PROGRAMME PLAN

CLIMIT

JANUARY 2022

Foreword

CLIMIT is a programme that supports the research, development and demonstration of CO_2 capture and storage (CCS). The programme is delivered as partnership between the Research Council of Norway, which manages the R&D element, and Gassnova which manage the programme's demonstration element. The programme has a joint secretariat and programme board.

Since 2005, CLIMIT has supported the development of technology for CCS in Norway. Knowledge and solutions created during this period have laid the technological foundations for the Norwegian full-scale project known as Longship. Additionally, there are multiple technologies that have matured to a higher Technology Readiness Level (TRL) and many industrial facilities are evaluating which CCS solutions may be appropriate for them. Furthermore, the programme has made a significant contribution to work on CCS beyond Norway, especially as a result of the Accelerating CCS Technologies (ACT) initiative.

The Paris Agreement signed in 2015 imposed an important order on decision-makers in society. In Europe, this order is continued by means of the European Green Deal. Likewise, this programme plan imposes an order on stakeholders in the Norwegian CCS sector.

CLIMIT's current programme plan places an emphasis on targeting the programme at future activities relating to CCS and the opportunities that international use of the technology may create. The results achieved should be relevant both in the short- and long-term, and it should be possible to apply them in a variety of industries and beyond the country's borders. The programme plan describes the focus of the programme and what is expected from applicants who are awarded funding.

It is essential that the programme plan has a long-term horizon while also retaining a focus on short-term operational matters. The programme plan is revised once every two years by the programme board and is next due to be updated in the autumn of 2023. This is done to ensure that the most important perspectives are included.

CLIMIT Programme Board
January 2022

Photo credits:
Front page: shutterstock.com, MPE p. 06: TCM DA
p. 08: Northern Lights p. 22: Styrk Fjærtoft p. 41: MPE
Other photographic materials: iStockphoto.com

Graphics production:
ETN Grafisk

In case of any ambiguity, the Norwegian version will take precedence:
https://gassnova.no/app/uploads/sites/4/2021/12/CLIMIT-programplan_des2021.pdf

Contents

1. Summary 07
2. Background and Challenges 09
3. Programme Goals 13
4. Priorities 17
   - 4.1 Focus Areas and Performance Targets 18
   - 4.2 Technical Priorities 22
5. Structural Priorities 30
   - 5.1 Common Framework 31
   - 5.2 CLIMIT R&D 32
   - 5.3 CLIMIT Demo 33
6. Collaboration and Communications 34
   - 6.1 National Collaboration 35
   - 6.2 International Collaboration 37
   - 6.3 Communications and Meeting Places 39
7. Expected Results, Impacts and Societal effects 40
   - 7.1 Results from Projects supported by CLIMIT 41
   - 7.2 Impacts the Programme will have 43
   - 7.3 Expected Effects on Society 45
8. Resources and Budget 46
9. Management and Organisation 48
10. Links and Abbreviations 51


CLIMIT

1. Summary

CLIMIT is a programme that supports the research, development and demonstration of CO_2 capture and storage (CCS) technology, and is administered jointly by Gassnova SF and the Research Council of Norway. The programme is rooted in the Norwegian Government's CCS strategy, and the Programme Board is appointed by the Norwegian Ministry of Petroleum and Energy (MPE).

CLIMIT's primary goal is to contribute to the development of CCS technology and solutions, and to reduce the costs and risks for those adopting this technology.

The primary aim of the Government's focus on CCS is the worldwide implementation of this technology in order to achieve global climate goals at the lowest possible cost. The investment decision for the Longship project taken in January 2021 represents an important step towards meeting these goals.

For CCS to be a competitive climate solution, it is essential to bring new CO_2 capture, transport and storage concepts to maturation.

To this end, the programme has identified three focus areas with associated performance targets

A. Decarbonisation of industry and energy resources
B. Large-scale CO_2 storage sites on the Norwegian continental shelf
C. Innovative technology development and solutions for CCS

The programme focuses on the entire development process from research to demonstration, as well as the entire value chain from capture through to the transport and storage of CO_2. A key premise of the programme is the need for long-term carbon storage in order for CCS to become a viable climate initiative.

CLIMIT is a key instrument in Norway's national ambitions for CCS. The programme contributes to the creation of networks of stakeholders who spread expertise and strengthen international cooperation on CCS, and also contributes to a general national project portfolio.

2. Background and Challenges

To achieve our climate goals, CCS must be widely adopted around the world. At the 2015 Paris climate summit, the countries of the world agreed to limit the increase in global temperatures to a maximum of 2 °C, and to endeavour to limit the increase to 1.5 °C[1]. Both the United Nations' Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) have identified CCS as an essential measure to achieve these goals[2,3].

There are many different scenarios that outline how both the target of 1.5 °C and 2 °C can be met. What most of them have in common is that CCS must be widely adopted to achieve the necessary emission reductions. The scenarios where the 2 °C goal is reached without adopting CCS show that it would be significantly more expensive for society[2]. The European Commission laid out its green growth strategy, the 'European Green Deal' just before the new year in 2019, based on the goal of achieving climate neutrality in the EU by 2050[4]. In July 2021, the European Commission launched 'Fit for 55'[5], a plan for how the EU will reduce its greenhouse gas emissions by 55% by 2030. In connection with the COP 26 climate summit in Glasgow in 2021, many countries and individual companies announced their aims of achieving climate neutrality within 30-40 years.

CO_2 capture, transport and storage technology is available today. CCS has been adopted in many places around the world where framework conditions and requirements are already in place[6]. The EU's CCUS Roadmap to 2030[7] sets out a technology status and the steps that need to be taken to achieve large-scale CCUS implementation. Even though implementing CCS would be beneficial to society, the cost of adopting the technology is too high for most owners of CO_2 emitting sources. In other words, there are still substantial barriers and market failures that are preventing CCS from being adopted and being able to contribute to achieving climate goals at the lowest possible cost to society. In 2020, the EU agreed on a taxonomy for sustainable economic activity to ensure transparency around investments in this area up to 2050. This taxonomy will be important for ensuring the adoption of sustainable solutions.

---

1 KLD: 'The Paris Agreement', under the United Nations Framework Convention on Climate Change, 12.12.2015, https://lovdata.no/dokument/TRAKTATEN/traktat/2015-12-12-32?q=parisavtalen

2 IPPC: 'Global warming of 1,5°C', 2018, https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

3 IEA: 'Global Energy Review 2021', 01.07.2021, https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage

4 The European Commission: 'European Green Deal', the European Commission's Green Deal website, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

5 The Council of Europe: 'Fit for 55' https://www.consilium.europa.eu/en/policies/green-deal/eu-plan-for-a-green-transition/

6 GCCSI: 'Global Status of CCS 2021 – CCS acceleration to net zero', https://www.globalccsinstitute.com/resources/global-status-report/

7 CCUS Set-plan 'CCUS Roadmap to 2030', October 2021, CCUS Roadmap to 2030 (ccus-setplan.eu)

Global energy markets are in a state of change, and these changes are taking place faster than many experts had predicted. Even though analyses indicate that fossil fuel-based energy will continue to be an important part of the energy mix far into the future, the pressure on fossil fuel-based energy producers is increasing. The implementation of the Paris Agreement will further increase the pace of the energy transition. This is apparent from technology developments, policy developments, changing consumer behaviour and new business models. The steep fall in the cost of producing renewable energy and increasing interest in the use of hydrogen are examples of this.

The industry must safeguard its activities through a renewed focus on the climate. Society's increasing awareness of climate issues has led to industries with large carbon emissions encountering increased demands from investors, public authorities and other parts of society. Oil and gas producers are focusing more and more on renewable energy and reforming natural gas into hydrogen along with CCS. Energy efficiency is important for the industry, but to achieve climate neutrality, there are many industries that have no other alternative than to use CCS. In line with stricter climate regulations, CCS will therefore play a decisive role in many industries achieving climate goals. The taxonomy will also increase the pace of the climate transition within the industry and thereby also increase the probability of new CCS projects. In a carbon neutral society, operators that do not reduce their greenhouse gas emissions will see their market position weakened in comparison to other operators. Looking to the future, carbon negative solutions such as bioenergy with CO_2 capture and storage (BECCS) and direct air capture (DAC) will, in all likelihood, become essential.

The role of CCS in a low-emission society is gradually becoming clearer. For many years, CCS has primarily been used as an 'end-of-pipe' solution for existing industries, so that their business activities can continue with reduced greenhouse gas emissions. Recent developments have provided greater clarity as to where CCS can make relevant contributions. For example, the EU's new climate and energy strategy has set out a goal of integrating energy systems across both borders and energy sources, focusing particularly on electrification and hydrogen. Therefore, the need for CCS in the EU will be linked primarily to reforming natural gas into hydrogen and to the processing industry, such as cement production and waste incineration, which cannot be decarbonised through electrification or the use of hydrogen.

In Norway, there is broad political consensus on taking an offensive strategy on CCS. Norway, along with a few other countries, is leading the way on CCS. The primary goal of the Government's focus on CCS is the global adoption of this solution and for it to contribute to achieving climate goals at the lowest possible cost[8]. The decision in January 2021 to realise Longship represents an important contribution to the work of spreading CCS globally[9]. The project also contributes to reducing the market failures associated with the widespread use of CCS. Moreover, there is a broad spectrum of activities nationwide that may have ripple effects on Longship and develop new knowledge on CCS. This includes the Centre for Environment-Friendly Energy Research (FME), the CLIMIT programme, The Technology Centre at Mongstad (TCM), and participation in international collaborations for promoting CCS, such as ACT.

Norway is well-equipped for the development and implementation of CCS technology. The oil and gas industry, various R&D and technology communities and maritime businesses have considerable expertise and resources relevant to the development of CCS technology. Europe's only two full-scale CCS projects in operation, the Sleipner and Snøhvit gas fields, and TCM are important assets for Norway. A future international CCS market will provide Norwegian technology communities and service providers with new business opportunities. Furthermore, the Norwegian continental shelf is well-suited for the storage of large volumes of CO_2[10]. In Europe, there is public resistance in many countries to the underground CO_2 storage onshore. CO_2 storage on the Norwegian continental shelf could become a key aspect of Europe's CCS efforts.

8 MPE: 'Prop. 1S (2014-15) Proposition to the Storting (proposal for the Storting's decision)', ch. 4 'The Government's strategy for work on CCS', 12.09.2014 https://www.regjeringen.no/no/dokumenter/Prop-1-S-20142015/id2005418/

9 MPE: 'Meld. St. 33 (2019-2020) Longship – Carbon capture and storage', 21.09.20 https://www.regjeringen.no/no/dokumenter/meld.-st.-33-20192020/id2765361/

10 OD: 'CO_2 Storage Atlas – Norwegian North Sea', 2011 https://www.npd.no/globalassets/1-npd/publikasjoner/atlas-eng/co2-atlas-north-sea.pdf

3. Programme Goals

CLIMIT

The overarching strategic goals of the Government's focus on CCS is "to achieve a stabilisation in the concentration of greenhouse gases in the atmosphere at a level that will prevent dangerous man-made effects on the climate system." The objective of the initiatives commenced by the Government is "to provide an independent and measurable contribution to the development and demonstration of technology for CO_2 capture and storage with a potential for wider distribution"[6].

CLIMIT is a national programme that supports the research, development and demonstration of CCS technology, administered jointly by Gassnova SF and the Research Council of Norway. CLIMIT R&D is the part of the programme run by the Research Council of Norway, and supports research and development. CLIMIT Demo is the part of the programme run by Gassnova, and is focussed on development, pilot and demonstration activities.

CLIMIT is a key instrument in Norway's national ambitions for CCS. The interplay between CLIMIT R&D and CLIMIT Demo will build synergy with the aim of reducing the risks and costs of realising CCS technology solutions, and reducing the time it takes to go from research to demonstration of new technology. The programme contributes to the creation of networks of stakeholders which accumulate and spread expertise and strengthen international collaboration on CCS.

CLIMIT's primary goal, laid out in MPE regulations for their grant scheme[11], is to contribute to the development of CCS technology and solutions.

11 MPE: 'Regulations for the grant scheme – Development and demonstration of CCS technology (CCS Fund)', 17.02.2021 https://gassnova.no/app/uploads/sites/4/2021/05/Regelverk_for_Gassnovas_forvaltning_av_CLIMIT.pdf

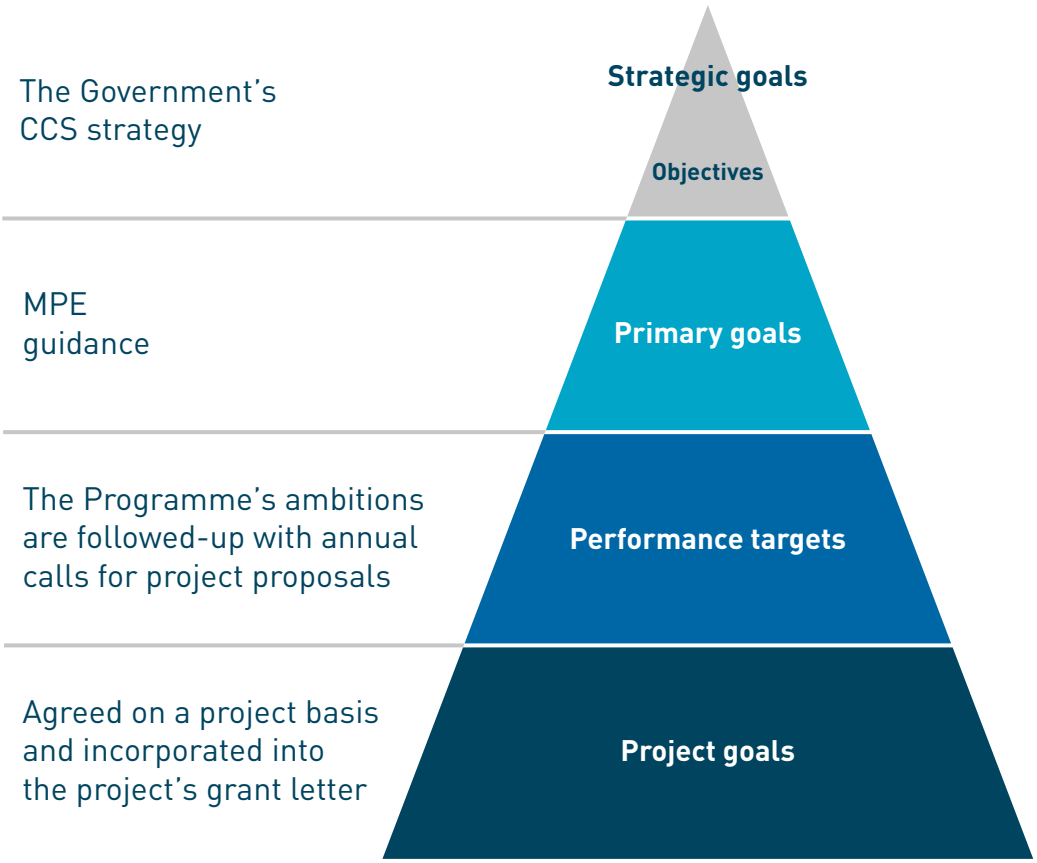
CLIMIT supports projects for the development and demonstration of CCS technology and solutions. The projects contribute to the development of knowledge, expertise, technology and solutions that could deliver a vital contribution to cost reductions and the broad international propagation of CCS technology. Projects supported by CLIMIT will make use of Norwegian national advantages and develop new technology and service concepts that have both commercial and international potential. The projects will provide capacity building and a transfer of experience both in Norway and beyond.

Many of the projects supported by CLIMIT contribute to the development of technology and solutions which can be adopted and contribute to a benefit realisation linked to the implementation of Longship[12]. The Government's ambition of realising a CCS facility in Norway has led to an increased interest from industry in supporting CCS projects. With its CO_2 storage solution, Longship has made CCS more attractive to industrial stakeholders both nationally and internationally. Consequently, national stakeholders can develop CCS in areas where Norway has a competitive advantage. Norway's long tradition of industrial technology development plays an important role here as do robust knowledge institutions in Norway.

The programme has its own calls for project proposals and also collaborates with other policy agencies. The programme must have an appropriate portfolio that supports the overall public efforts for CCS technology development. CLIMIT covers technology development within all parts of the CCS chain, from different industrial processes and energy systems with integrated CO_2 capture to the transportation and storage of CO_2. There is a demand for long-term storage[9] and CLIMIT can therefore only support the development of technology that uses CO_2 to make new products (CCUS), if there is no risk of CO_2 being released into the atmosphere. CLIMIT also supports social science research related to CCS.

12 MPE: 'Prop. 1S (2020-21) Proposition to the Storting (proposal for the Storting's decision)', 'Programme category 18.40 CO_2 capture and storage', 25.09.2020

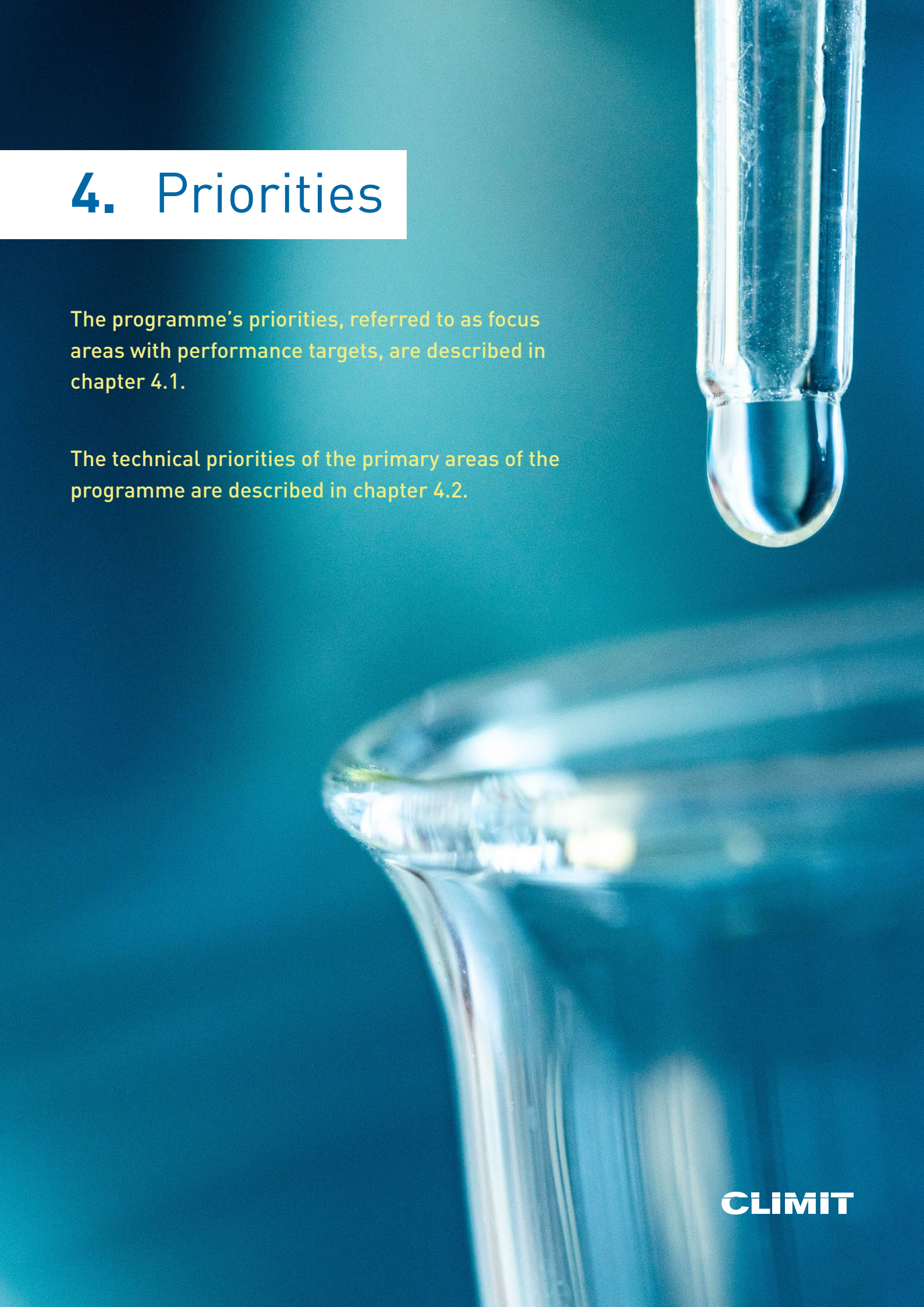
Annual calls for project proposals will set out the programme's priorities. When awarding funds to individual projects, goals are set according to the programme's priorities. The programme's overarching goal hierarchy is summarised in the table below.



4. Priorities

The programme's priorities, referred to as focus areas with performance targets, are described in chapter 4.1.

The technical priorities of the primary areas of the programme are described in chapter 4.2.



CLIMIT

4.1 Focus Areas and Performance Targets

The programme's focus areas and performance targets point to drivers that are important for the realisation of CCS, and provide guidance for the prioritisation of projects CLIMIT will support.

The projects supported by CLIMIT must contribute in one or more of these focus areas:

- **A.** Decarbonisation of industry and energy resources
- **B.** Large-scale CO_2 storage sites on the Norwegian continental shelf
- **C.** Innovative technology development and solutions for CCS

The focus areas balance the need for short and long-term perspectives on technology development, at the same time as integrating technology developments into the commercial value chain for CCS on an industrial scale.

There are performance targets for each of the focus areas, which CLIMIT will work to achieve in the long-term.

A. *Decarbonisation of industry and energy resources*

Technology and solutions for CCS deployment are available today, as demonstrated by Longship for the entire value chain. For a number of years, the CLIMIT programme has supported the development and maturation of technology and solutions at an industrial level along the entire chain. However, there is still a need to prioritise technology development, cost reductions and risk management for CO_2 capture in the industrial sector. This also involves the development of technology and infrastructure, including mass and energy balances, for CO_2 capture in industrial clusters with CO_2 transport and storage. The transfer of experience and benefit realisation[13] from Longship is a key topic, along with establishing new European value chains. Synergy between the first full-scale industrial projects and new research and development projects around expertise and technology development is also expected.

Hydrogen production with CCS along with the use of renewable energy will be part of the process of decarbonising industry and energy resources. Waste incineration[14] will present an opportunity to capture negative emissions (BECCS). It will also be necessary to develop market mechanisms and risk models. They must address barriers and incentives for the widespread commercial roll-out of CCS.

Social science research will provide knowledge and expertise needed for developing business models and frameworks for the implementation of large-scale CCS.

Performance targets

Norwegian technology and solutions are made accessible to the CO_2 value chains.

The technology becomes cheaper and delivers cost-effective solutions for the needs of the processing industry.

13 Gassnova: 'Benefit realisation plan – The full-scale project', 14.02.2020 Gassnovas-gevinstrealieringsplan -2020-reklassifisert-åpen.pdf (ccsnorway.com)

14 The Environment Agency: 'Klimakur 2030' https://www.miljodirektoratet.no/globalassets/publikasjoner/m1625/m1625_sammendrag.pdf

B. *Large-scale CO_2 storage sites on the Norwegian continental shelf*

The proven potential of storing CO_2 on the Norwegian continental shelf is substantial. The development of CO_2 storage sites on the Norwegian continental shelf with a capacity of several gigatonnes will be necessary in order to achieve the Paris Agreement's European climate goals. The development of supporting infrastructure for transport and storage must be emphasised. This could involve the potential re-use of infrastructure and fields from the oil and industry.

Low pressure solutions can pave the way to more flexible transport of large volumes of CO_2 by ship. Low pressure gas transport is an untested solution with higher risks than intermediate pressure gas transport. In order to realise low pressure gas transport, there needs to be evaluations of everything from basic ship construction, tanker design, loading and unloading processes to solutions and services. More cost-effective pipeline transport is necessary for large, permanent CO_2 deliveries.

The Northern Lights CO_2 storage site is being developed using current petroleum technology, and potential cost reductions should become clear from this. The costs and risks of future storage sites may be reduced by looking at what simplifications, standardisations and optimisations can be made. New or improved experimental analyses and methods may provide a better understanding of storage capacity, injection rate, sealing, monitoring and flow properties. Simulation tools are important for evaluating storage sites during the injection phase, and decommission of the storage sites. Operation and maintenance of storage facilities, including wells and fixed and floating installations, are important to reduce project risks. It is also necessary to develop standards, commercial models and practical solutions.

Extensive CO_2 storage on the Norwegian continental shelf depends on a solid legal framework for transporting and storing CO_2 and broad public acceptance of CO_2 storage. Social science research is important for getting good solutions implemented.

Performance target:

Infrastructure and CO_2 storage on the Norwegian continental shelf are developed and realised at gigatonne level.

C. *Innovative technology development and solutions for CCS*

It is expected that new CCS technological concepts will result in significant cost reductions. This requires concerted efforts throughout the development chain from research to piloting. There are many technologies with low technical maturity that can reduce the cost of CCS in the longer term. Improvements can be achieved through lower demands for energy, process simplification, integration, and a lower environmental impact. The time scale for such development projects is difficult to determine.

Groundbreaking and innovative technology solutions are required to bring forward totally new concepts. Basic research is necessary to advance cost-effective CCS technologies. The risks must be acknowledged and understood. There is a need for climate positive solutions, including BECCS, Direct Air Capture (DAC) and CO_2 capture from seawater. Infrastructure for CO_2 transportation must be developed further.

As CCS is scaled up to capture and store billions of tonnes of CO_2, social science research will be required to establish the correct business models and to properly manage barriers, risks and social aspects of such an enormous technological transition.

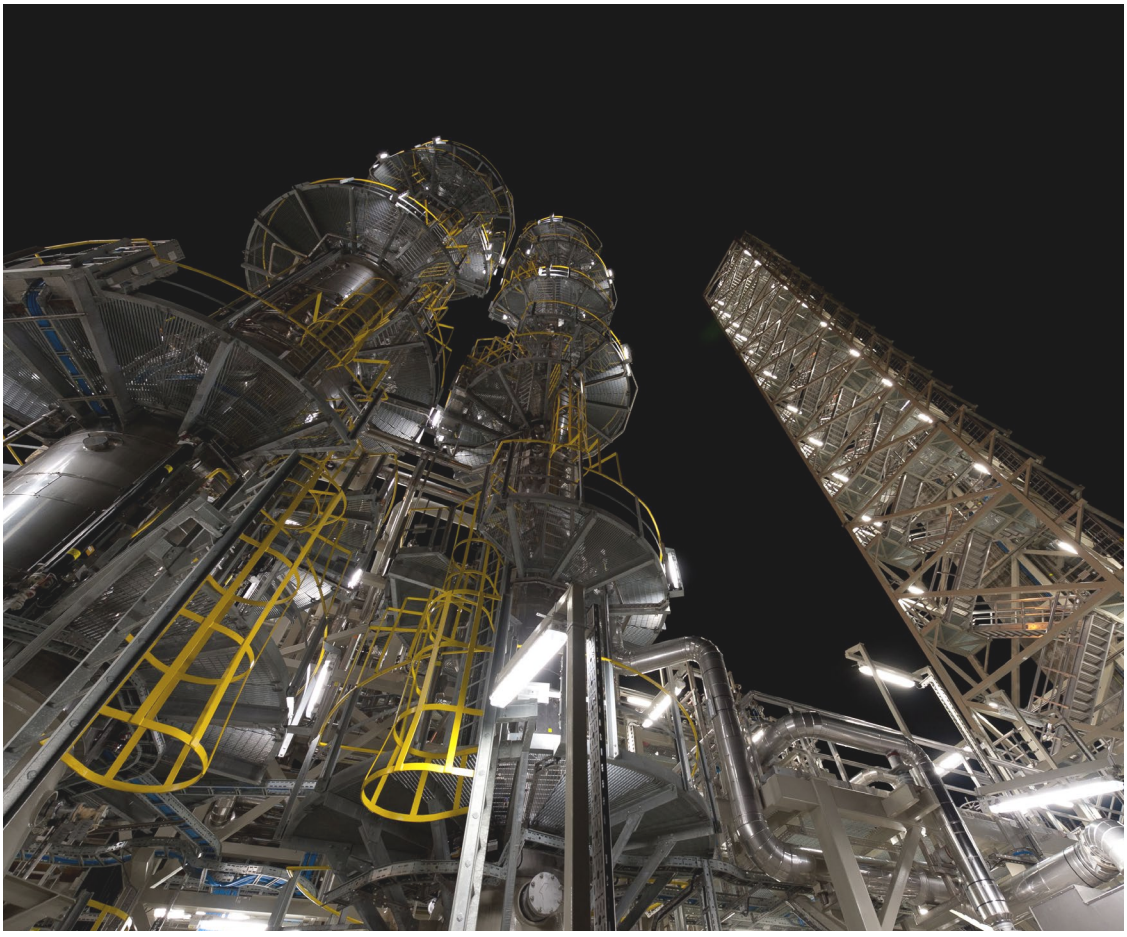
Performance target:

Development of new groundbreaking CCS technologies.

Faster development of more competitive, cost-effective, sustainable and safe CCS technology in a life cycle perspective.

4.2 Technical Priorities

This chapter lays out the desired developments within various technological fields. Specific priorities will depend on the technology needs identified by stakeholders who are implementing CCS. Specific priorities will also depend on gap analyses performed in advance of announcements of calls for project proposals.



CO_2 capture

Since the establishment of the programme in 2005, CLIMIT has supported the maturation of Aker Carbon Capture's (ACC) capture technology from the lab stage to the commercial scale in the Longship project. During the Solvit project, hundreds of different amines were tested before they landed on the amine that Aker is currently pushing. The amines were tested at Tiller and at TCM, and over many development projects, the process was optimised, and Aker achieved a 35% reduction in energy consumption at the same time as seeing a marked reduction in emissions. In Norcem's CLIMIT-supported test centre project, four different capture technologies were tested on Norcem's flue gas in Brevik. The technologies then underwent third-party benchmarking. As a result of this project, Norcem chose ACC solutions for the full-scale capture technology for Longship.

There are a range of capture technologies at different levels of maturity. Mature technologies are used in full-scale plants today, but it is expected that risks and costs can be reduced even more[15].

Projects applying for support from CLIMIT should have the industry's goals of reducing carbon emissions at their core, and must aim at improving, optimising and reducing the risks and costs of mature technology. This can be achieved by improving solvent-based absorption technology or through hybrid solutions. Improvements can also be achieved with better capture technology integration and adaptation at the emission source. This includes improved solutions for heat recovery, optimising the capture rate and carbon neutral or carbon negative processes. Optimising the capture rate may, for example, involve getting it to 100%, having a reduced capture rate combined with using biomass in industrial processes, direct air/seawater capture, or a combination of these concepts.

15 Coal Industry Advisory Board Submission to the International Energy Agency: 'The cost reduction potential for CCUS at coal-fired power plants', 2019 https://ccsknowledge.com/pub/CIAB_Report_LessonsByDoing_CCUS_onCoal_Nov2019(1).pdf

Different CO_2 capture technologies can be optimised in various ways depending on which industry the technology is being implemented into. In some situations, the available residual heat may be a key factor, while in others, the space requirements of the CCS facility, electricity usage or the tolerance for variations in the composition of flue gas may be the most important. It is important to support projects that evaluate industry-specific contexts between choice, integration and operation of capture technology in all key industry segments such as cement, waste incineration, metallurgic industry, gas power, hydrogen production from natural gas and more.

CLIMIT will also support research into groundbreaking capture technology and new solutions. This can be either new technology or existing technology that is being used in new ways. Such projects should focus on faster gradual development to increasing maturity where the potential for the process is substantiated in the long-term. Examples of this may be projects focussing on developing sorbents, solvents, or membranes, the use of new materials and simpler solutions or smarter designs. More specific examples of what these might be are integrated solutions for industrial processes at the same time as CO_2 capture, hydrogen production with CO_2 capture, BECCS and seawater or direct air capture. Supporting further development and testing of relevant elements of capture technology that are ready to be scaled up to the pilot or demo stage will also be necessary. Examples of this are CO_2 capture at low temperatures, solid sorbents, oxy-fuel technologies and hydrogen combustion.

CO_2 transport

The programme is able to support projects that will contribute to reducing the risks and costs of CO_2 transport. Furthermore, the programme may support the development of technologies and innovations that facilitate the financing and commercial operation of CO_2 transport systems. Current areas are:

- How impurities in the CO_2 flow affect the thermodynamic properties of the CO_2 mixture, the corrosive environment, precipitation and flow characteristics of the transport system.
- Research on and testing of materials across the entire value chain.
- Development of software to simulate multiphase CO_2 flow.
- Designing ships and loading/unloading systems, including offshore unloading to floating intermediate storage sites or direct injection to storage formations.

Technology and solutions for measuring and reporting CO_2 flow volume, monitoring the transport system, designing and operating hubs where CO_2 flows from different sources meet and are mixed together. The programme can also support the development of knowledge, methods and standards as a foundation for developing market regulations, commercial operations and documentation that can meet ETS requirements and other emissions trading systems.

CO_2 storage

More CO_2 storage sites must be matured and scaled up for commercial use in order for CCS to become a global climate initiative. CLIMIT will prioritise project proposals that lead to the maturation of more CO_2 storage sites on the Norwegian continental shelf. The scaling up and optimisation of technology will be key to finding cost-effective solutions. Proper risk handling is also needed to evaluate, build and operate CO_2 storage sites.

Maturing new CO_2 storage sites can be accelerated by mapping geological parameters that are important for large-scale CO_2 storage. This can be based on knowledge from other offshore CO_2 storage sites. It is also important to build on existing petroleum technology. New expertise on CO_2 storage can be established by studying fields that have had their petroleum resources completely or partially depleted. These empty fields can also be reused for CO_2 storage.

Research, development and demonstration in the following five topics are a priority.

- **CO_2 wells**
  Well integrity is of great significance. New well technology knowledge is required to improve, simplify and secure well drilling, safe injection and well-plugging. New expertise on direct CO_2 injection from ships is also needed.

- **CO_2 storage reservoirs and caprocks**
  To achieve the optimal use of pore space, new knowledge is required on CO_2 injection strategies and the water production from reservoirs that are appropriate for CO_2 storage. New methods and tools are needed that can provide better understanding of how CO_2 can be best stored. Procedures for pressure monitoring in the storage reservoir are also needed. Better knowledge on caprocks and sealing mechanisms is also necessary.

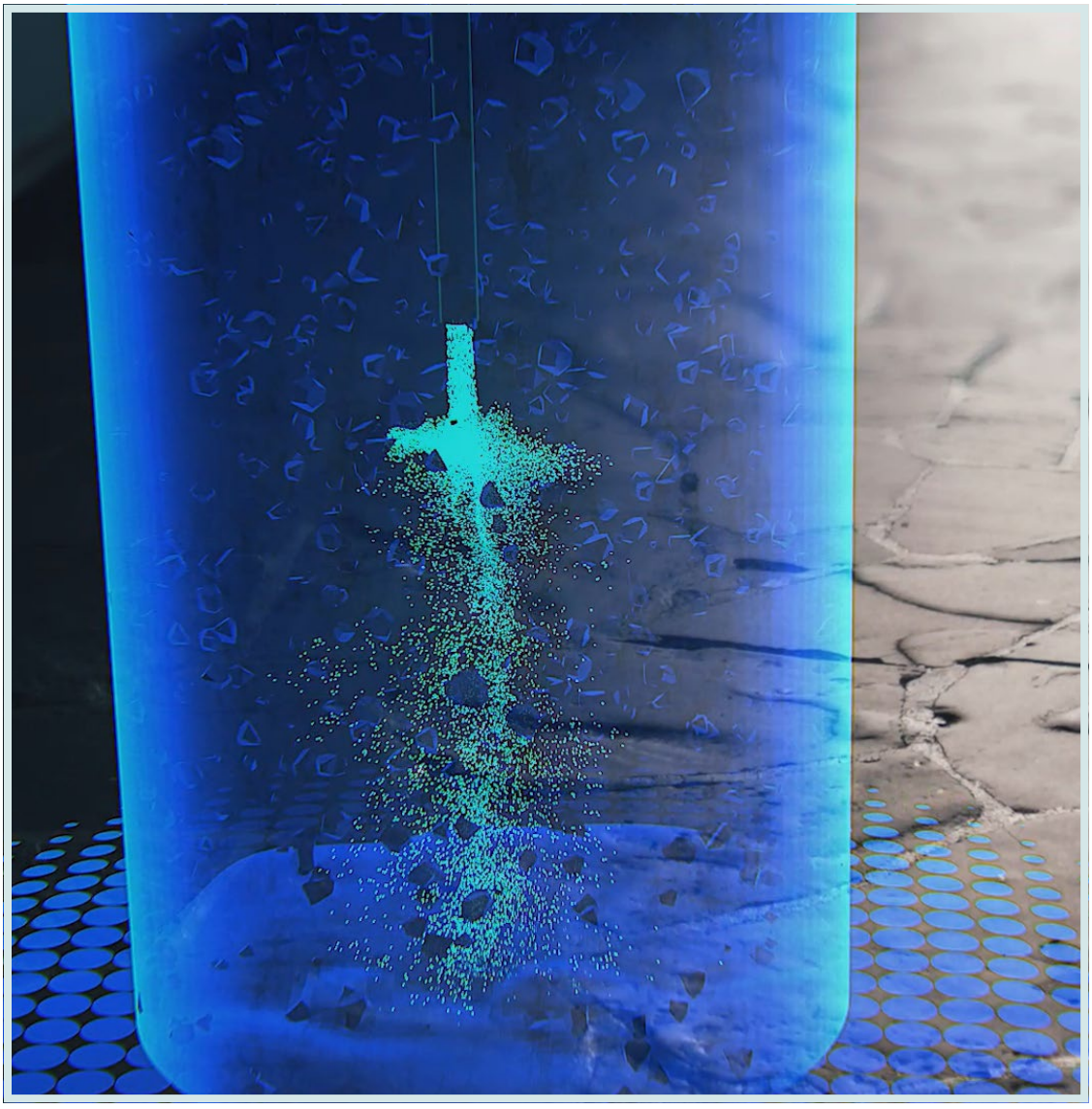
- **Monitoring**
  Methods for monitoring the CO_2 storage sites and the marine environment must be further developed to achieve efficient and cost-effective real-time monitoring of the most critical parameters. There is a need for methods, procedures and tools for CO_2 storage sites in different phases, including site operation, shut down and post-injection monitoring. It is also necessary to create procedures for quantifying the risks related to unwanted incidents in a life-cycle perspective. Methods to avoid or mitigate unwanted incidents must also be developed. This is especially important for gaining public trust in CO_2 storage.

- **Modelling and digitisation**
  Digitisation, artificial intelligence and automation can contribute to safe and cost-effective CO_2 storage. New or improved models and methods may provide a better understanding of storage capacity, injection rate, sealing, monitoring and flow properties. Better modelling and methods will lead to better risk management and will also ensure that CO_2 storage sites can be operated with minimal negative environmental impacts.

- **Social sciences**
  The costs and risks of CO_2 storage can be reduced through simplifications and standardisations. Large-scale storage can also be made more efficient through hubs that are designed to efficiently receive CO_2 from different sources with different compositions. The methodology for qualifying such systems is important for risk management. Research is also needed to define conditions for processes leading to CO_2 storage licenses. Social science research is also necessary to understand social aspects and barriers to large-scale CO_2 storage. Clear communication of the risks to the public, politicians and other specialists is important. There is also a need for thorough analyses of legal conditions and incentives that can promote a market for CO_2 storage.

CO_2 for enhanced oil or gas recovery combined with long-term CO_2 storage can also be supported by CLIMIT, as long as the focus of the research is on CO_2 storage, and not on petroleum production. This can increase the commercial value of CCS projects and provide useful experience for subsequent storage plants.

Carbon storage through mineralisation and alternative forms of storage like 'black carbon' and other possible areas of CO_2 utilization are of a lower priority, but may still be given support if it can be documented that this is a cost-effective alternative to geological storage and that the climate impact is significant.



Social science research

A green transition that sees CCS implemented at both a national and international level is far more than just a technological challenge. Industrial operators require long-term and transparent incentives to invest in large-scale CCS. Social science research is necessary to analyse barriers, and to identify incentives, potential market mechanisms and risk models for the value chain that can contribute to the faster implementation of CCS.

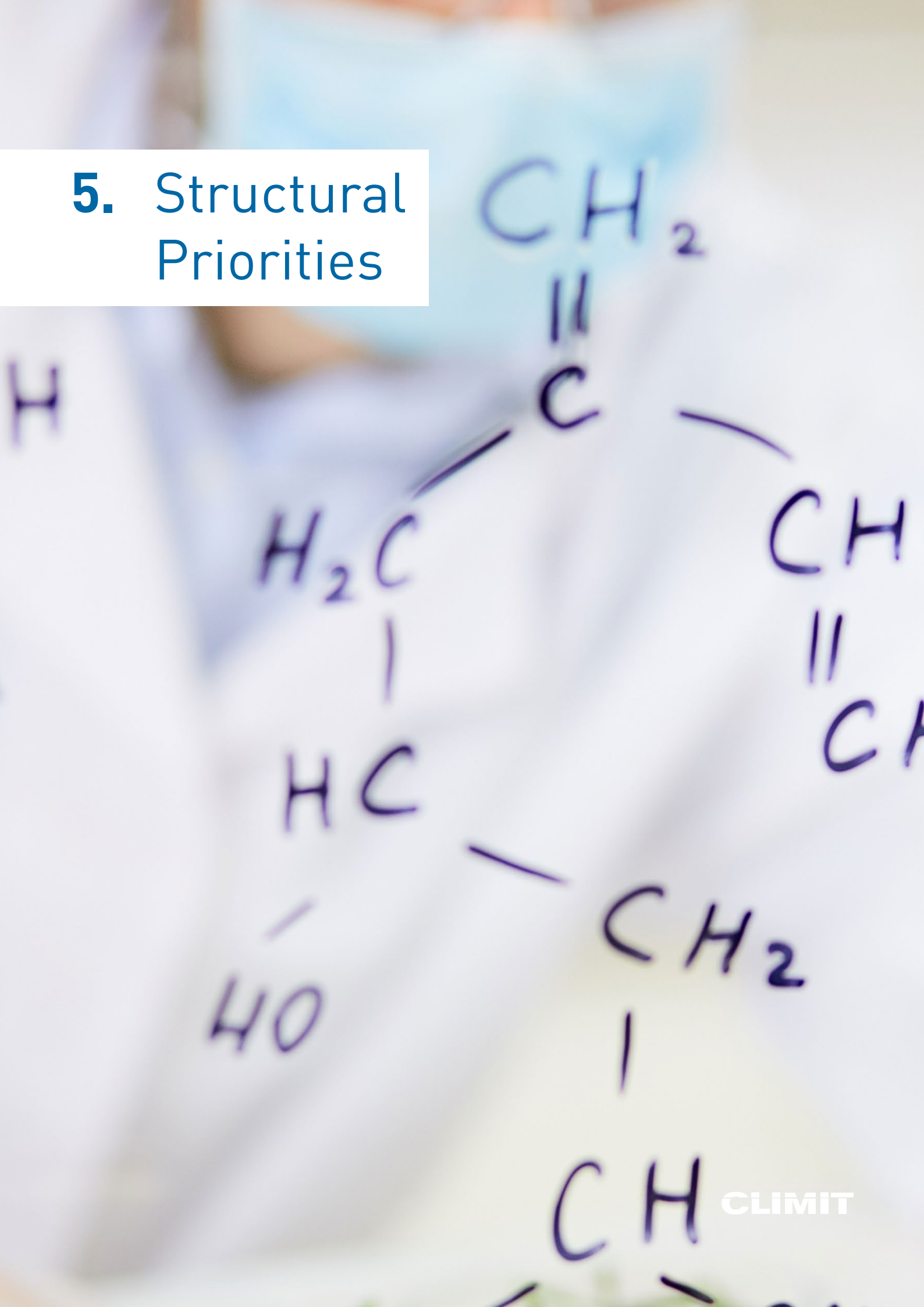
The Research Council of Norway's part of the CLIMIT programme is open to social science research. Key topics will be incentive frameworks, innovation processes, socio-technical analyses of transition processes, knowledge of human behaviour and attitudes in different parts of society, and knowledge on public transition processes.

Social science research will have many important effects. Experience from working on the first full-scale projects can be used for further expertise and technology development. Technology and solutions for large-scale CO_2 storage on the Norwegian continental shelf can be scaled up and accelerated. Additionally, future CCS technology must be adaptable to different scenarios for future energy and industrial markets.

Innovation research will be important in understanding scaling up, including the role of pilot projects and demonstration plants. Accelerated technology development must be understood through sector connection and system development. User groups must be analysed, and the significance of social networks and social learning must be better understood.

Recognising that a green transition is not possible without public participation means that social sciences and interdisciplinary research are vitally important. CCS has been met with scepticism in many countries. The public's attitude must be better understood and it is important to identify initiatives that can provide the public with knowledge about CCS.

5. Structural Priorities



5.1 Common Framework

The CLIMIT programme is able to support technology companies, service providers, technology users, research institutes, universities and colleges, and in some cases NGOs in their projects if they apply through the calls from the programme. Those receiving support from CLIMIT must be an accountable legal person. Applications must provide responses to the goals laid out in chapter 4. To ensure that supported technology development covers specific industrial needs, all CLIMIT projects place particular emphasis on industrial relevance and the involvement of the industrial sector.

Moreover, emphasis is placed on interdisciplinary research, collaborations between industrial and research communities, and international collaboration on projects to strengthen the dissemination of knowledge and ensure their relevance for industrial application. By interdisciplinary research we mean the bringing together of expertise from multiple different disciplines. From experience, better results are achieved when project groups as a whole have broad expertise spanning several academic fields.

Applications of the highest quality and relevance will be given priority when competing for funding. Standard procedures at the Research Council of Norway and Gassnova for evaluating project applications will be followed.

5.2 CLIMIT R&D

Funding from CLIMIT R&D may be applied primarily for the following:

- **Research projects**
  Basic research that will lead to innovation and development, at the same time as advancing the international research front. Research projects should include doctoral level education.

- **Knowledge-building and collaboration projects (KSP)**
  KSPs will lead to new knowledge and build the research expertise needed by society or the industrial sector to meet important societal challenges. Collaboration between research communities and relevant operators outside of the research sector is required.

- **Innovation projects for the Industrial Sector**
  Business-led innovation projects with comprehensive research and development (R&D). The innovation projects should lead to improvements and sustainable value creation for the participating companies. They should also lead to socioeconomic benefits by making new knowledge and solutions available.

- **International projects**
  A portion of CLIMIT's funds will be allocated to international calls through the ACT collaboration. CLIMIT can support Norwegian partners in international ACT projects. Activities performed by Norwegian partners must meet the priorities laid out in chapter 4.

A smaller portion of the CLIMIT budget will be allocated for networking project and support for events through separate calls.

CLIMIT R&D will also collaborate with other programmes at the Research Council of Norway in joint calls when this will contribute to the priorities of the CLIMIT Programme Plan. The same goes for joint calls with other policy agencies.

5.3 CLIMIT Demo

It is possible to apply support from CLIMIT Demo to develop and demonstrate knowledge, expertise, technology and solutions for CO_2 capture, compression, transport or other CCS technology, as well as storage or usage leading to long-term storage.

This support can be given depending on the type of project as described in more detail in the MPE regulations[16].

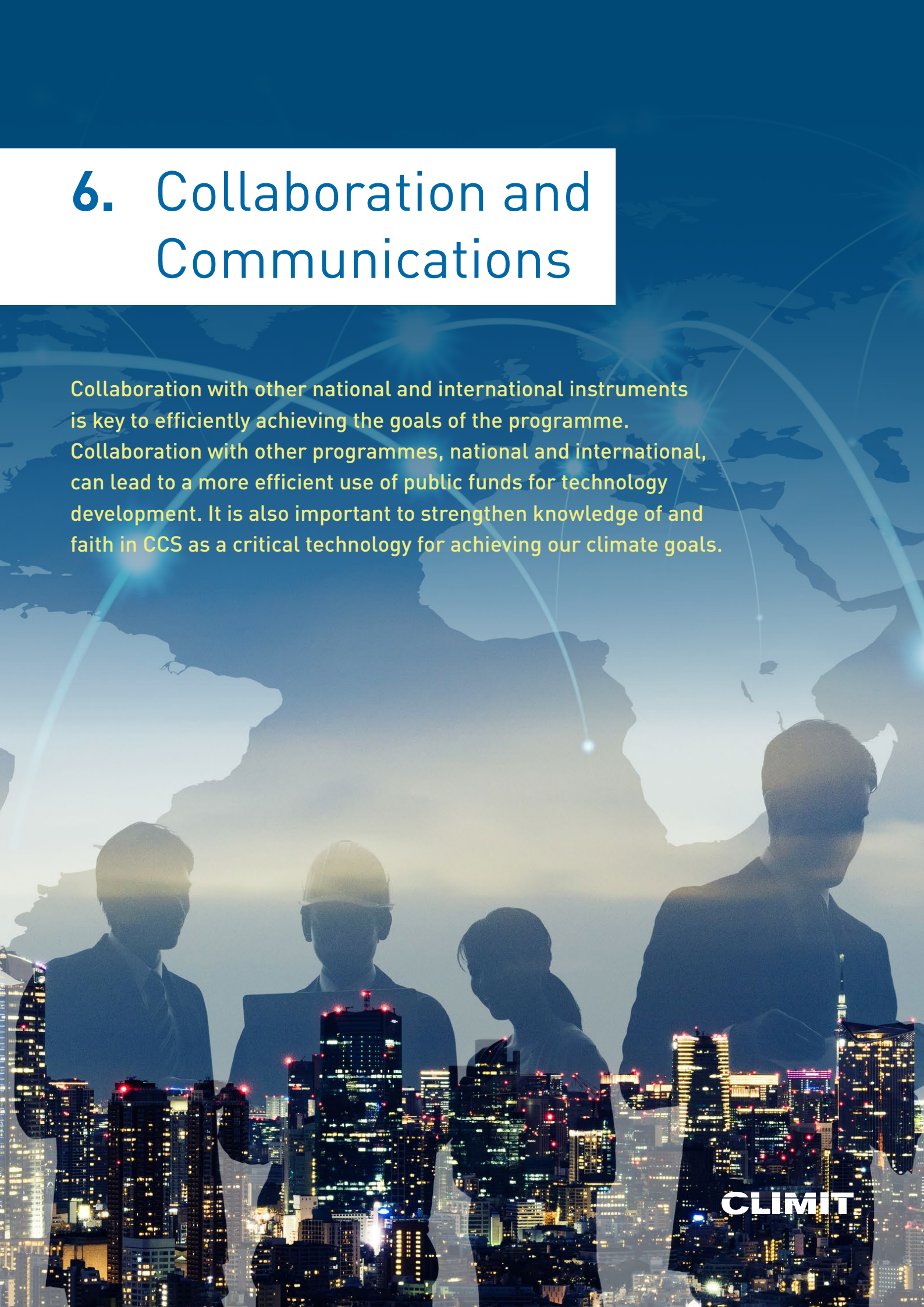
- Techno-economic feasibility studies
- Pilot stage technology testing
- Demonstration facilities
- Commercializable service concepts or methods
- Professional network building and spreading expertise
- International projects such as ACT
- Benefit realisation for Longship

Applications to CLIMIT Demo must demonstrate that they will contribute to Norwegian value creation. CLIMIT Demo also require that the project applicants will demonstrate how development work can be included in a commercialisation plan, including managing intellectual property rights (IPR). The project must have a good academic grounding, a practical plan for execution, and this support must act as a trigger.

16 MPE: 'Regulations for the grant scheme – Development and development of CCS technology (CCS Fund)', 17.02.2021 https://gassnova.no/app/uploads/sites/4/2021/05/Regelverk_for_Gassnovas_forvaltning_av_CLIMIT.pdf

6. Collaboration and Communications

Collaboration with other national and international instruments is key to efficiently achieving the goals of the programme. Collaboration with other programmes, national and international, can lead to a more efficient use of public funds for technology development. It is also important to strengthen knowledge of and faith in CCS as a critical technology for achieving our climate goals.



6.1 National Collaboration

Through collaboration with other national instruments, CLIMIT will properly coordinate Norway's overall CCS technology development efforts. There should be good synergy between CLIMIT and the FME scheme; expertise already gained from the FME scheme and CLIMIT projects should be used for further development; infrastructure such as ECCSEL and TCM should be busy with relevant activities, and there should be good synergy between CLIMIT and Longship.

Applications to CLIMIT should use the ECCSEL research infrastructure as much as possible when ECCSEL has the relevant equipment and laboratories for projects seeking support.

Beyond coordinating CLIMIT's activities with strategic agencies like Energi21, Prosess21 and OG21, CLIMIT will also collaborate and coordinate its activities with other instruments managed by organisations like Innovation Norway and Enova.

The Green Platform Initiative and Heilo are examples of important collaboration platforms. The Green Platform Initiative is a venture across Norwegian funding agencies that can provide support for research and innovation-driven green growth. Its intention is to create green jobs and a more sustainable future. Heilo is also a collaborative effort across a range of funding instruments, and its aim is to develop hydrogen value chains. As far as CLIMIT is concerned, hydrogen production from natural gas combined with CCS is a key focus area.

CLIMIT will also collaborate with the Research Council of Norway's ENERGIX programme in order to ensure that applications covering both hydrogen production and CCS do not fall through the cracks, but receive the same treatment as the other applications.

Collaboration between CLIMIT and the Research Council of Norway's PETROMAKS2 programme is important for applications relating to both petroleum production and CO_2 storage.

Collaboration with other instruments within CCU, CCUS, EOR, energy efficiency and material development will be considered if it can lead to the achievement of CLIMIT's goals.

Digitisation and artificial intelligence are disciplines that might be significant for the development of CCS technology. Collaboration between operators from these areas is also important to CLIMIT.

6.2 International Collaboration

CLIMIT will contribute to the international adoption of CCS. This will be done by assisting Norwegian technology and knowledge environments to be internationally competitive. In order to develop knowledge and competitive technology, it is important to prioritise collaboration with countries that have a market for CCS and that have ambitions to further utilise the technology.

Another goal of international collaboration is to update Norwegian technology for use abroad. Examples of countries that are advanced in this field are Canada, the USA, the United Kingdom, and the Netherlands.

Norway and the USA have established a bilateral Memorandum of Understanding (MoU) within energy at the ministerial level. Its goal is to create synergy by collaborating on CO_2 capture, transport and storage as well as on EOR for large-scale pilot testing, technology development and research.

The European sustainable development goals are embodied in what is known as the *European Green Deal*[17]. The EU's *SET-plan*[18] provides European ambitions for the energy sector, including implementation, innovation and research within CCS. The SET Plan is a strategic instrument for the EU framework programmes, and so is of great importance to the EU's climate and energy policy. This is laid out further in a separate working group known as the *CCU-CCUS Implementation Working Group*. The goals and activities of CLIMIT-supported projects should be compatible with the *European Green Deal* and the *CCU-CCUS Implementation Working Group*.

At the same time, it is important that Norwegian operators are also active in the European arena to ensure that Norwegian and European strategic CCS focusses and priorities are in good alignment.

17 The European Commission: 'European Green Deal', European Commission's website for the Green Deal, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

18 The European Commission: 'Strategic Energy Technology Plan', https://ec.europa.eu/energy/topics/technology-and-innovation/strategic-energy-technology-plan_en

One of CLIMIT's goals is to put Norwegian stakeholders in a strong position to receive support from the European framework programme for research and innovation, Horizon Europe. Through CLIMIT projects, Norwegian operators will build up knowledge, expertise and networks so that they are in a strong position to apply for support for new projects with Horizon Europe.

CLIMIT projects will also allow Norwegian operators to build up the necessary expertise to apply for financial support from other European schemes such as the EU Innovation Fund (IF), Projects of Common Interest (PCI) and Important Projects of Common European Interest (IPCEI).

CLIMIT will use a significant portion of its available budget for international calls, primarily through the ACT collaboration. ACT will have larger calls for projects at low TRL every other year and an open-ended call for projects at high TRL. CLIMIT can support Norwegian partners in international ACT projects, while foreign project participants will be supported by funding agencies from their own countries.

The EU is planning a new research and innovation partnership for low-carbon energy technology . This is called the *Clean Energy Transition Partnership* (CETP), and is a potential platform for future ACT calls.

Due to the EEA agreement Norwegian funds have been earmarked for bilateral R&D cooperation on low-carbon technologies with individual Eastern European countries (namely Poland, Hungary and the Czech Republic). CLIMIT's Secretariat will work to build synergy between CLIMIT and CCS projects coming out of EEA funds.

Bilateral calls with other countries will also be considered if they will contribute to achieving CLIMIT's goals. This depends on other countries showing interest in collaborating and contributing funds to the calls.

CLIMIT collaborates with multiple international platforms in order to ensure the international roll-out of CCS technology. This collaboration covers *The Carbon Sequestration Leadership Forum* (CSLF), *IEAGHG*, *Clean Energy Ministerial* (CEM-CCUS) and *Mission Innovation* (MI). The CLIMIT Secretariat participates in these arenas to ensure the compatibility of Norwegian and international CCS priorities. At the same time, projects supported by CLIMIT should deliver results that are relevant to the international organisations mentioned above.

6.3 Communications and Meeting Places

The CLIMIT programme will share and spread the knowledge it has gained. Projects funded by CLIMIT are expected to perform dissemination activities where results are communicated to a broader audience. This is important to make sure the public in general are well informed about achievements within CCS. All projects funded by CLIMIT are also encouraged to publish their results in scientific journals.

Research results will be disseminated at the 'CLIMIT Summit' conference, which is organised by CLIMIT every other year. Newsletters and the CLIMIT website www.climit.no/en are also used to pass on information about projects. Seminars and workshops arranged by CLIMIT itself or in collaboration with others are also used for knowledge dissemination.

Projects supported by CLIMIT are encouraged to dissemination activities targeting the general public. It is important that projects supported by CLIMIT contribute with the dissemination of information to provide the general public and decision makers with sufficient information on CCS, demonstrating that it is a necessary climate initiative to achieve national and international climate goals. In addition to publishing and other announcements of project results, CLIMIT also wants popular science communication in the mass media, on social media, in discussion forums and at other non-technical fora.

7. Expected Results, Impacts and Societal effects

CLIMIT

7.1 Results from Projects supported by CLIMIT

Projects that receive support from CLIMIT should contribute to the attainment of the programme's goals. The programme's performance targets are broad and long-term in nature. Therefore, each project should have its own targets that are laid out in their project descriptions. Projects should strive to achieve all of their goals.

In situations where it becomes clear during a project that it will fail to achieve its goals, the Programme Board may decide to cancel the project.

If a project application is accepted, the *project goals* will be included in the contract/ grant letter signed by the project leader and the Research Council of Norway/Gassnova (for CLIMIT R&D and CLIMIT Demo respectively). The project goals should describe the results that are expected to be achieved by the end of the project. The goals shall be verifiable and, as far as possible, measurable. The project goals shall substantiate one or more of the following elements:

- **Cost reductions**
  This can be measured as a cost reduction in either capital expenditure (CAPEX) or operating expenditure (OPEX) when installing CO_2 capture, transport, or storage technology. Cost reductions can be achieved through more efficient processes, integration with neighbouring systems, and economies of scale.

- **Risk reduction**
  When implementing CCS on an industrial scale, there are both technical and financial risks involved. Risk reduction can be measured by documenting the reduction in risk mitigation initiatives the project leads to.

- **Improved efficiency**
  Projects can result in more efficient CCS technology, for example through energy efficiency.

- **New technology and new models**
  CLIMIT projects can bring about entirely new technology or models that did not exist at the start of the project. This also includes the qualification of new technical solutions, methods and components.

- **Education**
  CLIMIT projects can help educate future experts by including PhD positions and post-doctoral research fellowships.

7.2 Impacts the Programme will have

Projects financed by CLIMIT shall result in the achievement of one or more of the following effects:

- **New knowledge**
  New knowledge will be created that will lead to the maturation of CCS technology. As far as possible, results from projects should be freely available so that all of society can benefit from them.

- **New business opportunities**
  Through CLIMIT projects, stakeholders will build up expertise that can then be used to create new business opportunities.

- **Efficient framework**
  The implementation of full-scale CCS depends on an improved and efficient framework for studies, authorisations and impact assessments. Social science research will provide the knowledge and expertise necessary.

- **Increased national cooperation**
  Projects supported by CLIMIT shall contribute to increased national cooperation through Norwegian operators from the academic and industrial sectors. Good synergy will be built with ECCSEL and research centres financed through the FME scheme.

- **Increased international cooperation**
  If CCS is going to be a successful climate initiative, the technology must be adopted across the world. Projects supported by CLIMIT shall work to increase international cooperation on CCS.

- **Benefit realisation of Longship**
  A long-term goal is for the infrastructure built in Longship to be expanded to include storing CO_2 from many other sources both in Norway and elsewhere in Europe. Projects supported by CLIMIT must also provide a positive contribute to this value creation.

- **Knowledge base**
  Projects supported by CLIMIT can establish a knowledge base that will be the grounding for strategic focuses on climate, energy and industry for public authorities.

- **Sustainability**
  All technology developments must be sustainable and in line with the EU taxonomy. CLIMIT projects must also provide a positive contribution to the UN Sustainable Development Goals.

7.3 Expected Effects on Society

The ultimate success of the programme is the global adoption of CCS on such a scale that it will end up being a crucial contribution in avoiding dramatic climate change.

Through CLIMIT, Norwegian R&D environments will become world leaders meaning Norwegian stakeholders will be preferred partners in international research and innovation projects.

With support from CLIMIT, Norwegian industrial operators shall develop the expertise and technology necessary to turn them into leaders in an international market for technology and solutions for the capture, transport and storage of CO_2.

CLIMIT shall contribute to societal effects which are set out in the Government's CCS strategy and are referred to as a *societal goal* and an *impact goal*[19].

19 GCCSI: 'Global Status of CCS 2021 – CCS acceleration to net zero', https://www.globalccsinstitute.com/resources/global-status-report/

8. Resources and Budget

CLIMIT is financed through annual funding allocations from across the Norwegian state budget from MPE to the Research Council of Norway and Gassnova. The funds from MPE can vary from year to year, but have been around NOK 160 million per year for the last few years.

Funding is announced through calls administered by the Research Council of Norway and Gassnova. Active and planned calls are available on the CLIMIT and the Research Council of Norway websites.[20]

Projects receiving support normally run over several years. Project funding is paid in line with the agreed timeline for project's progress.

20 CLIMIT website: https://climit.no The Research Council of Norway website: https://www.forskningsradet.no/om-forskningsradet/portefoljer/energi-transport-og-lavutslipp/

9. Management and Organisation

CLIMIT R&D is administered by the Research Council of Norway, while CLIMIT Demo is administered by Gassnova. There is a joint secretariat which coordinates the programme's efforts. Gassnova chairs the secretariat function. CLIMIT has a Programme Board which is appointed by the Ministry of Petroleum and Energy (MPE), with a separate mandate provided by MPE[21].

The Programme Board decides on CLIMIT proposals. These are announced on the CLIMIT and the Research Council of Norway websites. Applications to CLIMIT R&D should be submitted through the Research Council of Norway website. Applications to CLIMIT R&D are primarily assessed by external experts. The applications are evaluated according to standard procedures at the Research Council of Norway. Project applications to CLIMIT Demo must be submitted to Gassnova, which evaluate applications continuously. These applications are assessed by experts in the CLIMIT Secretariat, in accordance with regulations set out by MPE[22]. It is the CLIMIT Programme Board which makes the final decision on funding of new projects based on recommendations from the Secretariat.

Gassnova and the Research Council of Norway have a duty of confidentiality according to the Public Administration Act, section 13. This means that the Secretariat will ensure that information of a commercially sensitive nature is not shared or used for purposes other than the evaluation process.

A decision on allocating funds represents an individual decision according to the Public Administration Act. When deciding on allocating funding, the Programme Board uses its professional judgement. When allocating funds, the Programme Board can set out terms that the applicant must meet in order for the decision to be valid. The Programme Board does not have to provide justification for its decisions.

The Programme Board's professional judgement cannot be challenged in line with regulations in the Public Administration Act, Sections 21f and 30d. However, there is a limited right to appeal decisions from CLIMIT R&D according to normal practice in the Research Council of Norway.

---

21 Appendix 3 of Gassnova's 2021 mission statement: 'Mandate for the Programme Board of the CLIMIT programme' https://gassnova.no/app/uploads/2021/03/Oppdragsbrev-til-Gassnova-SF-for-2021.pdf

22 MPE: 'Regulations for the grant scheme – Development and development of CCS technology (CCS Fund)', 17.02.2021 https://gassnova.no/app/uploads/sites/4/2021/05/Regelverk_for_Gassnovas_forvaltning_av_CLIMIT.pdf

Five programme board meetings are usually held per year. The programme board reports results achieved in the programme to MPE through the Research Council of Norway and Gassnova.

For issues relating to CLIMIT R&D, the CLIMIT Programme Board reports to the Research Council of Norway's portfolio board for energy, transport and low emissions. The portfolio board is responsible for the overall strategy of energy, transport and low emissions, while the Programme Board is responsible for CLIMIT's calls and the allocation of funds to new projects.

The Programme Board has a pro-active portfolio management. This means that the programme will prioritise applications in areas with a particular need for new knowledge and expertise. Portfolio management is also used to ensure that the sum of all projects supported leads to the best possible goal achievement. This may mean that rather than starting on many projects in the same area, it may be more practical to spread the available budget across multiple different areas.

10. Links and Abbreviations

ACT	Accelerating CCS Technologies	http://www.act-ccs.eu/
BECCS	Bioenergy with CO_2 Capture and Storage	
CCS	Carbon Capture and Storage	
CCU	Carbon Capture and Utilisation	
CCUS	Carbon Capture Utilisation and Storage	
CEM CCUS	Clean Energy Ministerial	https://www.cleanenergyministerial.org/initiative-clean-energy-ministerial/carbon-captureutilization-and-storage-ccus-initiative
CETP	Clean Energy Transition Partnership	https://ec.europa.eu/info/files/european-partnership-clean-energy-transition_en
CLC	Chemical Looping Combustion	
CLIMIT		https://climit.no/en
CSLF	The Carbon Sequestration Leadership Forum	https://www.cslforum.org/cslf/
DAC	Direct Air Capture	
ECCSEL	European Research Infrastructure for CCUS	https://www.eccsel.org/
EOR	Enhanced Oil Recovery	
EU ETS	EU Emissions Trading System	EU Emissions Trading System
FME	Centre for Environment-friendly Energy Research	https://www.forskningsradet.no/sok-om-finansiering/midler-fra-forskningsradet/fme/

Horizon Europe		https://www.forskningsradet.no/eus-rammeprogram/horisont-europa/
IEA	International Energy Agency	https://www.iea.org/
IEAGHG	IEA Greenhouse Gas R&D Programme	https://ieaghg.org/
IF	Innovation Fund	https://ec.europa.eu/clima/policies/innovation-fund_en
IPCC	Intergovernmental Panel on Climate Change	https://www.ippc.int/en/
IPCEI	Important Projects for Common European Interest	https://ec.europa.eu/competition-policy/state-aid/legislation/modernisation/ipcei_en
IPR	Intellectual Property Rights	
MI	Mission Innovation	http://mission-innovation.net/
MoU	Memorandum of Understanding	https://en.wikipedia.org/wiki/Memorandum_of_understanding
NGO	Non-Governmental Organisation	
MPE	The Norwegian Ministry of Petroleum and Energy	https://www.regjeringen.no/no/dep/oed/id750/
PCI	Project of Common Interest	https://ec.europa.eu/energy/topics/infrastructure/projects-common-interest_en
Tiller	SINTEF's CO_2 laboratory, Tiller	https://www.sintef.no/alle-laboratorier/tiller-co2-laboratorium/
TCM	Technology Centre Mongstad	https://tcmda.com

CLIMIT is a programme that supports the research, development and demonstration of CCS.

www.climit.no/en

CLIMIT