This appendix describes how the National Research Programme for Climate is linked to other programmes and strategies, both nationally and internationally, and how synergies can be achieved among them.

The National Research Programme for Climate is one of the seven national research programmes. The research programmes, together with the government's collaboration programmes and the strategic research and innovation areas, are complementary components of the government's research policy. Taken together, these initiatives will strengthen Sweden's research and innovation system and help Sweden to become more competitive and better manage its major societal challenges. The initiatives will also create platforms for enhanced international cooperation and strengthened Swedish participation in the European programmes. The different programmes share common themes, providing opportunities for joint efforts in specific areas.

International

The programme committee is tasked with identifying relevant international initiatives and national efforts in other countries that can complement Swedish investments or opportunities for cooperation. Efforts to highlight relevant international initiatives continue in the implementation phase, and the investments below will be supplemented on a continuous basis.

- Sweden has a long history of sitting on the UN's Climate Panel (IPCC) since it was instituted.
- Horizon 2020: At the European level, Sweden is participating in the framework programme for research and innovation, Horizon 2014-2020, with its three strategic goals: high scientific quality, industrial leadership and societal challenges.

The national research programme on climate has more or less great potential for synergies with these various EU initiatives.

The following initiatives and programmes may be especially relevant for future efforts in the research programme to enable mutual influence and leverage between Swedish researchers and international stakeholders. They include joint programme initiatives (JPIs), ERA-NET and other research and innovation initiatives in the EU.

- JPI Climate – Connecting Climate Knowledge for Europe. JPI Climate strives to integrate different areas of climate research and provide useful climate knowledge to society.
- JPI FACCE – Agriculture, Food Security and Climate Change. JPI FACCE focuses on how to secure the future of agriculture and the food supply in light of ongoing climate change.
- JPI Oceans – Healthy and Productive Seas and Oceans. JPI Oceans focuses on how to use our seas and oceans sustainably and how to develop new products and services to ensure their Good Environmental Status.

- JPI Urban Europe. This JPI is an initiative for creating European solutions for sustainable urban development through research and implementation. Its focus is on transforming urban areas into innovation and technology centres, ensuring social cohesion and integration, reducing ecological footprints to promote climate neutrality, leveraging technological solutions, and realising efficient and sustainable urban systems and networks.
- JPI Water. This JPI aims to create sustainable water systems in a sustainable economy throughout Europe and globally. Water is a prerequisite for smart, sustainable and inclusive growth.
- ERA4CS Climate Services. ERA4CS, the European Research Area for Climate Services, supports research for developing climate services that make climate information available and relevant for different areas of application and users.
- BONUS for Baltic Sea Science deals with the Baltic ecosystem and its links to activities on land and at sea.
- Climate Knowledge and Innovation (Climate-KIC).

Other research and innovation cooperation initiatives that may be particularly relevant for the programme to connect with:

- NordForsk operates under the Nordic Council of Ministers and promotes Nordic cooperation in research and research infrastructure. NordForsk administers a bio-economy programme and a programme on sustainable development of the Arctic called “Pathways to Action”.
- SNS Joint Nordic Forest Research. SNS is a cooperating body funded with grants provided by the Nordic Council of Ministers. It aims to promote research into the diverse functions of the forest for sustainable forestry and to advise the Council on issues relating to forests and forestry research.
- The bilateral agreement between Sweden and France for climate and environmental research. The agreement provides for the funding of collaborative projects between Swedish and French researchers.
- Belmont Forum is an international partnership between funding agencies with the task of meeting global environmental and climate challenges. The partners coordinate strategies, learn from each other’s experiences, and coordinate and co-fund joint research programmes. Formas has been a full member of Belmont Forum since 2016. This allows Formas to more actively participate in Forum meetings and activities, strengthening our global network.
- SMHI hosts the international project office for CORDEX (Coordinated Regional Climate Downscaling Experiment) on behalf of the WCRP (World Climate Research Programme).
- Future Earth has five of its core project secretariats in Sweden.
- The Swedish Environmental Protection Agency supports the global initiative New Climate Economy.
- Sweden supports research in developing countries through Sida. All regions are supported, but the focus is on sub-Saharan Africa.

- SMHI represents Sweden in the World Meteorological Organisation (WMO), the European Network of Meteorological Weather Services (EUMETNET) and other international organisations.
- Sweden contributes to the essential climate variables (ECVs) of the Global Climate Observation System (GCOS), which include long-term observations and measurements of temperature, precipitation, wave height, ice conditions, glacier variations and satellite observations.
- Sverige bidrar till framtagande av en ny infrastruktur för globala observationssystem, främst genom Copernicus Sentinel-satelliterna. Sverige har ett omfattande deltagande i internationell forskningsinfrastruktur, såsom ICOS (Integrated Carbon Observing System – European Research Infrastructure Cooperation)
- The International Energy Agency (IEA) has about 40 multilateral technology collaboration programmes (TCPs) for technology collaboration. Within each collaboration programme, countries as well as public and private organisations can share research results on new technologies, fill research gaps and create partnerships for pilots or demonstration projects. Sweden takes part in 22 of the IEA's TCPs through the Swedish Energy Agency and Swedish Transport Administration.

Government collaboration programmes and strategic innovation programmes

- www.vinnova.se/en/m/strategic-innovation-programmes/
- www.regeringen.se/regeringens-politik/regeringens-strategiska-samverkansprogram/

Other national research programmes

National research programmes shed light on significant national and global societal challenges related to complex issues that are not well-delimited or well-defined areas. The drivers, consequences and solutions around one particular challenge also relate to other challenges, so there are many interactions, synergies and conflicts of interest between the challenges.

Because of the complexity, the programme committee's mission is to identify synergies and collaborative opportunities between the climate programme and the other national research programmes. This can involve agreeing on responsibilities for supplementary actions and activities, or initiating joint operations and activities in an area relevant to two or more of the programmes.

For example, the climate area has obvious touchpoints with:

- The programme for sustainable spatial planning, which involves questions around transport, energy, consumption, policy instruments, adaptation, circular economy, etc.
- The food programme, which involves questions around consumption, policy instruments, adaptation, circular economy, etc.
- The migration and integration programme, which involves questions around the impact of climate change, driving forces for migration, etc.

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Appendix 3 Targets in the global sustainability goals relevant to the programme

The national research programme for climate is linked to the following targets of Agenda 2030:

1. No poverty

1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.

2. Zero hunger

2.4. By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

3. Good health and well-being

3.D Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

4. Quality education

4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.

5. Gender equality

5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.

5.A Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.

5.B Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.

5.C Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels.

6. Clean water and sanitation

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

7. Affordable and clean energy

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.

7.3 By 2030, double the global rate of improvement in energy efficiency.

7.A By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.

7.B By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States.

8. Decent work and economic growth

8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead.

9. Industry, innovation and infrastructure

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities..

10. Reduced inequalities

10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.

10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions.

11. Sustainable cities and communities

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

11.3 By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

11.B By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels..

12. Responsible consumption and production.

12.1 Implement the 10-year framework of programmes on sustainable consumption and production patterns, all countries are taking action, with the developed countries in the forefront and taking into account the development and conditions of developing countries.

12.2 By 2030, achieve sustainable management and efficient use of natural resources.

12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities.

12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.

12.A Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.

13. Climate action

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

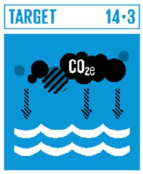
13.2 Integrate climate change measures into national policies, strategies and planning.

13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

13.A Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goalof mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of

developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.

13.B Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.



14. Life below water

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive ocean.

14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels..

15. Life on land

15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

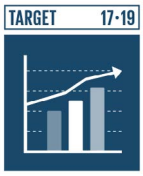
15.B Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.

16. Peace, justice and strong institutions

16.6 Develop effective, accountable and transparent institutions at all levels.

16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels.

16.B Broaden and strengthen the participation of developing countries in the institutions of global governance. .



17. Partnerships for the goals

17.7. Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed.

17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation.

17.14 Enhance policy coherence for sustainable development.

17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development.

17.16. Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries.

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries.

Appendix 4 Research funder investments

Programmes and calls included in the survey of ongoing climate action 2012-2020..

Funding source	Programme/Call	Programme period	Funding
Strategic innovation area	Focus on climate	2012–	1.2 billion SEK
Formas	Open call	2012–2017	Approx. 500 MSEK
	ERA-Net ClimateServices	2017–2019	20 MSEK
	ERA-Net AXIS	2018–2020	15 MSEK
	ERA-NET. BiodivERsA Cofund 2016	2016–2019	54,8 MSEK
	JPI Climate/Belmont Forum Climate Predictability and Inter-Regional Linkages	2016	5,9 MSEK
	Bonus article 185. Sustainable ecosystem services	2013–2016	14,7 MSEK
	ERA-NET. (ERA-MBT) Marine Biotechnology 2015	2013–2017	12,5 MSEK
	JPI Societal transformation in the face of climate change	2014–2017	9 MSEK
	JPI - FACCE	2012–2014	1,2 MSEK
	Belmont Forum Arctic II		15 MSEK
	Linnestöd Bert Bolin Center	2012–2016	48 MSEK
Swedish Environmental Protection Agency	JPI Climate Russian Arctic and Boreal Systems	2014	6,1 MSEK
	NordForsk Responsible Development of the Arctic	2016–2019	20 MSEK
	“Sustainability and resilience - Tackling climate and environmental changes” (with SIDA and Formas)	2016, 2018	126 MSEK
	Collaboration with VR, Formas, CEA (FR), CNRS (FR), Versailles Saint-Quentin Univ (FR) within climate, environment and energy (ESS agreements).	2012–2017	36 MSEK
	Bilateral cooperation with South Korea	2015–2016	4 MSEK
	IODP/ECORD	2012 – 2020 (2003– 2023)	40,5 MSEK
	ICDP	2012– 2020 (2008–present)	6,5 MSEK
	Swedish Polar Research Collaborations (EPB, IASC SCAR)	2012–2020 (2001–present)	2,7 MSEK
	ICOS-ERIC	2013–2020	40 MSEK
	EISCAT/EISCAT_3D	2012 –2020 (1981–present)	164 MSEK
	Calculation and storage for climate modeling	2012–2020 (2001– present)	30 MSEK
	GBIF (Global Biodiversity Information Facility)	2012–2020 (2001–present)	24,3 MSEK
	Project grants and equipment granted through open calls	2012–present	Approx. 500 MSEK

Funding source	Programme/Call	Programme period	Funding
Swedish Research Council, cont'd.	SITES (Swedish Infrastructure for Ecosystem Science)	2013–2022	230 MSEK
	Svenska ICOS (Integrated Carbon Observation System)	2012–2020	108 MSEK
	Buoy-based environmental measurement system	2012–2017	13 MSEK
	Swedish LifeWatch	2012–2020	24,6 MSEK
	Biodiversity Atlas Sweden	2017–2020	17 MSEK
	Future Earth	2015–2018	12 MSEK
	Bonus article 185. Viable Ecosystems	2013–2016	8 MSEK
	Equipment for the icebreaker Oden	2013–2017	2,2 MSEK
	Basic research on energy	2014–2021	480 MSEK
Swedish Space Agency	ESA, Earth Observation programmes, Global Monitoring of Essential Climate Variables (CCI/CCI +), Copernicus et al.	2012– Indefinite	Swedish contribution approx. 962 MSEK during 2012-2017
	Earth Observation Envelope Programme (EOEP 5)	2017–2021	Swedish contribution approx. 110 MSEK
	Satelliten SIW, Stratospheric Inferred Winds	2018–2024	Approx. 89 MSEK
	Satelliten Odin	2001– Indefinite	Operating cost approx. 35 MSEK in 2012-2018
	MATS, Mesospheric Airglow/Aerosol Tomography and Spectroscopy	2014–2021	Approx. 120 MSEK
	National research programmes	Ongoing with annual calls	Approx. 180 MSEK during 2012-2018
Swedish Environmental Protection Agency	Environmental changes, measures and air pollution exposure from a health perspective	2012–2015	2,7 MSEK
	Policy instruments and consumption	2016–2018	22,6 MSEK
	Swedish consumer environmental impact PRINCE	2014–2018	15 MSEK (divided over 3 years)
	Urban planning for reduced environmental impact	2014–2017	SEK 10 million (granted by Swedish EPA)
	Clean air and climate (SCAC)	2013–2016	25 MSEK
	Air pollution effects (SCAC 2)	2013–2019	12 MSEK (for period 2017-2019)
	Sustainable shipping and environment in Baltic Sea region (SHEBA)	2015–2017	9,7 MSEK
	Climate change and environmental objectives CLEO 2	2012–2014	19 MSEK
	Sustainable and efficient transport in society	2018–2020	23 MSEK
	Management of ecosystems in a changing climate – forest, agriculture and aquatic systems	2018–2019	3 MSEK
Swedish Energy Agency	**Sustainable transport**		
	Battery fund programme	2017–2027	280 MSEK
	Demonstration programmes for electric vehicles	2011–2018	285 MSEK

Funding source	Programme/Call	Programme period	Funding
Swedish Energy Agency, cont'd.	Energy-efficient electric vehicles	2015–2019	88 MSEK
	Strategic automotive research and innovation (FFI)	2009-(Bi-annual review)	115 MSEK/year
	R&D programme on energy efficiency in transport sector	2014–2019	175 MSEK
	Centre of excellence CCGEx 2018-2021	2018–2021	40 MSEK
	Centre of excellence CERC 2018-2021	2018–2021	40 MSEK
	Centre of excellence combustion processes (KCFP) 2018-2021	2018–2021	40 MSEK
	Centre of excellence Catalysis (KCK)	2014–2017	32 MSEK
	ERA-NET Cofund Electric Mobility Europe (EME)	2017–2021	6,5 MSEK
	Swedish Electromobility Center - Stage 3, (2015-2019)	2015–2019	38,4 MSEK
	Sustainable electricity		
	BBG programme	2016–2020	25 MSEK
	ERA-net Smart Grids Plus	2015–2018	36 MSEK
	OCEANS ERA-net	2016–2020	18,1 MSEK
	Vindforsk IV	2013–2017	35,3 MSEK
	Swedish Wind Power Technology Centre (SWPTC)	2014–2018	32 MSEK
	VindEL	2017–2021	133 MSEK
	HåVa (Sustainable Hydropower)	2017–2021	60 MSEK
	SVC (Swedish Hydroelectric Engineering Centre)	2017–2020	27,9 MSEK
	SolEl Programme 2013-2017	2013–2017	7,5 MSEK
	Marine Energy Conversion 2015-2018	2015–2018	53 MSEK
	Elektra 2013–2017	2013–2017	29,7 MSEK
	Electricity from the sun	2016–2020	160 MSEK
	Research and Innovation programme SamspEL 2016-2020	2016–2020	173 MSEK
	Innovative and needs-driven R&D with relevance for energy	2013–2019	150 MSEK
	Strategic innovation programme Viable Cities	2017–2021	104 MSEK (Total 141 MSEK incl. funding from Vinnova and Formas)
	Sustainable Urbanisaton Global Initiative	2017–2020	9 MSEK (EM)
	ERA- Net Cofund Smart Cities and Communities (ENSCC)	2015–2018	Swedish Energy Agency funds 4 projects, Y MSEK
	SweGRIDS 2013–2017	2014–2017	82,8 MSEK
	Sustainable industry		
	Biofuel programme	2015–2021	45 MSEK/year
	Collaboration programme, Renewable fuels and systems	2014–2017	22 MSEK

Funding source	Programme/Call	Programme period	Funding
Swedish Energy Agency, cont'd..	Industrial energy use, R&D	2015–2019	72 MSEK
	Energy use of the pulp and paper industry, R&D	2015–2019	110 MSEK
	Collaboration programme, Iron and steel industry's energy use - R&D	2013–2017	76 MSEK
	Swedish Gasification Centre 2017-2020	2017–2020	80 MSEK
	Call for proposals to implement innovative efforts to reduce greenhouse gas emissions from the process industry	2016–2019	65 MSEK
	People, energy systems, society	2017–2022	160 MSEK
	Sustainable bio-energy		
	Fuel programme, Sustainability	2011–2017	95 MSEK
	Fuel conversion programme	2011–2017	73 MSEK
	Fuel supply programme	2011–2017	104 MSEK
	CECOST – Development and application of tools for the study of combustion processes	2014–2017	32 MSEK
	ERA-NET Bioenergy	2014–2021	Approx. 10-15 MSEK per call
	International cooperation for eco-innovations – energy in China - ISMEK	2013–2017	20 MSEK
	Energy technology for thermal energy processes	2014–2018	46 MSEK
	Collaboration programme Fjärrsyn (district heating) 2013-2017	2013–2017	26,4 MSEK
	Collaboration programme in energy gas technology 2013-2017	2013–2017	32 MSEK
	Strategic innovation programme RE:Source	2016–2018	154,5 MSEK
	Collaboration programme in fuel-based power and heat production (SEBRA)	2016–2019	21 MSEK
	Turbines for energy systems of the future	2016–2019	40 MSEK
	Centre of excellence: High-temperature corrosion (HTC)	2014–2017	32 MSEK
	Biomass for energy and materials	2017–2021	70 MSEK
	Energy Systems research school	2014–2019	40 MSEK
	Strategic energy systems research	2014–2018	130 MSEK
	Resource-efficient buildings		
	E2B2 collaboration programme for research and innovation in energy-efficient building and housing	2013–2017	140 MSEK
	R&D programme, Energy, IT and Design - Stage 3	2013–2017	60 MSEK
	Programmes for energy efficiency in culturally valuable buildings - Save and Preserve - Stage 3	2015–2018	40 MSEK
	Energy efficiency in lighting 2017-2021	2017–2021	50 MSEK

Funding source	Programme/Call	Programme period	Funding
Swedish Energy Agency, cont'd.	EFFSYS EXPAND 2014-2018	2014–2018	33,6 MSEK
	Call for applications to tackle challenges around achieving more resource- and energy-efficient buildings	2016–2020	15 MSEK
	Commercialisation and entrepreneurship		
	Verification of new energy innovations - with a business focus	2013–2018	20 MSEK
	Overall		
	Basic research on energy	2014–2021	480 MSEK/year
Vinnova	Open Lab, Innovative Startups	2016–2017	7,4 MSEK
	SIP Medtech4Health, InfraSweden2030	2016–2018/19	9,2 MSEK
	2017-2018/22		31,2 MSEK
	Innovation research	2012–2018	15,2 MSEK
	Social Innovation	2015–2017	0,5 MSEK
	Incubator programme 2015 +	2015–2017	3,3 MSEK
	SIP BioInnovation	2016–2017	4,6 MSEK
	SIP Swelife, SIP PiiA, SIP STRIM, SIP Lightweight	2014–2018/19	7,8 MSEK
	Materials-oriented waste competitiveness	2014, 2016–2018	1,3 MSEK
	Programme for enhanced EU cooperation	2013–2019	2,6 MSEK
	Innovation management and organisation	2013–2019	6,4 MSEK
	Innovations for sustainable society, service innovation	2013–2020	71,7 MSEK
	TM test beds in environmental	2012–2018	19,4 MSEK
	UoH strategic collaboration	2013–2019	15,5 MSEK
	International cooperation for environmental innovations	2012–2014	1,1 MSEK
	Innovation projects in the public sector	2013–2017	3,8 MSEK
	Strategic innovation programmes	2013–2016	6,9 MSEK
	Open Innovation	2012–2016	3,2 MSEK
	Mobility for Growth	2014–2018	8,4 MSEK
	Challenge-driven innovation - Societal challenges as growth opportunities	2013–2019	177,8 MSEK
	National innovation programme - Building Innovation	2012–2018	5 MSEK
	EU relations, global collaboration	2012–2018	14,6 MSEK
	Innovation capacity in the public sector, programme for financial market research, services for ICT strategic projects, etc.	2013–2019	18,1 MSEK

Funding source	Programme/Call	Programme period	Funding
Vinnova, cont'd.	Innovation projects in companies, strategic automotive research and innovation, transport policy and collaboration, Eureka Eurostars, forestry and wood programme, VINNVÄXT, TM-international collaboration programmes, etc.	2012–2019	61,2 MSEK
MISTRA	Mistra Indigo - Instrument Design for Global Climate Mitigation	2012–2015	25 MSEK
	Mistra-SWECIA - Mistra Swedish Research Programme on Climate, Impacts and Adaptation	2008–2015	83 MSEK
	Future Forests	2009–2016	111 MSEK
	Mistra Arctic Sustainable Development	2014–2018	30 MSEK
	Mistra – Sustainable Consumption	2017–2021	45 MSEK
	Mistra Carbon Exit	2017–2021	56 MSEK
	Mistra Financial Systems	2016–2019	30 MSEK
	Mistra Geopolitics	2017–2020	48 MSEK
	Mistra Innovation	2012–2019	88 MSEK
The Riksbank's Jubilee Fund	Climate and sustainability in developing countries	2016–	40,7 MSEK
	Climate ethics and future generations	2017–	40,9 MSEK
	Other projects	from 2012	9 MSEK
Knut & Alice Wallenberg Foundation	Project grants	from 2013–	172,9 MSEK
	Wallenberg Academy Fellows	from 2011–	50 MSEK
	Wallenberg Wood Science Cener	2008–2028	850 MSEK
	Wallenberg Scholars	2011–	30 MSEK
Marianne and Marcus Wallenberg Foundation	Project grants	from 2015–	11,2 MSEK
Marcus and Amalia Wallenberg Foundation	Project grants	from 2016–	5 MSEK
European framework programme for research and innovation Horizon 2020	Work programme for societal challenge 2: Food security, sustainable agriculture and forestry, marine, maritime and inland water research and bio-economy	2014–2017	approx. 486 MSEK
	Work programme for societal challenge 3: Safe, clean and efficient energy	2014–2017	approx. 945 MSEK
	Work programme for societal challenge 4: Smart, green and integrated transport	2014–2017	920 MSEK
	Work programme for societal challenge 5: Climate action, environment, resource efficiency and raw materials	2014–2017	624 MSEK

Appendix 5 Workshop with societal stakeholders on the National Research Programme for Climate

Participating organisations

AP7 – Seventh Swedish National Pension Fund Biolnnovation

Swedish Energy Agency

Eskilstuna Municipality

F3 – Swedish Knowledge Centre for renewable fuels

Forte

GMV Gothenburg Centre for Environmental Science

Swedish Agency for Marine and Water Management

InfraSweden2030

IQ Centre for Innovation and Quality in the Built Environment

Jernkontoret (Swedish steel producers' association)

Swedish Board of Agriculture

Swedish Consumer Agency

Royal Swedish Academy of Agriculture and Forestry

Farmers National Association

Lighthouse

Food industry operators

Swedish Civil Contingencies Agency

Swedish EPA

Swedish National Heritage Board

Swedish Space Agency

Statistics Sweden

SIDA, Board of international development cooperation

Forest Industries Federation

SMHI Swedish Meteorological and Hydrological Institute

Swedish Geotechnical Institute Sustainable Innovation

Swedish Water & Wastewater Association

Technology companies

Swedish Transport Administration

Swedish Research Council

Viable Cities

World Wildlife Fund (WWF)

1. What are the most important challenges that Sweden faces if we want to achieve the national and global climate targets?

- How to integrate a long-term approach in our decision-making processes. We have got to make it easier to take the right decisions. Many decisions that need to be taken need to be long-term, but the incentives are for short-term political, economic and personal interests. Decisions must be factual/evidence-based. At the same time, we have to take the decisions, so how we manage the risks of taking long-term decisions.
- Policy instruments: To begin with, we need to find out which instruments give the most effect and which combination of instruments works. This can be different types of instruments, like legal or financial. Global and national decisions should also be converted into the policy instruments.
- Sustainable use of global resources: How we can use the earth's resources in a sustainable way to ensure the need for food, energy and natural ecosystems. We need a better understanding of and more cooperation at the local, global and national levels around achieving change. We can't export our emissions, but have got to look at the whole picture.
- Achieve sustainable consumption: The public as consumer – public money vs. climate – goal conflict. Public procurement rules should be adapted to sustainability and knowledge is needed to be able to set the criteria. How to encourage early adopters and mainstreaming for more people? Reduce the Swedish footprint of production abroad. Important sectors: Energy efficiency – often efficiency improvements are worse closer to the consumer. How do we package services to serve the consumer and businesses so that they can make money?
- Implementation of new results and solutions. The transition will be a bumpy journey – we'll get solutions that later turn out to be wrong and will have to be replaced. At the same time, we have to take action. We need structures that support investments in new solutions. We need to be continuously improving the knowledge base. So, we need cooperation and dialogue between different sectors of society, both public and private. Communication of the latest research but also the costs and benefits linked to the measures.
- Develop technology for sustainable solutions. Develop policies to manage goal conflicts. Follow up and evaluate technology development and policies to learn from what is being done. Energy solutions and materials are mentioned as important areas. Find new solutions even on the adaptation front.
- Consumption and welfare: Reduced ecological footprint, security of supply, a systems perspective, new economic models, behavioural change, making it easy to do the right thing.
- Gather knowledge that crosses interdisciplinary research and cross-sectoral boundaries. Everything from basic research needs should reach the municipalities that will use the knowledge/solutions. Develop applied knowledge. Interaction for common learning

between different societal stakeholders. Find ways to systematise and organise the data we have available to make it useful to society.

- To be able to look at the whole, a systems perspective. Need for research that has a systems perspective. Important to highlight and design Swedish efforts from a global perspective. Tools for developing policies to manage goal conflicts/impact optimisation.
- How to ensure food production? Achieve security of supply. Transition of agriculture using new technological solutions. Climate adaptation of agriculture. Increase agriculture's contribution as carbon sinks. Sustainable production and consumption of foodstuffs (especially meat and new protein sources). Reduce food waste. Diet and lifestyle changes.
- Emission reductions in all sectors of society – transport (good demo case), base industry (steel/cement), food, focus on areas/sectors with synergies, efficiency, substitution of non-fossil materials and resources without risking biological diversity.
- Manage goal conflicts: Spans many areas: Most stakeholders are rational but have different goals – don't assume people are stupid. People need to find common goals and challenges. Understanding for how goal conflicts can affect different interests. Politically important challenge! Currently substandard.
- Need breakthroughs: How to engage and mobilise people in the change efforts, how to change behaviours and lifestyles? It's a real challenge changing your circle to another one. View the necessary breakthroughs as opportunities that contribute to things like sustainable consumption. Put pressure on companies and decision-makers to take the right decisions. Important to be concerned about gender equality goals, not changes at the expense of any particular (weak?) group but the importance of everyone's equal value and rights. Technology is an enabler.
- The entire transport sector needs to transition. Substitution of fossil fuels. New transport and travel methods, including behavioural and consumption issues. Policy instruments, frameworks etc. for a modal shift from one transport mode to another.
- Governance and policy – Make visible the multiple effects and positive examples, create incentives, lack of coordination between government agencies and ministries, include decision-makers as requirements specifier in the efforts.

2. Which fields of knowledge and solutions are most important in these efforts to achieve these goals?

- How to transform financial markets so that they take a more long-term view (green economy). Development of decision support. Evidence-based research that focuses on how we take short-term decisions that benefit the long-term perspective (both on an individual level and an organisational level).
- Climate-efficient spatial planning: Put people at the centre. Systems perspective in urban planning. Science-based targets. Attractive sustainable solutions. Trustworthy decision-support data for urban planning (emissions from construction). Energy and food production in cities. Innovation leadership in the public sector. Waterways in cities.
- Sustainable use of global resources – research with a systems perspective. Interdisciplinary research. Innovations and new solutions for increasing resource efficiency. Tools for consumers so they can consume in a climate-smart way. New products. Knowledge transfer to other countries. Heading the efforts and educating on a local, a national and a global level.
- The connection between green infrastructure needs and how to finance green infrastructure. We know that there are huge investment requirements for green infrastructure but few objects to invest in. Money is available on the capital markets but the projects are not set up for investment – there are too few green bonds to invest in..
- Prioritise areas where Sweden can be the role model – building in wood, collaboration, renewable fuels (lignocellulose), waste management, circularity.
- Policy instruments – important to invest in the evaluation of the investments. A systems perspective, in which we assess any unexpected positive and negative effects of the investments. Decision-makers must have a holistic perspective in their decision-making processes. Research on policy instruments, their effects, and the effects of different combinations of policy instruments. Knowledge-sharing with relevant stakeholders.
- Climate adaptation measures – climate impact research on local and regional scales. Translate the knowledge into practical tools and methods, and involve users at an early stage in the projects. Knowledge transfer, making the information available to relevant stakeholders. Facilitate decision-making under uncertain circumstances. We need open and accessible data. More research within cost-benefit analyses. Clarify the responsibilities between state, municipality and individuals.
- How do we create more investment opportunities in green solutions that meet investors' demands for returns on investment? More support for test environments, proof of concept.
- People at the centre – knowledge-sharing, behavioural research, living labs, interdisciplinary science.

- Incentives to make the most of innovations – governance, transition services instead of gadgets, the sharing economy, more environmentally friendly gadgets, streamlining, meta analyses, methods and models to ensure the visibility of multiple values, research on barriers, and drivers for the transition.
- What a long-term, sustainable management of water, agriculture and forestry looks like. Action-oriented research showing synergies, opportunities and conflicts of objectives.
- Consumption: Knowledge of instruments and incentives, channels for knowledge-sharing. Behaviour and consumption research. Mobility as a service. New financial systems and business mode that can be used in many sectors. Appealing business models that will stimulate sustainable choices. Simulations and scenarios. Investigate what affects people's choices.
- Possible breakthrough: How to engage/mobilise change efforts: Help politicians cope with the uncertainty/fear of unpopularity? Plan for the biggest societal changes? Stimulate innovation. Manage change (future and behavioural research, propensity to change) & get politicians & voters to go hand in hand? Media and communication research. Culture around societal interest and living conditions? Show the whole, who does what & how to respond to challenges? Do business! Technical part important, much knowledge produced does not reach its targets.
- Next to the listed societal areas, we want to add urban planning, spatial planning, infrastructure and health (conflict, migration) in relation to climate adaptation.
- Manage goal conflicts: All areas! Mainly: Institutional and organisational conditions, territorial perspectives, contribute to planning. Understanding of political processes: When does the researcher/agency best reach out with their messaging? Lessons learned from other societal areas and countries. Action-selection studies. Find success factors. Problem-based/case. Temporal part of the conflict of objectives. Build trust in the process and towards common goals, even in implementation. What do we have to understand in order to move forward? Understand the steps needed! Backcasting.

Appendix 6 The commission on climate

Extract from: Government decision 1:12, 2017-05-18, Ministry of the Environment and Energy, Commission to establish national research programmes on climate and on sustainable spatial planning

The government's decision

The government tasks the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) to establish national research programmes for climate and sustainable spatial planning, in accordance with the government decision of 18 May 2017 (ref. no. U2017/02404/F). The commission runs for ten years, through 2026. Formas shall also announce calls for special three-year grants to support research on social housing policy. Formas must annually report on the implementation of the national research programme commission to the Government Offices (Ministry of the Environment and Energy) when it issues its annual report.

Background

National Research Programme for Climate 2017-2026

Climate change is one of humanity's greatest challenges. It is also one of the government's top priority issues. As a result of climate change, the global temperature increase is estimated to be 3.2-5.4 degrees Celsius towards the end of this century compared with preindustrial times. The consequences of such a temperature increase are expected to be dramatic, with adverse effects on people, communities, ecosystems and the economy. In Sweden, the challenge of reducing emissions is particularly pressing in the transport, agriculture and base industries. Reducing human impact on the climate requires extensive transitions in Sweden, within the EU and globally. Research efforts are also needed to strengthen society's adaptation to a changing climate. We need more knowledge about carbon flows and carbon sinks in forests and farmland. Research and innovation efforts are needed in the energy system, industry, agriculture, forestry and aquaculture, land use, marine and coastal ecosystems, transport and the built environment, and production and consumption.

The need is great for research that has practical application, especially concerning how society can reduce emissions and adapt to climate change in an effective and inclusive way, while taking into account the individual's place in society. We must strengthen interdisciplinary research that considers user perspectives and studies of people's behavioural patterns, as well as the research and evaluation of policy instruments including their cost-effectiveness, not least at the EU level. We need a better understanding of the roles of different stakeholders in driving the transition to a fossil-free society. Research is also needed to better understand climate-related processes, both nationally and globally. Swedish climate research continues to be well positioned to contribute to future IPCC reports, a vital contribution for Sweden as a research nation.

More about the commission

National Research Programme for Climate 2017-2026

Formas shall establish and launch a ten-year national research programme for climate research. The government believes that climate research represents an important basis for achieving the climate objectives. The need for research and innovation efforts to meet the climate challenge is set out in Bill 2016/17:50, "Collaborating for knowledge – for society's challenges and strengthened competitiveness". We need to increase our knowledge and develop solutions to enable Sweden to become a fossil-free welfare society and to be a leader in the global effort to realise the Paris Agreement's ambitious goals and the Agenda 2030 sustainability goals. We also need research efforts to strengthen society's adaptation to a changing climate. Achieving this requires both empirical scientific and interdisciplinary research, where science and technology are linked with research and knowledge in other sciences. We must also raise the ambition level when it comes to compiling existing research, and communicating and using research results. The programme can span the entire spectrum – from research, innovation and technological development to demonstration, market introduction and dissemination.

Appendix 7 Referral bodies, draft agenda for the national research programme for climate

Universities and colleges

Blekinge Institute of Technology

Chalmers University of Technology

Ersta Sköndal Bräcke University College

Swedish Defence University

Swedish School of Sport and Health Sciences

University Of Gothenburg

Stockholm School of Economics

Dalarna University

University of Borås

University of Gävle

University of Halmstad

University of Skövde

Kristianstad University

University College West

Karlstad University

Karolinska Institutet

University of Arts, Crafts and Design

Royal Art Academy

Royal College of Music

KTH Royal Institute of Technology

Linköping University

Linnaeus University

Luleå University of Technology

Lund University

University of Malmö

Mid Sweden University

Mälardalen University

Red Cross University College of Nursing

Sophiahemmet Högskola

Jönköping University Foundation

Stockholm University of the Arts

Stockholm University

Swedish University of Agricultural Sciences

Södertörn University College

Umeå University

Uppsala University

Örebro University

Research institutes

Institute for Futures Studies

IVL Swedish Environmental Research Institute

RISE Research Institutes of Sweden

SEI Stockholm Environment Institute

Skogforsk

VTI National Road and Transport Research Institute

Funders not included in the programme committeen

Swedish Trade Council's research fund, Knowledge Foundation

County Insurance Research Fund

Swedish Riksbank's Jubilee Fund

Foundation for strategic research

STINT Foundation for International Cooperation in Research and Higher Education

The Wallenberg Foundations

Myndigheter

Swedish National Housing Board

Public Health Agency of Sweden

Swedish Agency for Marine and Water Management

Swedish Board of Agriculture

Swedish National Institute of Economic Research

Swedish Consumer Agency

Lantmäteriet (Swedish land registration authority)

Swedish National Food Agency

County administrative boards

(Climate adaptation portal)

Swedish Civil Contingencies Agency

Swedish National Heritage Board

Sami Parliament

Forestry Agency

SMHI Swedish Meteorological and Hydrological Institute

Geological Survey of Sweden

Swedish Geotechnical Institute

National Veterinary Institute

Statistics Sweden Swedish

Transport Administration

Other public sector

AP7 National Pension Fund

The Climate Municipalities

Swedish Association of Local Authorities and Regions

Strategic innovation areas and other research centres

F3 Swedish Knowledge Centre for Renewable Transportation Fuels

InfraSweden 2030

Lighthouse, Maritime Centre for Excellence

Nordregio

SDSN Northern Europe

SIP Drive Sweden

SIP Smart Built Environment

SIP Viable Cities

SIP BioInnovation

SIP Lightweight/LIGHTer

SIP Re:Source

Civil society organisations

Swedish Society for Nature Conservation

WWF

Professional associations

Waste Management Association

Energiforsk

The Haga Initiative

IQ Centre for Innovation and Quality in the Built Environment

Jernkontoret (Swedish steel producers' association)

Farmers National Association

Food industry operators

Forest Industries Federation

SveBio

Swedish Public Transport Association

Solar Energy Association of Sweden

Swedish Wind Energy Association

Confederation of Swedish Enterprise

Swedish Water & Wastewater Association

Sweden's Construction Federation

Association of Swedish Engineering Industries

Scientific academies

Royal Swedish

Academy of Engineering Sciences

Royal Swedish Academy of Agriculture and Forestry

The Royal Swedish Academy of Sciences, Young Academy of Sweden

Think tanks

Fores

Global utmaning

SNS Center for Business and Policy Studies