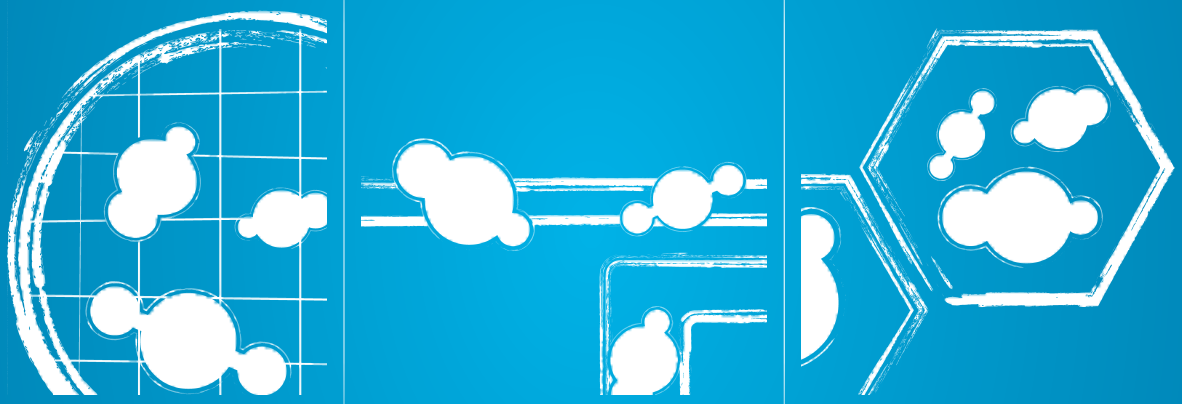
CLIMIT



2013
ANNUAL REPORT

CONTENT

EDITORS

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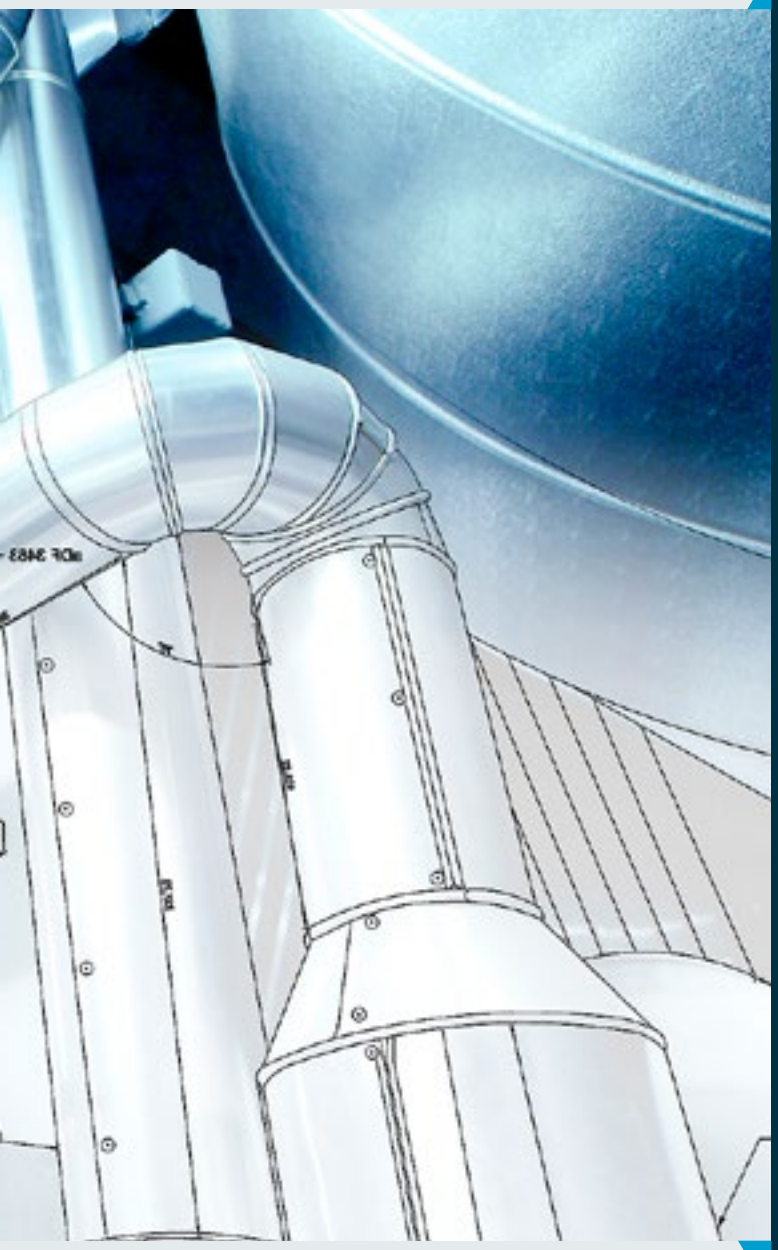


THE CLIMIT PROGRAMME

CLIMIT is the Norwegian national programme for research, development and demonstration of technologies for carbon capture and storage (CCS). The programme covers the Research Council of Norway's support programme for research and development (R&D part) and Gassnova's support for development and demonstration (the Demo part).

CLIMIT'S VISION IS TO:

Accelerate commercialisation of CCS through financial stimulation of research development and demonstration of CCS technology.

CLIMIT is key to Norway's CCS work


Marianne Holmen, acting chair of CLIMIT's programme board.

"After one year with a new strategy and programme plan, we can safely say that CLIMIT in 2013 has already made positive contributions to achieving the paramount goals within our focus areas. Our mission is to help promote good technological solutions for CCS. This is a precondition for realisation of full-scale CCS, but this alone is not sufficient to achieve results in the area," says acting chair of CLIMIT's programme board, Marianne Holmen.

"Through this annual report, we will document both the width and depth of CLIMIT's activity in 2013. We highlight activities and factors that demonstrate opportunities and limitations in the CCS work in Norway," says Holmen.

NEW STRATEGY AND PROGRAMME PLAN

The objective of the new CLIMIT programme for the period up to 2020 is contributing to lower costs and early international realisation of CCS. In addition, we have the ambition of implementing CCS in Norwegian industry and realising the storage potential in the North Sea.

Projects supported by CLIMIT contribute knowledge and expertise to improve safety and close technological gaps. Other prioritised projects are ideas focusing on ground-breaking technologies or service concepts with international potential.

NORWAY CAN CONTRIBUTE

In 2014 the means for funding projects have been increased. And we are very happy about this," says Marianne Holmen, who emphasises that costs increase significantly when projects go from pilot to demonstration stage. It is important that we have promoted many 1st generation capture technologies to the demonstration stage, while there is also good diversity in 2nd and 3rd generation capture technologies which can be further developed and yield positive results.

"Norway can play a part in multiple areas, but has particular advantages as regards storage. This will necessitate geopolitical cooperation and facilitation of an infrastructure which would allow for storage in the North Sea. This is a role Norway can take on, and few other nations have the opportunity to do so," says Marianne Holmen.

The Full-scale Mongstad project has been a motivation for commercial industrial players. The decision to cancel the project was not totally unexpected. This does not mean that also CCS work will stop. Rather, it will take a new direction. We believe CLIMIT's role will become even more important in this situation. We are awaiting the government's new strategy report and believe it is essential that support for demonstration facilities is emphasised along with continuous focus on research and development.

"We hope Norwegian environments, including research, university and industrial players continue their work, despite the somewhat longer horizon," says Marianne Holmen.

MILESTONE

CLIMIT has awarded millions of NOK to high-quality projects and has identified technology solutions that could reduce the costs of CCS and enable storage.

"From a natural starting point in research and development, we have gradually also increased the number of pilot projects. A milestone in this regard is the award in 2013 to the first capture project from an industrial emission source; Norcem's cement plant in Brevik," says Marianne Holmen.

Going forward, CLIMIT hope that many of the good research and development projects (R&D) will be continued, and

not stalled. The primary challenge is stimulating and motivating industrial interest in the time to come.

INTERNATIONAL COOPERATION

CLIMIT are increasingly emphasising international cooperation in general, and working in particular on the EU's ERA-NET Cofund in connection with Horizon 2020, the EU's framework programme for research and innovation. Here the European Commission presents options for substantial additional financing to projects where several countries participate.

"We have faith in the international cooperation, and that Norway can make greater strides and achieve more by participating. International cooperation is also inspiring. That is why our calls for proposals will also emphasise international cooperation," says Marianne Holmen.

Programme board

In 2013, the programme board was composed of the following members:

FROM LEFT TO RIGHT:

- **Nils Røkke**, SINTEF
- **Per Reidar Ørke**, Energreen
- **Olav Kårstad**, Statoil
- **Elisabeth Rose**, DNV GL
- **Per Aagaard**, University of Oslo
- **Eva Halland**, the Norwegian Petroleum Directorate
- **Hans Jörg Fell**, chair of the CLIMIT secretariat
- **Marianne Holmen**, Statkraft – acting chair from September 2013

NOT PRESENT WHEN PICTURE WAS TAKEN:

- **Kim Dam-Johansen**, Denmark's technical university
- **Anita Utseth**, the Norwegian Petroleum Directorate
- **Kjell Bendiksen**, IFE – Chair – resigned in 2013

In addition, the Ministry of Petroleum and Energy has appointed adviser Ingar Steinsvik as an observer at the programme board meetings.

Five ordinary and three extraordinary programme board meetings were held in 2013.

Unique instrument

for promoting and supporting technological development

"The key to success is to be proactive and to build networks, nationally and internationally. Our new 2013-2020 programme plan defines technological gaps in relation to the performance goals. Our task is helping to close the gaps," says Hans Jörg Fell, head of technology and expertise in Gassnova and chair of the CLIMIT secretariat.

"We are very pleased with the increased allocation of NOK 30 million from the Norwegian state, which will be distributed equally between research and development (R&D) and demonstration of technology (Demo). This helps strengthen CLIMIT's position," says Hans Jörg Fell.

The programme is a cooperative venture between Gassnova and the Research Council of Norway. CLIMIT covers the Research Council of Norway's support programme for research and development (R&D part) and Gassnova's support for development and demonstration (the Demo part). Gassnova has the overall responsibility and heads the programme secretariat.

CHALLENGING

"The biggest change for CCS in Norway in 2013 is undoubtedly the termination of the full-scale project at Mongstad. The industrial players have devoted considerable resources to developing and demonstrating technology so far. By postponing commercialisation, industrial funding of projects will be more challenging," says Fell.

In line with CLIMIT's new strategy plan, the ESA programme (EFTA's Surveillance Authority) is applying for re-notification of the CLIMIT programme under terms more adapted to the market. This is important in order to provide triggering support to projects in the development and demonstration phases. The current notification expires in 2015.

STRENGTHENING CLIMIT

Financing projects is challenging. CLIMIT therefore implements new measures to strengthen the number of applications. For CLIMIT R&D we are focusing on new, promising third-generation capture projects.

In March, CLIMIT R&D will have a new call for proposals aimed at new concepts for CO_2 capture that could create opportunities for new, ground-breaking projects. Applications will be assessed based on new evaluation criteria to promote projects with higher potential and greater risk than the average calls for proposals.

In the autumn of 2013, we announced an idea competition for CLIMIT Demo where we earmarked NOK 1 million, and where each applicant could receive up to NOK 200 000 for preparatory work.

"This activity, which was followed-up by reaching out to relevant institutes, was intended to help developing good ideas up to a project application. So far, this initiative has been successful and resulted in multiple conceptual studies," says Hans Jörg Fell. This entails e.g. finding the right industry partners, applying for patents, contact with international environments, workshops with potential partners and preliminary studies needed to support the idea up to a project application.

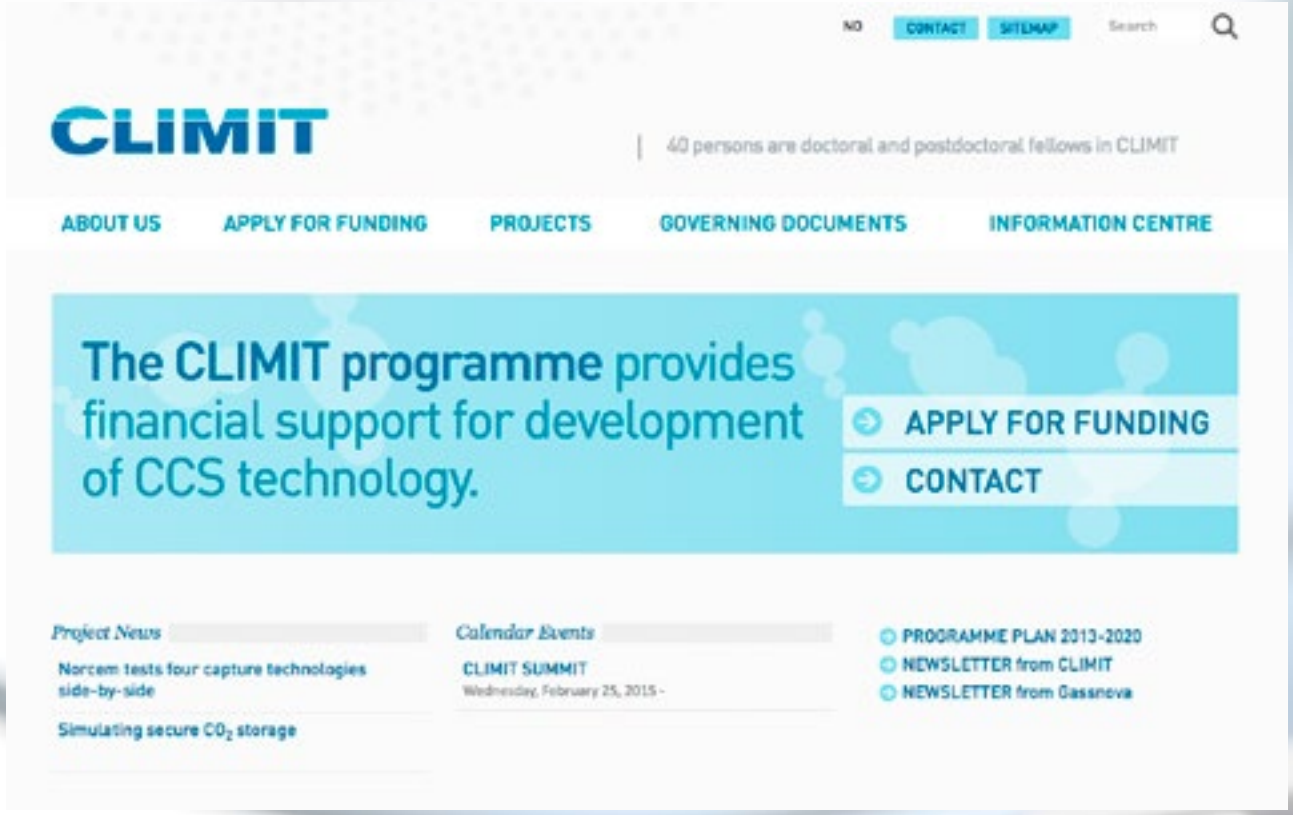
KNOWLEDGE AND EXCHANGING EXPERIENCE

It is important to have established meeting arenas where technical environments can exchange knowledge and experience. CLIMIT SUMMIT 2013 is such an arena, which gathered representatives from research, industry and the authorities for presentations and debates. For the first time, the conference also had an international element with presenters and participants from the US, UK, Sweden and Germany.

"However, I do believe that there will be more interesting applications going forward," says the chair of the CLIMIT secretariat. Our research expertise at universities and university colleges is world class thanks to our efforts, not least through Mongstad and the work done by Aker Solutions, Statoil and Alstom, to mention a few.

CLIMIT gets a new website

In the latter half of 2013, the secretariat worked on developing content for the CLIMIT programme's new website, which was launched in mid-January 2014. The new pages shall focus on the applicants and a separate database has also been made for the projects in CLIMIT's portfolio.



www.climit.no/en

In brief

Programme plan CLIMIT 2013-2020

Through support to projects throughout the value chain from research to demonstration, CLIMIT helps develop knowledge, expertise, technology and solutions that can yield important cost reductions and broad-based international application of CCS. At the same time, CLIMIT must contribute to exploitation of national advantages and development of new technology with international potential.

CLIMIT HAS THE FOLLOWING GOALS:

Effect goals

- Lower costs and early international realisation of CCS
- CCS in Norwegian industry
- Realisation of storage potential in the North Sea

Performance goals

- Knowledge and expertise to close technological gaps and increase safety
- Cutting-edge technologies and service concepts with international potential

CALLS FOR PROPOSALS 2013:

The most important calls for proposals in 2013:

- Call for proposals through the participation scheme for projects related to strategic work vis-à-vis the EU's SET plan with an application deadline of 13 February 2013. The budget was NOK 0.9 million.
- Joint call for proposals with Norway, Poland, Greece and the UK through FENCO-NET with an application deadline of 29 May 2013. CLIMIT contributed NOK 6 million to the call for proposals.
- Ordinary call for proposal of KPN and FP with application deadline of 4 September 2013. Total budget for call for proposals in KPN, FP and IPN was NOK 69 million.
- Ordinary call for proposals in IPN with an application deadline of 16 October 2013.
- CLIMIT Demo has a continuous call for proposals and applications to CLIMIT Demo are processed by designated experts in the secretariat (Demo part) according to regulations that apply for this funding scheme, where the purpose is to safeguard applicants' desires for confidentiality surrounding a technology. CLIMIT Demo awarded NOK 136.3 million in 2013, the second highest award since the fund was established in 2005.
- Idea development funds; support development of new, highly efficient processes that do not take a basis in small incremental improvement of traditional technologies, but with the potential for major reduction of the CO_2 capture cost. The funding scheme is intended to support the idea development phase. This scheme will be continued and expanded in 2014.

The programme board in CLIMIT makes the final decision regarding whether or not to award support to applications based on recommendations from the secretariat.

Workshop: Bio-energy with CCS

It is a captivating thought to fire power plants with biofuel, capture the CO_2 from the flue gas and then dispose of it. This makes biofuel not only carbon neutral, but carbon negative. CLIMIT's workshop showed that this is possible, but not easy, to achieve.

Key players from research and industry met to look at the opportunities for bioCCS (bio-energy with CCS) in Norway and internationally, and how Norwegian players can contribute.

Some of the participants at the workshop were representatives from Borregaard, Statkraft, Norske Skog, ZEG Power, the Norwegian University of Life Sciences, SINTEF and Finnish VTT.

SOME OF THE CONCLUSIONS FROM THE WORKSHOP:
Power plants fired with biofuel in combination with CO_2 capture could appear to be the simplest road to carbon negative CCS, but require major-scale transport and storage which, at best, is a long-term venture. Capture of CO_2 from production of biofuel (such as ethanol), seems promising from a technical standpoint, but the possibilities for transport and storage from small spot sources are uncertain.

CLIMIT SUMMIT 2013

Nearly 200 participants took part in the CLIMIT SUMMIT in February. The summit was held for the third time at the Soria Moria hotel and conference centre in Oslo.

Research scientists, representatives from the industry and the authorities all gathered here to share knowledge and experience. For the first time, the conference had an international element with presenters and participants from the US, the UK, Sweden and Germany.

The participants could learn about topics such as the CCS activities in the US and the UK. The energy company EoN and technology supplier Alstom presented their perspectives on CO_2 capture, and the Norwegian Petroleum Directorate gave a presentation on the storage potential on the Norwegian shelf. The results from the CLIMIT projects were presented during two parallel sessions. There was also a poster exhibition where more than 60 CLIMIT projects were represented.

Both presentations and posters were of a high standard, and helped give the participants deeper insight into this important field.

After a successful event and inspiring summit, the CLIMIT secretariat is looking forward to organising the CLIMIT SUMMIT once again in 2015.

IEAGHG CCS SUMMER SCHOOL

The International Energy Agency's programme for research and development on greenhouse gases (IEAGHG) organises an international CCS summer school every year.

This was the seventh consecutive year, and it was held at the University of Nottingham from 21-26 July. Various topics associated with CCS were highlighted through presentations, field trips and group work over the course of the week.

The students are selected based on an application, and 60 master and PhD students from around the world participated this year. There were also 37 so-called mentors at the summer school to teach, advise and inspire, from universities, public authorities, NGOs (non-governmental organisations) and industry.

Erik Gjernes participated from the CLIMIT secretariat, and gave a presentation on possible health and environmental impacts in connection with amine-based CO_2 capture.

The CLIMIT programme has supported IEAGHG's summer school since 2011 with a fixed annual amount of NOK 70 000.

More than 50 young researchers participated at the CLIMIT PhD-Seminar which was held in October 2013 in cooperation with the BIGCCS research centre.

The participants met in October 2013 at Lerkendal Stadium in Trondheim. Photo: The Research Council of Norway

The future's solutions at CLIMIT's PhD seminar

"An important part of CLIMIT is ensuring good recruitment, and doctorate studies for nearly 50 PhD and PostDoc candidates are financed through CLIMIT projects. This is where we can find the future's solutions within capture, transport and storage of CO_2," says special advisor in the Research Council of Norway, Aage Stangeland.

More than 50 young researchers participated at the CLIMIT PhD Seminar which was held in October 2013 in cooperation with the BIGCCS research centre.

ANNUAL EVENT

The CLIMIT PhD seminar has become a tradition and is held every year. The younger researchers greatly appreciate this event and view it as a unique opportunity to network and learn from each other.

"There are no doubt that the various types of doctoral work address interesting topics that highlight relevant issues within capture and storage of CO_2," says Aage Stangeland.

EXCITING PROJECTS

Several exciting PhD projects were presented at the seminar:

- There are several PhD candidates researching more stable membranes which could yield more efficient CO_2 capture.
- Extensive experiments are ongoing at SINTEF to determine thermodynamic properties of CO_2 mixtures so we can simulate CO_2 transport more accurately. CO_2 storage is fully possible, but still challenging.
- Several interesting presentations showed new insight into storage mechanisms, application of advanced mathematics to simulate CO_2 storage, as well as interesting interpretations of phenomena observed from storage of CO_2 in the Snøhvit area.

"The doctoral candidates educated through the CLIMIT programme represent extremely important expertise that will be significant going forward to solve challenges associated with CCS," says Stangeland.

Special adviser Aage Stangeland, The Research Council of Norway

MEMORANDUM OF UNDERSTANDING

- The CLIMIT secretariat has participated at several meetings in the US under the Ministry of Petroleum and Energy's (MPE's) and Department of Energy's (DOE's) Memorandum of Understanding (MoU) on CCS

  - **12th annual conference on CCUS**
    The programme covered both political and regulatory topics, in addition to approx. 120 parallel technology presentations covering the entire CCUS Carbon Capture, Utilization and Storage chain.

  - **CO_2 storage - annual project review meeting**
    The conference gathered about 200 researchers that are involved in the authorities' storage programmes. Prior to this meeting, a workshop took place between Norwegian R&D projects financed through the CLIMIT programme and representatives of corresponding American CO_2 storage projects. The objective of the meeting was exchanging experience and identifying potential ways to collaborate.

- The Research Council of Norway also has a Memorandum of Understanding with the EU Commission's research institute, Joint Research Institute (JRC). In this connection, CLIMIT's administration organised a study trip for key Norwegian R&D environments to JRC's office in the Netherlands. The goal is for this over time to contribute to a fruitful R&D cooperation with JRC as regards CCS.

INTERNATIONAL WORK

CLIMIT has carried out and contributed at several international workshops and cooperation meetings where top experts were invited to discuss various topics.

THE CLIMIT SECRETARIAT CONTRIBUTES TO INTERNATIONAL COOPERATION BY BEING A REPRESENTATIVE IN SEVERAL NATIONAL AND INTERNATIONAL FORUMS:

- Head of technical group in Carbon Sequestration Leadership Forum (CSLF)
- Norwegian representative in IEA Greenhouse Gas R&D Program
- Norwegian representative in EII CCS (European Industrial Initiative on CCS)
- Member of Government Group in the EU's technology platform ZEP (Zero Emission Fossil Fuels Power Plants)
- Member of ZEP task force on Policy and Regulations (ZEP TF P&R)
- Member of ZEP task force on Technology (ZEP TFT)
- Head of FENCO-NET (network that is a direct follow-up of the previous ERA net)
- Member of the CCS group in TFI (Nordic Top-Level Research Initiative) and represented in TFI's programme committee.

INTERNATIONAL PROJECTS

A prioritised topic in both Norway and the EU is development of research infrastructure for CCS. This will be carried out in the ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure) project headed by NTNU (Norwegian University of Science and Technology). This is a joint European project under the EU's ESFRI (The European Strategy Forum on Research Infrastructures) scheme, which has the purpose of building joint European research infrastructure. The administration in CLIMIT R&D is following this project very closely, which ensures good coordination between the CLIMIT programme and the infrastructure being planned in ECCSEL.

The secretariat also follows up the NORDICCS (Nordic CCS Competence centre) centre which was established under the Nordic Top-Level Research Initiative (TFI). This is a Nordic centre which will pave the way for realisation of CCS facilities in the Nordic region. In 2013, NORDICCS organised a Nordic summer school for 30 students in Trondheim with a scheduled visit to CO_2 Technology Centre Mongstad (TCM).

Through the cooperation in FENCO-NET (The Fossil Energy Coalition Network), CLIMIT has been an initiator for carrying out a joint call for proposals between participating European countries within capture, transport and storage of CO_2. This resulted in a joint call for proposals with Norway, the UK, Greece and Poland, and four new international cooperation projects were approved in the autumn of 2013.

CLIMIT R&D has contributed in the process of designing the call for proposals for a Norwegian-Polish R&D collaboration within CCS. The call for proposals was EUR 10 million, and was organised under the Research Council of Norway's international programmes and administered by the National Centre for Research and Development in Warsaw.

The possibility of a future partnership within CCS was discussed at a bilateral contact meeting between Norway and Germany. The Ministry of Petroleum and Energy, German Ministry of Economics and Energy, PT Jülich, as well as the CLIMIT secretariat were represented. Within the Horizon 2020 EU programme, ERA-NET Cofund could be suitable as the support programme for a such partnership.

INTERNATIONAL CONFERENCES

CLIMIT encourages international cooperation and contributes to contact through participation at international conferences

- **Visits to Oxyfuel pilot facilities in Spain and France**
  Both Spain and France are making offensive investments in research and demonstration of oxyfuel technology in combination with storage.

- **Carbonate Looping - visit to the University of Stuttgart**
  The University of Stuttgart, Institute of Combustion and Power Plant Technology, has two carbonate looping pilots.

- **3rd oxyfuel combustion conference**
  The conference organised by IEAGHG in Ponferrada, Spain, is the largest oxyfuel conference so far.

- **Scottish Carbon Capture and Storage - CO_2 storage in the North Sea**
  A conference regarding opening up the possibilities for CO_2 storage in the North Sea for Europe. Scottish authorities, the European Commission Energy, ZEP and CO_2 storage specialists attended.

- **Clean coal technology conference**
  BIT's Low Carbon Earth Summit 2013 was held in Xi'an, and the Clean Coal Technology conference was part of this. The Chinese Ministry of Commerce, Ministry of the Environment and Ministry of Culture hosted, together with several organisations.

CLIMIT must have a diverse project portfolio within:

- **Technology areas** (capture, transport and storage)
- **The development chain** (research, development and demonstration)

KEY FIGURES

The robust activity within CLIMIT R&D shows that Norwegian CCS research environments are extensive. Seen in relation to the activity in CLIMIT Demo, it is reasonable to say that we have been unable to exploit the full potential represented by the R&D activity.

This could be because the research environments are generally larger than what the industry is able to absorb, and the distance to a commercial market for CCS technology is still long, particularly in Europe. Unless the market receives significant new investment signals for CCS, this trend will continue.

Diagrams 1 and 2 show the distribution by area, and highlight a good distribution between capture and storage, throughout the development chain. There is considerable R&D activity within transport, but few projects within the demo part of the programme. This also reflects the areas with the greatest challenges when it comes to costs and technological risk.

Diagrams 3 and 4 show the programme's distribution along the development chain. They show that within CLIMIT R&D, more than 70% of the allocations in the active portfolio are related to projects where the industry is involved, while nearly 30% of the allocations in the portfolio are related to pure research projects. Expertise projects (for businesses) include both basic research and applied research, while Innovation projects (for businesses) target applied research.

Most projects in CLIMIT Demo fall under the "development" category. However, 20% of ongoing projects are classified as demo projects. These are projects considerably closer to commercialisation, and have rarely been used so far.

Since CLIMIT was started in 2005, annual disbursements have increased. (diagram 5)

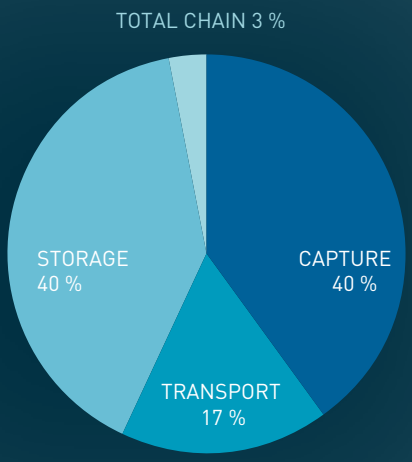
From CLIMIT R&D, the awards are in line with the record year 2012. Despite reduced budgets in 2011 and 2012, a decision was made to maintain the funds announced at a relatively steady level to ensure a stable activity level. This means that newly started projects tie up a large part of the budgets and that the effects of the budget reductions are balanced over several years.

CLIMIT Demo disbursements have risen considerably after 2008. This is both because allocations to new projects have increased in the period and because the duration of the projects entails that the disbursements have a natural lag in relation to the allocations. Disbursements in 2012 are on par with the annual award from the MPE and in line with disbursements in 2011, in spite of the record level of funds awarded, both in 2012 and 2013. This is because several of the approved projects in 2012 and 2013 have not progressed far enough to receive full disbursements by the end of 2013. A high level of disbursements is therefore expected going forward.

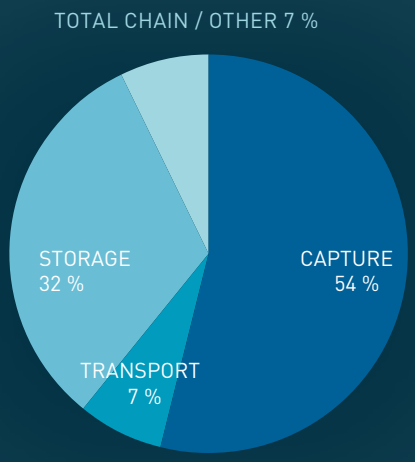
DISBURSEMENTS FROM CLIMIT 2013

	CLIMIT R&D (NOK million) **Total 65 projects**	CLIMIT Demo (NOK million) **Total 44 projects**
Capture	37,8	100,4
Transport	16,3	14,0
Storage	43,1	17,4
Other*	2,5	4,5
SUM	**99,7**	**136,3**

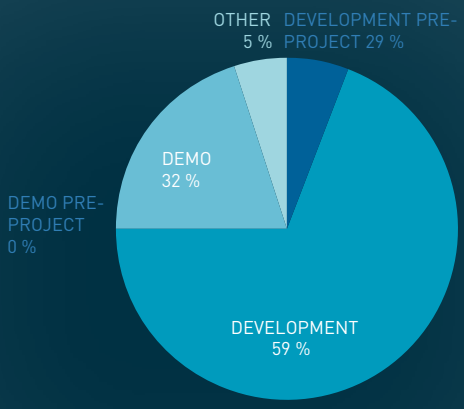
* Comprises projects that include the entire value chain from capture to transport and storage as well as various conferences and network gatherings.



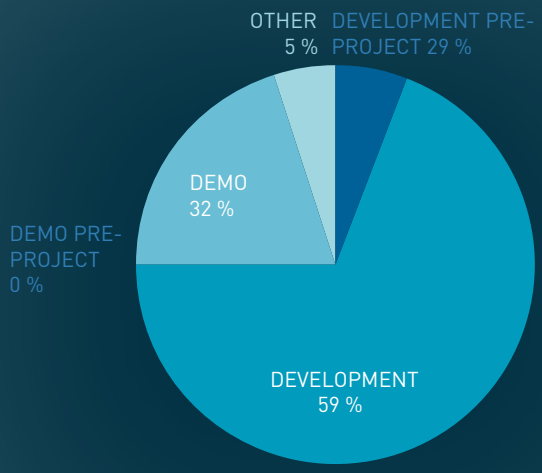
1 CLIMIT R&D: DISTRIBUTION BY AREA
ONGOING PROJECTS 2013, APPROVED



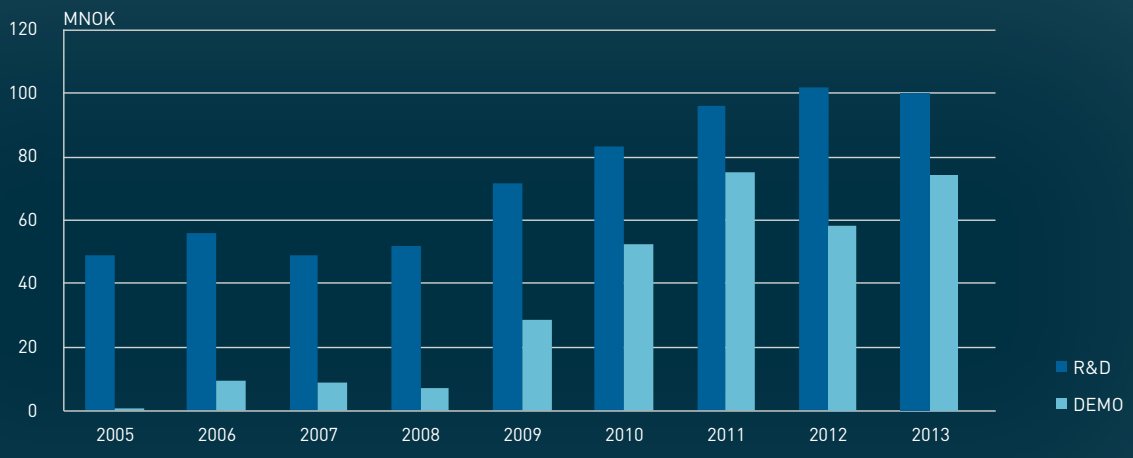
2 CLIMIT DEMO: DISTRIBUTION BY AREA
ONGOING PROJECTS 2013, APPROVED



3 CLIMIT R&D: DISTRIBUTION BY AREA
ONGOING PROJECTS 2013, APPROVED



4 CLIMIT DEMO: DISTRIBUTION BY DEVELOPMENT STAGE
ONGOING PROJECTS 2013, APPROVED



5 PAYMENTS MADE TO PROJECTS CLIMIT, R&D AND DEMO

CLIMIT:
Champion of good ideas

CLIMIT seeks out the good solutions within all areas of CCS. There are many promising projects in CLIMIT's portfolio, and the players also undoubtedly have even more good ideas.

Jørild Svalestuen in Gassnova and Åse Slagtern in the Research Council of Norway work on stimulating good ideas within CCS. Innovation happens along the entire development chain of a product or service. The ability to see opportunities or create possibilities for good ideas is essential in order to make progress. And CLIMIT has chosen to pave a new path.

THE GOOD IDEAS

The CLIMIT programme provides financial support for CCS development. The acknowledgement that many good ideas need help in order to mature, is why the CLIMIT secretariat makes an effort to champion the good ideas.

In the autumn of 2013, the CLIMIT secretariat worked on finding out how we can further develop policy instruments to promote new innovative solutions. This resulted in two different instruments. One adapted to CLIMIT R&D and one adapted to CLIMIT Demo.

IMPORTANT TO HAVE MANY IDEAS

CLIMIT wants to mature a broader spectrum of ideas within capture, transport and storage and for these ideas to be developed into pilot and demo projects more quickly. It is important to link the industry to the research projects, to make sure there is a demanding customer and to highlight the industry's needs.

The CLIMIT secretariat has chosen a proactive role in its focus on innovation and idea development. This includes reaching out to both new and familiar CLIMIT players. It is important for CLIMIT to maintain close contact with the players so we can learn how to help facilitate cooperation venues and the possibility of establishing new networks among the players.

CLIMIT R&D - NEW CALL FOR PROPOSALS SPRING 2014

In the spring of 2014, CLIMIT R&D will announce a new call for proposals called "New concepts" directed at CO_2 capture. The call for proposals takes a basis in research projects with 100 per cent financing from CLIMIT R&D. Emphasis will be placed on new criteria such as "Newsworthy", "Potential" and "Risk handling" during evaluation to promote ground-breaking ideas.

"It will be exciting to see whether the new call for proposals in CLIMIT R&D can promote entirely new, ground-breaking solutions," says Åse Slagtern.

CLIMIT DEMO - IDEA DEVELOPMENT SUPPORT

In CLIMIT Demo, we have chosen to focus on the processes that precede the normal applications, i.e. promoting idea generation amongst the players, as well as giving them an opportunity to assess whether there is a basis for continuing the idea.

The funds for idea development are mainly intended to be used to carry out the necessary preliminary studies to consider whether to develop the idea. Part of this involves finding the right partners. It has emerged that several projects are now spending more time finding the right industrial partners, and the support could be an important contribution in this regard to help establish the necessary contact with industrial partners and international environments.

In the autumn of 2013, we earmarked NOK 1 million for this purpose, limited upwards to NOK 200 000 per idea development. There was a good response to the call for proposals, and we received seven applications over the course of the five months the call ran for. One of these came from an environment which has not previously applied to CLIMIT for support," says Jørild Svalestuen.

This has been so successful that we are now continuing the trial scheme until the end of the year - increasing the investment to NOK 5 million. This scheme is primarily intended for CLIMIT Demo, but could also help promote new ideas that are more suitable within R&D in an earlier phase.

Senior adviser Jørild Svalestuen, Gassnova
and special adviser Åse Slagtern, The Research Council of Norway

SOLVit in final phase:

Crucial that development projects also come to Norway

Aker Solutions' mobile test facility (MTU) has been an important step in the SOLVit programme. The photo shows testing at Mongstad.

"The goal of the seven-year long SOLVit research project is developing better chemicals and processes for CO_2 capture in flue gas from fossil power plants and the processing industry. SOLVit is among the largest R&D projects in Europe, with a total budget framework of NOK 332 million. The project has contributed significant expertise within CCS in Norway. We are now in the final, concluding phase of the programme, which wraps up in 2015," says technical director Oscar Graff in Aker Solutions.

Aker Solutions work will now include the findings made through the project's earlier phases. For example, the uncertainty that arose regarding carbon capture with the amine technology associated with health and emissions, was resolved through increased knowledge and emission reductions.

CONFIRMS THE RESULTS

"We are checking the optimal fluid mixture for various systems and determining the performance for various types of flue gas," says Oscar Graff. As regards the environment we have delivered; with low degradation, "green" chemicals and low CO_2 emissions, which is e.g. demonstrated in our mobile test facility (MTU).

The basis for the SOLVit programme has been that CO_2 capture with amine technology is energy-intensive. The primary goal has therefore been to halve energy consumption. Through the test facility at the CO_2 Technology Centre Mongstad, MTU and the new pilot facility at Tiller, Aker Solutions have demonstrated considerable reduction in energy consumption.

COOPERATION PROJECTS

The CO_2 capture technology research and development programme is headed by Aker Solutions, along with the leading research environments SINTEF and NTNU in Trondheim.

In the programme, SINTEF has been an important collaborator with extensive testing at their laboratories, and the test facility at Tiller was built as part of the SOLVit programme.

Through NTNU, with support from the Research Council of Norway, we have established basic research and a more long-term perspective through theoretical analyses. In total, five doctoral students are working on the project. The most promising ideas are studied further in SOLVit.

"In a project like this, it is important to also secure industrial partners, as a guarantee that customers and end-users are interested. In the third and current phase, the German power company EnBW (Energie Baden-Württemberg AG) is a partner," says Oscar Graff.

AFTER MONGSTAD

"Following the decision to terminate the full-scale facility at Mongstad, we see a complex market. Several of the planned projects have been cancelled. However, there are positive developments in amine-based capture technology. SaskPower is completing a full-scale capture facility in Canada and FEED was started at Peterhead in the UK, both based on amine. "This shows that are others who have faith in the technology," says Oscar Graff.

Norway has invested approx. NOK 8.5 billion on developing capture technology. Now we need to start using it. Application is the key to further advances. More development projects are crucial for CO_2 capture and storage in Europe.

CLIMIT IMPORTANT

"Norway has done a lot of things right when it comes to R&D, both as regards education and other expertise development. We have established research programmes, pilots and the technology centre at Mongstad. There has been a high activity level within both research and industry, but this expertise could easily fade without projects. Therefore, application is the only way to succeed," finial comments from Oscar Graff.

Technical director Oscar Graff, Aker Solutions

Capture project in Brevik:

We share results with everyone!

The three cleaning technologies that will be tested at Norcem in Brevik will be in place over the course of April. They will be tested on the same flue gas. The fourth will be tested in Germany. At the beginning of next year, Norcem will know more about which of the four tested technologies was the best.

Project manager Liv-Margrethe Hatlevik Bjerge at Norcem in Brevik is facing exciting times. She is crystal clear in her belief that, regardless of method, CO_2 capture is necessary in order to realise the company's zero vision: no CO_2 emissions through the products' lifetime by 2030. Two-thirds of the CO_2 emissions come from the raw material in the cement production, limestone.

FOUR DIFFERENT TECHNOLOGIES

Most of the infrastructure that needs to be in place to start testing the two first technologies, is now in place, and tests will start at the beginning of March. They are both in early development phases:

Membrane technology will be tested in small-scale infrastructure and delivered by DNV BG, NTNU and Yodfat Engineers.

Solid absorption technology will also be tested in small-scale infrastructure and delivered by RTI, US.

Amine technology is delivered by Aker Solutions. The test unit is currently at Mongstad and will arrive at Brevik at the end of March. This is first-generation capture technology.

Calcium cycle is the fourth technology. It is delivered by Alstom Power and is considered second-generation technology. These tests will be conducted at a test facility at the University of Stuttgart in Germany.

ZERO VISION

"I am absolutely certain we will achieve it. The question is - with what effect and at what cost? We would need an additional power plant to capture 100 per cent. Using waste heat from production, we can make 24 megawatt of energy available. Current calculations indicate a reduction of 30-40 per cent CO_2, corresponding to 300 000-400 000 tonnes."

In order to realise our zero vision in HeidelbergCement Northern Europe, we need to utilise more tools: energy efficiency, increased use of biofuels, reducing the "clinker percentage" in cement (crushing process), and the cement products also absorb CO_2. And finally, CO_2 capture is necessary in order to achieve the goal. However, we can promise to maintain full focus on the entire "tool box", according to the project manager.

THE CEMENT INDUSTRY

"This is an international project where one of the partners is the European cement organisation; ECRA (European Cement Research Academy). We are concerned with disseminating information and sharing the results with the entire industry. The project has also garnered interest outside Europe," says Hatlevik Bjerge.

Globally, the cement industry is responsible for about 5-6 per cent of overall CO_2 emissions, while Norway has a percentage of 2.6. Success in this effort is therefore important.

IMPORTANT PRECONDITIONS

"Over the course of 2014 and 2015, we will reach important milestones in the project and gain new knowledge. Over the first half of 2015, we expect to be able to evaluate what we believe can be achieved with regard to capture of flue gas from the cement industry. However, capture is only the first step in the chain that needs to be in place," says Hatlevik Bjerge.

"It is important to get players in place for all steps," says the project manager at Norcem in Brevik. Infrastructure with commercial players is required in order to handle the CO_2 being captured. Norcem is also looking at the possibilities of using CO_2 in other production and products.

"Financing also needs to be in place and public support is essential to move forward. There is no doubt that the first facilities will be expensive," says the project manager.

Project manager Liv-Margrethe Hatlevik Bjerge, Norcem

Senior adviser Svein Eggen, Gassnova

CO_2-injection project in the final phase

COMPLETE is the final stage in a German CO_2 injection project that has been ongoing in Ketzin outside Berlin since 2009. The project is headed by the German national geological research centre (GFZ).

"CLIMIT supports the project through Norwegian participation from SINTEF. In the work now being carried out, we will acquire valuable knowledge concerning what happens during the shutdown phase of an injection project, and the programme also includes subsequent monitoring," says geologist Svein Eggen in Gassnova.

GROUND-BREAKING

The project was started by German GFZ in 2004. Injection of CO_2 in wells at the pilot facility in Ketzin started five years later. For the very first time, a project will observe and map what takes place during the shutdown phase and after the pilot project is completed.

"This is the first time we will learn about the entire life cycle of a CO_2 storage project in pilot scale, preparation – injection – completion and follow-up," says Svein Eggen. International cooperation gives us access to CO_2 injection projects where we can acquire new knowledge and confirm theoretical models.

COMPETENT NORWEGIAN ENVIRONMENTS

Following initial contact with GFZ, a general cooperation agreement was signed between GFZ and CLIMIT in 2012. The agreement was made more specific through the intention to cooperate on the COMPLETE project. In the autumn of 2013, CLIMIT announced a competition among Norwegian research environments regarding participation in the project.

"Six applicants came forward, and among the four that submitted a project application following initial screening, we chose two in cooperation with GFZ, both from SINTEF Petroleum," says Eggen. The projects will run for four years and will focus on how to depict distribution of CO_2 in the reservoir, as well as insight into well integrity, how CO_2 reacts with metal, various types of rock and well cement, which will help provide stability over time.

GLOBAL PROBLEM

"A global problem can only be solved through broad-based international cooperation. That is why we are concerned with connecting Norwegian research and industrial environments to relevant international projects. And it is nice to see that our technical and research environments in Norway are recognised in this area," says Eggen.

CO_2 storage is essential in implementing CCS and Norway has significant experience in this area which could benefit the EU.

CLIMIT has earmarked MNOK 21 for the 2013-2018 period as support for Norwegian participation in the COMPLETE project.

Unique data available in the **COMPLETE project**

"Through the COMPLETE project and cooperation with the German national geological research centre (GFZ) we receive valuable knowledge and access to data from pre-injection to the shutdown phase in a storage project, which we would otherwise not have received," says head of research at SINTEF Petroleum, Menno Dillen.

The two projects SINTEF will work on in connection with CO_2storage technology are related to monitoring and well technology.

MONITORING AND WELL INTEGRITY

"We use different geophysical data from the storage pilot in Ketzin to gain greater insight into how CO_2 behaves when it is injected underground and a better understanding of, for example, the geology in the storage areas. CO_2 storage takes place in a very long-term perspective, for hundreds and thousands of years," says Menno Dillen.

"Within the well integrity area we receive important data from GFZ with material from the location which we subject to further laboratory analysis. We will e.g. get material from cement, obtained when the well was drilled and before CO_2 was injected, and correspondingly after two years of injection. This will give us a unique basis of comparison and allow us to see the impact the CO_2 injection has had on the material in the well," says the head of research.

UNIQUE

From the US, there are examples of this with data on the impact on cement after a well. is shut down. However, there is no data from before injection started. It is therefore unique that we are now gaining access to both "before and after" data.

"We have had good contact with GFZ through several years, and the knowledge we are now gaining by participating in the COMPLETE project allows us in SINTEF to take the technology further," says Dillen.

"In this connection, we are very pleased that CLIMIT is giving us this opportunity. CLIMIT plays a significant role as facilitator and it is important that we can participate in international cooperation on tasks that bring us further," says Menno Dillen.

Head of research Menno Dillen, SINTEF Petroleum

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