

FROM NATIONAL TO INTERNATIONAL FOCUS – RESULTS AND IMPACTS FROM THE NORWEGIAN NATIONAL RD&D PROGRAMME FOR CCS (CLIMIT)

Aage Stangeland^{1*}, Åse Slagtern¹, Ragnhild Rønneberg¹, Lars Ingolf Eide¹, Ingrid Sørum Melaaen²

¹ The Research Council of Norway, Oslo, Norway

² Gassnova SF, Porsgrunn, Norway

* Corresponding author e-mail: ast@rcn.no

Abstract

The Norwegian national program for RD&D within CCS (CLIMIT) changed focus towards more international collaboration in 2017. The program has since then allocated approximately 20 percent of the available budget for international joint calls, primarily through the calls set up by the ACT transnational partnership. ACT is the abbreviation for *Accelerating CCS technologies*, and funding agencies from 16 countries, provinces and regions are collaborating on joint calls and knowledge sharing within this partnership. The effect of allocating a fifth of the available CLIMIT funds to international calls, has led to a shift from basic to applied research and consequently to larger projects of higher industrial interest. The international projects have managed to raise awareness of CCUS as a tool to combat global warming in a much more pronounced way than is normally seen in national RD&D projects.

Keywords: CCS, international project, RD&D funding

1. Introduction

CO₂ Capture and Storage (CCS) is a key technology to combat global warming, as highlighted by the International Energy Agency [1]. CCS has a large potential for global CO₂ emission reductions and if combined with other technologies, like biomass, it can lead to CO₂ removal from the atmosphere. Realizing the potential for CCS requires large scale demonstration of the CCS technology in parallel with ambitious research and development and demonstration.

The Norwegian government launched the Longship project in the autumn 2020 [1] which is scheduled to be in operation by 2024 to demonstrate a full scale CCS chain. The project includes CO₂ capture from a cement plant, CO₂ transport by ship, and permanent storage in an underground aquifer in the North Sea. Several other large-scale projects are also being planned in other countries [3].

The Norwegian national program for research, development and demonstration (RD&D) within CCS, the CLIMIT program [4] has since it was launched in 2005 supported national RD&D projects within capture, transport and storage of CO₂. Until 2015 most of the annual budget for the CLIMIT program was allocated to national calls for RD&D applications. Since 2016 and onwards a significant share of the budget for the CLIMIT program has been allocated to international calls.

The aim of this paper is to analyze the effects and impacts of allocating national Norwegian RD&D budget to international joint calls.

Section 2 analyzes how the new international focus has changed the project portfolio of the CLIMIT program. Effects and impacts when international calls are prioritized are highlighted in Section 3 followed by a

discussion on the way forward for Norwegian RD&D within CCS in Section 4. Conclusions are given in Section 5.

2. Analysis of project portfolio

The CLIMIT program is administrated in cooperation between the Gassnova State Enterprise and the Research Council of Norway (RCN). RCN supports research and innovation at lower Technology Readiness Level (TRL), whereas Gassnova supports demonstration and development at higher TRL. The CLIMIT program supported 142 projects in 2020 with a total of NOK 218 M. The projects typically run for three to four years.

The program has a joint secretariat with representatives from Gassnova and RCN and a board that takes decisions on strategic priorities, investment plans and project funding. The annual budget for the program is allocated by the Norwegian Ministry for Petroleum and Energy (MPE) over the National Budget.

The following project types can be supported:

- Basic research with up to 100 percent funding rate from CLIMIT.
- Competence building project led by research organization with support from industrial partners. Typical funding rate from CLIMIT is 80 %.
- Innovations projects led by industry. Support from CLIMIT is regulated by state aid guidelines.
- Demonstration and development projects where industrial partners have key roles in projects addressing development, piloting or demonstration at smaller scale. Support from CLIMIT is regulated by state aid guidelines.

- International RD&D projects where CLIMIT fund the Norwegian part of the projects. Funding rate regulated by state aid guidelines.
- Coordination activities.

CLIMIT has since 2016 allocated funding to international calls and bilateral projects. RCN is coordinating the international RD&D initiative called *Accelerating CCS Technologies* (ACT) where 16 countries and regions are collaborating on joint calls [5]. CLIMIT has made significant contribution to the three ACT calls launched in 2016, 2018, and 2020, respectively - with allocations from 60 to 70 million Norwegian kroner (NOK) to each call.

In addition, CLIMIT is open for and welcomes bilateral projects. This has led to the Preem CCS project [6], receiving funding from CLIMIT and the Swedish Energy Agency (Energimyndigheten) The project aims at CO₂ capture at the Preem refinery in Lysekil, Sweden.

Figure 1 shows the annual support from CLIMIT distributed on the different project types.

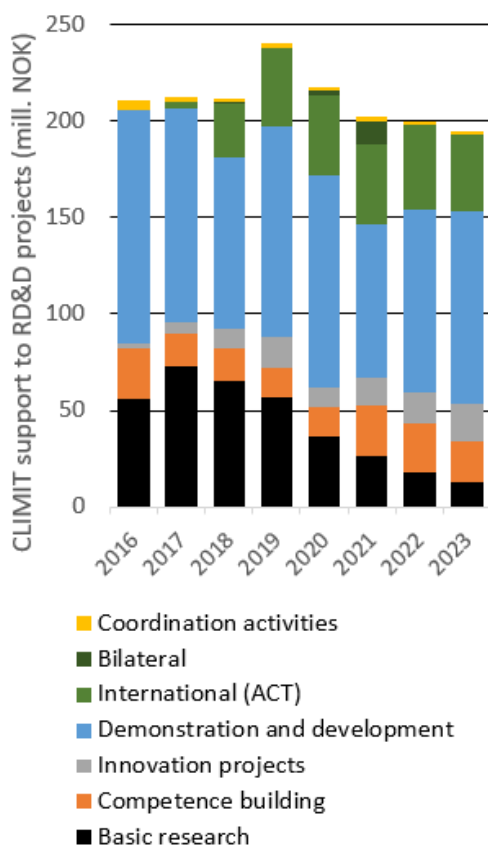


Figure 1: Annual support from the CLIMIT program to RD&D projects split on different project types.

The data in Figure 1 is based on historical support to projects and stipulated spending for the coming years. The figure shows a spending of approximately NOK 200 M annually until 2018, then an increase in 2019, partly due to allocation of significant funds to projects funded through the ACT calls. The decline after 2019 is a result of a 14 percent reduction in the National Budget for the CLIMIT program in 2020.

Figure 2 shows the shares of the total annual CLIMIT spending in 2016 and predicted spending in 2021. The figure shows that while there were no international projects in the portfolio in 2016, the share of international ACT projects has increased to 20 percent in 2021. In addition, there is also a 6 percent share for bilateral projects in 2021. The share of international ACT projects has stayed at the level of approximately 20 percent since 2019 and is stipulated to be stabilized at level for the coming years.

Please note that there is some international collaboration in many of the projects not classified as bilateral or international ACT projects in Figure 1 and Figure 2. The budget for such international collaboration is, however, limited. The projects highlighted as international projects in Figure 1 and 2 are projects funded by several funding agencies from several countries, but only the national Norwegian funding is shown in the figures.

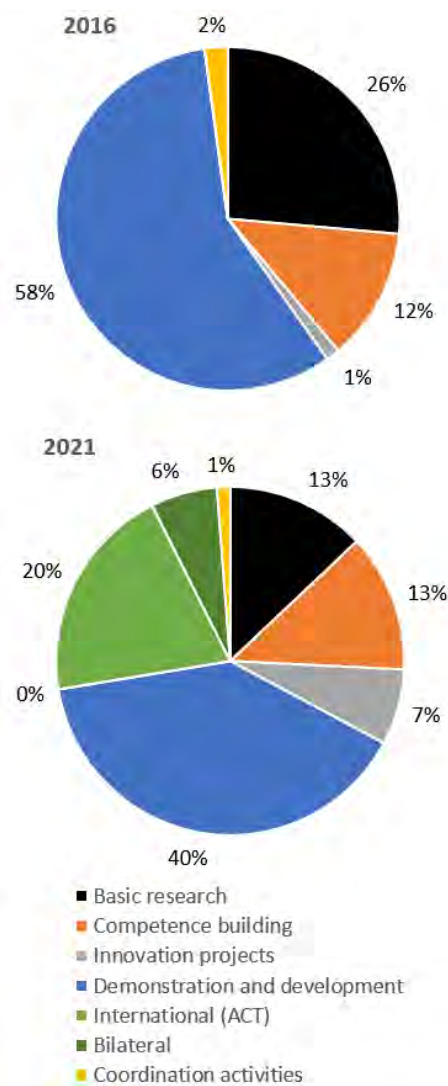


Figure 2: The share of different project types in the CLIMIT portfolio.

One consequence of increasing the share of the international projects is a decreasing share of national basic research projects. This has been a strategic planned change because the CLIMIT board wants to prioritize

international projects and projects with industrial involvement. Currently, as Norway is investing in the Longship project, it will be important to support projects on higher TRL which can build on the Longship project and close gaps that may appear during the construction and commissioning of the Longship. Moreover, it is expected that new large-scale projects will arise, and that they will have the potential to connect to the large-scale Norwegian infrastructure for CO₂ transport and storage that will be built as a part of the Longship project.

2.1 The ERA NET Cofund ACT initiative

ACT is the main international activity supported by CLIMIT. ACT started as an ERA NET cofund in 2016 with eight European countries participating in the first call. ACT has since then expanded beyond the European borders and there are now funding agencies from 16 countries, provinces and regions participating. Figure 3 shows the contributions from each ACT partner to the three ACT calls that have been set up until now.

Norway is the largest contributor to the ACT calls, closely followed by UK, Germany, the Netherlands, and the European Commission (EC). The first ACT call was cofounded by EC and their contribution was distributed among all countries participating in the first ACT call.

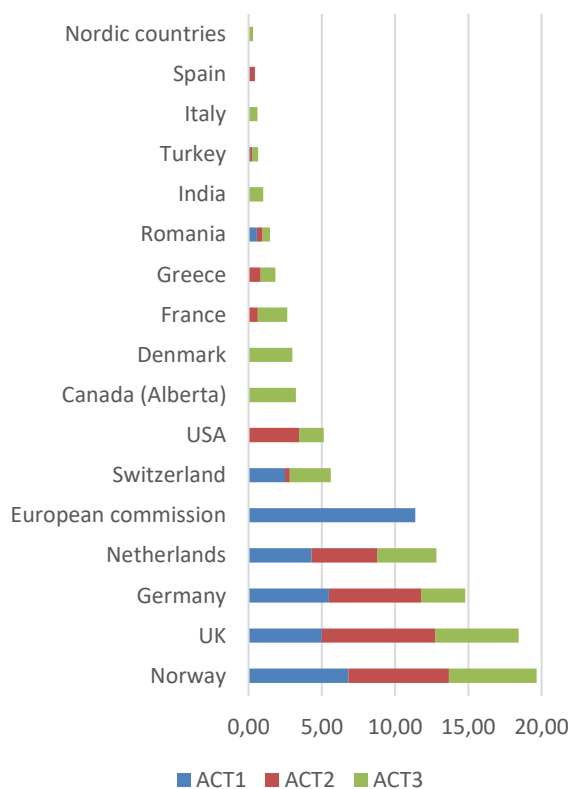


Figure 3: Countries, provinces and regions participating with funding for the three ACT calls.

The available funding for the three ACT calls have been in the range from € 31 to 36 M and the total budget for the three calls summarize to € 103 M. The first two ACT calls resulted in 20 projects granted € 67 M in support from ACT. The total budget for the 20 projects is € 94 M, including financial support from ACT, own financing, and contributions from industry.

3. Effects and impacts

3.1 Effects of increased international cooperation

The main effect after CLIMIT allocated more funding to international calls is that there are more projects in the CLIMIT portfolio where Norwegian researchers work closely together with researchers from other countries.

A consequence of prioritizing international collaboration is that other areas get less financing. In this case for the CLIMIT program, the funding for basic research has gone considerably down, from NOK 56 M in 2016 to expected spending of NOK 26 M in 2021.

ACT has a positive effect due to the cost sharing. ACT projects receives funding from several countries and the financial burden is distributed on several funding agencies. Furthermore, ACT has a positive structural effect on international RD&D because it contributes to aligning research objectives and activities across national borders. It is also believed that some countries have more comprehensive RD&D activities within CCS because of ACT than they would have had without ACT. However, this is difficult to quantify.

RCN is the coordinator of the ACT initiative. This is a resource demanding task, and RCN has therefore allocated an additional employee for coordination and management of ACT.

While most ACT projects perform applied research, there are also ACT projects with work packages addressing basic research. ACT projects addressing applied research have more industrial oriented approaches and deliverables are often designed to meet industrial needs. Consequently, there are often less peer-reviewed scientific paper publications in the ACT projects focusing on applied research compared to national basic research projects. This has only a minor effect on the total publication rate in the CLIMIT portfolio. The total number of peer-review publications from CLIMIT and ACT projects funded by RCN has been quite stable the last five years as shown in Figure 4.

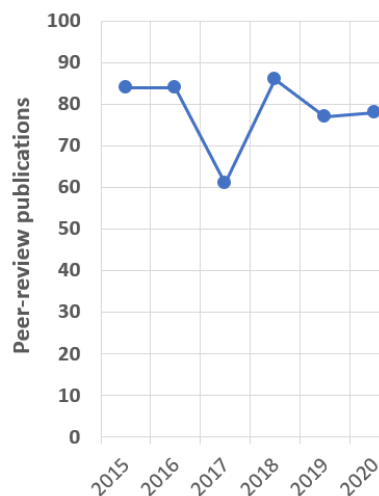


Figure 4: Number of peer-reviewed publications from CLIMIT and ACT projects funded by RCN.

Knowledge sharing is high on the agenda within the ACT consortium and within the projects funded by ACT. The projects are requested to emphasize on dissemination, and results created by ACT funded projects are therefore to a large extent available for the international environment of researchers, industrial stakeholders, and decision makers interested in CCS.

3.2 Impacts of increased international cooperation

There has been a strong industrial interest for the ACT projects. The industrial interest is higher for ACT projects compared to an average national CLIMIT project at similar Technology Readiness Level. With international collaboration on joint calls it has been possible to establish large projects that have better abilities to address industrial needs.

ACT projects have undoubtedly played a crucial and important role for the Norwegian CCS community. Representatives from industrial partners in the Longship project have stated that ACT projects are delivering results and competence needed for the Longship project. One example is the ACT funded project Pre-ACT [7] that has delivered new knowledge on how to handle pressure build-up during CO₂ injection. Industrial stakeholders have said that this knowledge is of high value for the Northern Light [8] project where the CO₂ storage solution for Longship is designed and constructed.

The ACT calls have addressed strategic priorities from the EU SET-plan [9] and the Mission Innovation (MI) [10] in the call texts. Projects funded by ACT are therefore important tools for generating results that are needed to achieve the ambitions of the EU SET-plan and Mission Innovation.

There are several important fora for international cooperation within CCS at a strategic level. Representatives from Norwegian authorities participate in several of them. The most important, in addition to two already mentioned (SET-Plan and MI) are the Carbon Sequestration Leadership Forum (CSLF), the Clean Energy Ministerial (CEM) CCUS Initiative, the IEA GHG, the Zero Emission Platform (ZEP), the bilateral Memorandum of Understanding (MoU) between Norway and USA, and the MoU between Norway and UK. When significant resources are spent at the strategic level it is important to make sure that there are activities that can lead to achievement of strategical ambitions. ACT has turned out to be an important tool to meet the strategic ambitions of the mentioned strategic fora.

Several ACT projects have joined forces to set up seminars in Brussels where key results are communicated to stakeholders and decision makers. There have been several CCUS seminars in the period from 2017 and the start of the corona lockdown spring 2020. One example is the ELEGANCY Conference 2018, set up in Brussels 8 November 2018 to address how hydrogen can contribute to decarbonization of the European energy system [11]. This conference, together with results from the ELEGANCY project, has contributed significantly to ensure that Hydrogen production combined with CCS is on the radar at political and industrial level in Europe.

Several ACT projects, together with other European CCS projects, set up at conference in Brussels 10 September 2019 to showcase the research results within CO₂ storage with special relevance for energy, environment and climate policy [12]. Events like this are very important for raising awareness of CCS as an important and necessary tool to combat global warming. National CLIMIT projects have not been able to address awareness in a similar way.

The shift in Norwegian RD&D within CCS from national to international projects also has some weaknesses. The share of basic research in the CLIMIT portfolio is decreasing. A consequence is limited funds available for studying new concepts that potentially could evolve to the highly needed next generation CCS technologies. Furthermore, the number of PhD candidates and Postdoctoral researchers in the CLIMIT portfolio is decreasing as shown in Figure 5. Educating the future CCS experts is important and CLIMIT is contributing less than the program did some years ago. Please note that Figure 5 only includes PhDs and Postdoctoral researchers financed by RCN. There are in addition some PhD candidates and Postdoctoral researchers in the CLIMIT projects financed by Gassnova. The figure focus on RCN only because educating future experts is an important key performance indicator (KPI) for RCN.

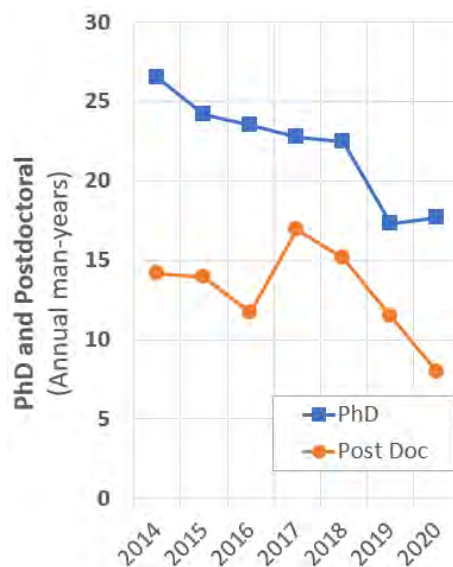


Figure 5: Annual man-years for PhD candidates and Postdoctoral researchers financed by the Research Council of Norway through the CLIMIT program.

4. The way forward for international cooperation on RD&D

When ACT started in 2016 a five-year grant agreement was signed with the EC. Now that this contract is coming to an end, there is ambitions among the ACT partners to continue the collaboration. The Clean Energy Transition Partnership (CETP) which is planned under Horizon Europe is seen as a good basis for continuing the collaboration. However, this depends on an effective governance structure being established that fits with the ACT governance model. ACT will continue the

collaboration with partners outside Europe and CETP will only be an alternative for ACT if it opens for effective collaboration beyond the European borders. ACT aim at continuing with USA, Canada and India as partners and also opens up for other countries to join ACT.

5. Conclusions

The Norwegian national program for RD&D within CCS, CLIMIT, changed focus towards more international collaboration in 2016. Since then about 20 % of the annual budget has been allocated to international calls.

Most of the CLIMIT budget allocated to international calls have been directed to the joint calls set up by the ACT partnership. In ACT, a total of 16 countries, provinces and regions are collaborating on bi-annual transnational joint calls and multinational knowledge sharing.

The shift from national to international joint calls have given the following positive impacts for CLIMIT:

- With international collaboration on joint calls it has been possible to establish larger projects that are able to efficiently address industrial needs.
- ACT projects have delivered results and competence needed and taken up in the large-scale Longship project.
- The ACT calls have addressed strategic priorities from the EU SET-plan [9] and Mission Innovation [10].
- Several ACT projects have joined forces to set up international seminars where key results have been communicated to stakeholders and decision makers. These events have been very important for raising awareness of CCS as an important and necessary tool to combat global warming. National CLIMIT projects have not been able to address awareness in a similar way.

There are also some disadvantages when international calls are prioritized instead of national calls:

- More funding allocated to international calls means less funding to national calls. Funding for basic research has decreased in the CLIMIT portfolio after international collaboration became more prioritized. Consequently, there are limited funding available for studying new concepts that potentially could evolve into next generation CCS technology.
- The number of PhD candidates in the portfolio has decreased. Educating the future CCS experts has become less pronounced in the CLIMIT portfolio when the focus has shifted from national to international collaboration.

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References

- [1] Energy Technology Perspectives 2020, Special Report on Carbon Capture, Utilisation and Storage, The International Energy Agency (IEA), 2020. <https://webstore.iea.org/ccus-in-clean-energy-transitions>
- [2] Longship – Carbon capture and storage, Meld. St. 33 (2019–2020) Report to the Storting (white paper) <https://www.regjeringen.no/contentassets/943cb244091d4b2fb3782f395d69b05b/en-gb/pdfs/stm201920200033000engpdfs.pdf>
- [3] Carbon Sequestration Leadership Forum (CSLF), Task Force on Clusters, Hubs, and infrastructure for CCS, September 2020, [Microsoft Word - Clusters report 2020 September update.docx \(cslforum.org\)](https://www.cslforum.org/Clusters_report_2020_September_update.docx)
- [4] The CLIMIT program, www.climit.no/en
- [5] Accelerating CCS Technologies (ACT), <http://www.act-ccs.eu/>
- [6] The Preem CCS project, <https://climit.no/project/techno-economic-feasibility-study-of-the-implementation-of-carbon-capture-from-major-emission-sources-at-preemraff-lysekil-preem-ccs/>
- [7] The Pre-ACT project, <https://www.sintef.no/pre-act/>
- [8] Northern Light [Northern Lights – A European CO₂ transport and storage network \(northernlightsccs.com\)](http://www.northernlightsccs.com)
- [9] SET-PLAN TWG9 CCS and CCU Implementation Plan, Report from the SET-Plan ACTION no. 9, September 2017. https://setis.ec.europa.eu/system/files/set_plan_ccus_implementation_plan.pdf
- [10] Accelerating Breakthrough Innovation in Carbon Capture, Utilization, and Storage, Report of the Mission Innovation Carbon Capture, Utilization, and Storage Experts' Workshop, Mission Innovation, September 2017. <https://www.energy.gov/sites/prod/files/2018/05/f51/Accelerating%20Breakthrough%20Innovation%20in%20Carbon%20Capture%2C%20Utilization%2C%20and%20Storage%200.pdf>
- [11] The ELEGANCY Conference 2018, Brussels 8 November 2018, <https://blog.sintef.com/sintefenergy/elegancy-conference-2018/>
- [12] EU CCS Storage Research Projects Science-Policy Showcase, Brussels 10 September 2019, <https://webgate.ec.europa.eu/maritimeforum/en/node/4417>