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CONTENTS

THE CLIMIT PROGRAMME	3
STRATEGIC FOCUS IN THREE AREAS	4
HIGHLIGHTS IN 2012	6
CLIMIT – KEY NATIONAL AND GLOBAL PLAYER	8
COLLABORATIVE ARENAS ARE IMPORTANT	12
LONG WAY FROM START TO FINISH	14
PROGRAMME BOARD	16
KEY FIGURES	20
STATE IMPETUS IMPORTANT TO MAINTAIN MOTIVATION!	22
CO ₂ CAPTURE PROJECT IN A LEAGUE OF ITS OWN AT NORCEM	24
HEALTH AND ENVIRONMENTAL EFFECTS IN CONNECTION WITH AMINE-BASED CO ₂ CAPTURE	26

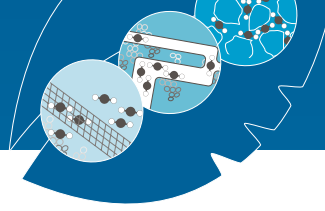
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PHOTO

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IRIS: Page 12



THE CLIMIT PROGRAMME



CLIMIT is the Norwegian national programme for research, development and demonstration of technologies for carbon capture and storage (CCS).

CLIMIT'S VISION IS TO:

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

The Ministry of Petroleum and Energy established CLIMIT in 2005 to support development of CCS technology for gas power plants. The programme was expanded to cover power production based on all fossil fuels in 2008, with a further expansion to include industrial emissions in 2010.

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 overall responsibility and heads the programme secretariat.

STRATEGIC FOCUS IN THREE AREAS



Kjell Bendiksen, chair of the Programme Board.

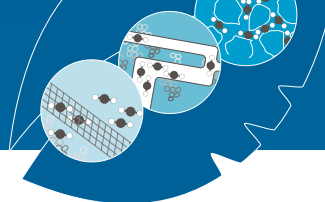
From the perspective of the Programme Board, CLIMIT's new strategy is an important milestone. It came into place in 2012 following a comprehensive process, based in part on a thorough evaluation of the programme by Oxford Research.

The chair of CLIMIT's Programme Board, Kjell Bendiksen (Institute for Energy Technology, IFE), states that a solid foundation for further work and prioritisation has been established. The strategy highlights three focus areas for CLIMIT towards 2020: new innovative solutions that can yield considerable cost reductions and increased safety, areas where Norway or Norwegian players may have special advantages and CCS from major point sources in Norwegian industry.

ENCOURAGING INDUSTRY PROJECT

In 2012, CLIMIT granted support to a major CO₂ capture project from land-based industry for the very first time, to Norcem in Brevik. The company plans to build a test facility for several different capture technologies for CO₂ emissions from cement production.

"This is actually a global pioneer project and a good example of our strategic focus on CCS from industrial emissions. If Norcem succeeds, this could be significant for the cement industry in Europe. Both Norwegian and international partners will participate in this work. The project could open new markets, both domestic and international – and could represent the start of an international success!"



MORE APPLICATIONS

The competition for funds has increased; seven out of ten applications submitted to CLIMIT R&D were rejected in 2012. Applications were submitted for about NOK 335 million in support from CLIMIT R&D, but the budget only allowed the award of NOK 70 million. These projects are vital and provide concrete results.

Bendiksen also emphasises the value of the fact that, last year, a whopping 36 doctoral students were associated with the research projects. "Just think about the expertise being built up and transferred to industry and businesses from this programme," he says.

"It is a shame that so many excellent applications, which people have worked hard and long on, have to be rejected because there simply aren't enough funds to cover it all," says the chair of the programme board. This will be particularly challenging in the future, as certain projects in CLIMIT Demo are applying for very large support amounts, almost the entire annual budget for CLIMIT Demo, approx. NOK 80 million.

"This does not provide room for many new upcoming projects. The supply of funding is declining while demand is growing. The authorities should do something about this," says Bendiksen.

THE THREE STRATEGIC PATHS

As mentioned, CLIMIT's strategy up to 2020 has three focus areas:

Innovative solutions

New innovative solutions that can yield considerable cost reductions and increased safety. One of the major challenges within CCS is that the processes are energy-intensive and require additional costs that are too high. CLIMIT will therefore prioritise next generation technologies in the future.

Norwegian advantages

To increase the possibility of success in a future CO₂ market, CLIMIT will prioritise areas where Norway or Norwegian players have particular advantages.

CCS in Norwegian industry

Most Norwegian CO₂ emissions come from outside the power sector, from petroleum activities, industry and transport. Unlike the rest of the world, our power supply is almost entirely based on renewable energy. Hydropower represents more than 95% of production in normal years, and the rest comes from gas and wind power. However, we have major CO₂ emissions from industrial sources, where we could both have a future domestic market for CCS and good opportunities for exporting expertise and technology in a growing global market.

EXPECTATIONS

"In the beginning, CLIMIT largely focused on CO₂ capture. Storage eventually became part of the agenda. The Longyearbyen CO₂ lab on Svalbard and the field laboratory in Svelvik are good examples of important storage projects. Today we have a reasonably good balance between capture and storage projects," says Kjell Bendiksen.

"I look forward to the success of the Norcem project in Brevik and to more industry projects. I expect that the grant budget will increase, so we are able to finance larger, promising projects in the future."

The international perspective is very important for developing good CO₂ capture and storage solutions, and not least, for putting them to use. CLIMIT therefore encourages applicants to consider international and multidisciplinary cooperation," says Programme Board chair Kjell Bendiksen.

HIGHLIGHTS IN 2012

CLIMIT contributes to commercialisation of CCS technologies.

The projects in CLIMIT's portfolio provide significant contributions to this through:

- New knowledge about the next generation of capture technology
- Improved understanding of how CO₂ can be transported
- Increased knowledge of how stored CO₂ flows and reacts

SUBSTANTIAL AMOUNTS

In 2012, the CLIMIT programme granted NOK 159.2 million in support for various projects and institutional support. NOK 58 million was disbursed through CLIMIT Demo and NOK 101.2 million through CLIMIT R&D.

CLIMIT Demo funding awards in 2012 reached a record level of NOK 165.9 million, of which 49.3% went to capture projects, 29% to storage projects, 1.5% to projects within value chains, 3.8% for projects within transport and 16.5% to other projects.

The technical activity within CLIMIT R&D is evenly distributed between capture and storage of CO₂, as well as a small percentage of projects within CO₂ transport.

This is a balanced distribution which reflects the key technical challenges. CLIMIT R&D's portfolio contains many research and expertise projects, but few innovation projects. This is a result of low industrial activity within CCS, as well as the fact that Gassnova covers the industrial development through the CLIMIT Demo programme.

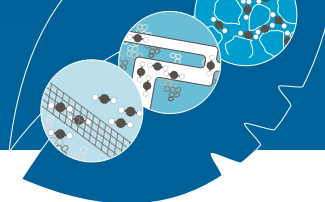
MARKET CHALLENGES

The capture and storage areas face comparable technical challenges. Certain R&D gaps also remain within CO₂ transport.

The main technical challenges are development of more cost-efficient technology for CO₂ capture and better understanding of COs behaviour in geological storage.

Within CO₂ capture, CLIMIT contributes to research in next generation technologies. There is a focus on developing new, innovative and more efficient capture technologies with the potential for lower costs and less energy consumption.

We believe that in the long term, e.g. from around 2030, several of these technologies could be developed into the next generation of commercial capture technologies. This is vital to ensure global deployment of CCS.



TECHNICAL CHALLENGES

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THE GOOD EXAMPLES

The Sleipner and Snøhvit projects illustrate that CO₂ storage is possible. However, the challenges in the Snøhvit project also indicate a major need for improved knowledge about CO₂ storage sites.

Storage projects supported by CLIMIT provide increased insight into geological, chemical and physical processes. This provides us with ever better CO₂ storage models, which will give researchers and industry the expertise needed to make the right choices as regards storage sites and effective CO₂ storage. Several projects are also developing technology to monitor CO₂ storage sites with a view to documenting storage safety.

The programme also supports projects within CO₂ transport that focus on improved understanding of how CO₂ can be transported by pipeline with minimal risk. This will provide us with important knowledge which ensures safe CO₂ transport.

CLIMIT

– KEY NATIONAL AND GLOBAL PLAYER

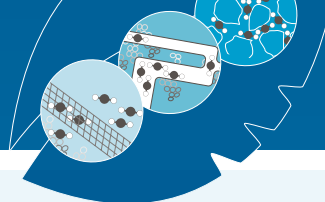
CLIMIT organised several workshops and cooperation meetings in 2012. Top experts from Norway and abroad have been invited to discuss core topics. Representatives from CLIMIT have also actively participated at key national and international events.

CLIMIT WORKSHOPS

During autumn 2012, CLIMIT organised a TCM workshop with participation from industry, research communities and universities to discuss the CO₂ Technology Centre Mongstad (TCM) as an important learning arena. The results from the group work have e.g. been included in CLIMIT's new action plan for 2013.

CENTRAL STORAGE INITIATIVE

A series of meetings and workshops have been held with the FMEs (Centres for environment-friendly energy research), as well as other R&D environments within CO₂ storage to discuss a more focused and unifying approach within CO₂ storage. Following this introductory work, CLIMIT tasked the key R&D players with assessing the geoscience and technological gaps in relation to implementing a central storage facility on the Norwegian shelf within a given timeframe.



SCOTTISH COOPERATION

In March 2012, a workshop organised by CLIMIT was held in Edinburgh to promote cooperation between Norwegian and Scottish research communities within CO₂ storage.

Areas of common interest:

- ✎ Mapping of geology in the North Sea
- ✎ A joint project for mapping potential test drilling areas
- ✎ A joint programme for analysis of potential storage projects
- ✎ Cooperation within CO₂ storage modelling
- ✎ Possible cooperation on applications for Horizon 2020
- ✎ Possible cooperation with the central storage project

GERMAN COOPERATION

Since 2009, CLIMIT has cooperated with Geoforschungszentrum in Germany on a storage pilot project in Ketzin. CLIMIT has provided funding for Norwegian players to participate in the next phase of the Ketzin project.

COOPERATION WITH THE US

CLIMIT participated in a bilateral workshop last August with the US Department of Energy (DoE) and the Norwegian Ministry of Petroleum and Energy with the aim of strengthening cooperation on CO₂ capture and storage. Based on recommendations from the meeting, concrete plans have been made with regard to cooperation in 2013.

IEA'S SUMMER SCHOOL

The International Energy Agency's (IEA's) greenhouse gas research and development programme (IEAGHG) held its summer school at the Tsinghua University in Beijing, China in August. CLIMIT staff participated as lecturers and advisers for the students.

IEA GHGT-11

The IEA's Greenhouse Gas Technologies conference (GHGT-11) took place last November in Kyoto, Japan. The CLIMIT secretariat presented a poster about the CLIMIT strategy work, and a presentation showcasing the work on amines and the environment that has been supported or initiated by CLIMIT, the CO₂ Technology Centre Mongstad (TCM) and Full-Scale CO₂ Capture Mongstad (CCM).

Of the 300 presentations held during the conference, a total of 30 were Norwegian, most of which are funded by CLIMIT.

RESEARCH HUBS

Cooperation is important in research and development activities. This helps ensure that research activities are relevant to TCM and the project for full-scale CCS at Mongstad.

The CLIMIT secretariat holds positions in several important 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 European Industrial Initiative on CCS (EII CCS)

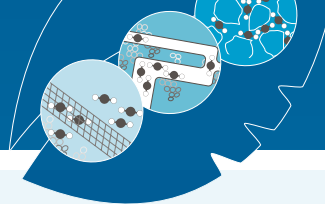
- Member of Government Group in the EU's technology platform ZEP (Zero Emission Fossil Fuels Power Plants)
- Member of ZEP task force on Policy and Regulations and ZEP task force on Technology
- Global CCS Institute
- Head of FENCO NET (European network of public authorities that finance R&D within CCS)
- Member of the CCS group in the Nordic Top-Level Research Initiative (TFI)
- Representative in the programme committee for the Nordic Top-Level Research Initiative (TFI)
- Member of the board for Energi 21
- Ministry of Trade and Industry's (NHD's) council on environmental technology

DOCTORAL STUDENTS

The interest in taking a doctorate within CCS has never been greater among students.

CLIMIT R&D organises an annual seminar for doctoral students (PhDs) in the programme. About 25 PhD candidates participated at this year's seminar. The seminar focused on the skills of the students in communication of R&D results.

Researchers play an important role in reducing the costs of capture, transport and storage of CO₂ down to a level which makes it more attractive for the industry to capture CO₂ than to release it into the atmosphere. They should also use the institutes' communications departments to spread information about



the technology to politicians, the media and the general public. Political decisions and widespread support from grassroots movements are decisive in order for CCS to succeed.

This was CLIMIT's third PhD seminar. The majority of the conference was spent on mutual information on projects and the status within capture, transport and storage of carbon dioxide, as well as external presentations on communication and perspectives from a research centre. There was also a presentation from a major industry player with needs and activities within CCS, which was greatly appreciated by the participants.

RESEARCH INFRASTRUCTURE

A prioritised topic in both Norway and the EU is development of research infrastructure for CCS. This will be carried out in the ECCSEL project headed by Norwegian University of Science and Technology (NTNU). This is a joint European project under the EU's ESFRI programme with the objective of developing joint European research infrastructure. CLIMIT follow-up this project very closely to ensure good national coordination, and that the infrastructure planned in ECCSEL corresponds with CLIMIT's strategy.

COORDINATION

A start-up meeting for new projects and a workshop have also been organised to coordinate Norwegian players in the application process for the EU's framework programme, the European Commission's seventh framework programme for research (FP7). This helps motivate researchers that will in turn provide more targeted efforts to reaching the programme's goals.

This also forms a sound basis for good applications for FP7.

CLIMIT follows up two Norwegian research centres in CCS called BIGCCS and SUCCESS. This ensures good coordination between projects supported by CLIMIT and the R&D activities in the two centres. The CLIMIT administration also follows up infrastructure grants directed at CCS.



RESEARCH DIRECTOR KRISTIN FLORNES, IRIS:

“COLLABORATIVE ARENAS ARE IMPORTANT”

The International Research Institute of Stavanger (IRIS) has projects ranging across the entire value chain from realisation of CO₂ storage sites, use of CO₂ injection for improved oil recovery and environmental aspects of CCS. The research institute is engaged in several projects supported by CLIMIT.

“One of our projects involves developing software together with SINTEF ICT, Uni CIPR, the University of Bergen and University of Stuttgart,” says research director Kristin Flornes, from IRIS’ reservoir group. The project is called “Numeric CO₂ laboratory”, and we are making a simulation tool for injection and storage of CO₂. The project also receives support from Statoil.”

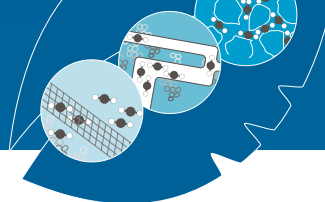
“We hope to continue the work in a project where we combine enhanced oil recovery (EOR) with CO₂ storage. Simulations will identify the best strategies in order to achieve both storage and improved recovery. In addition to industry partners, the International Energy Agency (IEA) has been asked to act as an adviser to the project.”

PORE-SCALE PROJECT

“The pore-scale project investigates how CO₂ is stored in rocks. We do this by studying phenomena on a very small scale (pore-scale). When we study distribution of liquid in the pores of the rock, we can determine how much CO₂ contributes to release oil and how well CO₂ can be stored in the rocks,” says Kristin Flornes.

We also study whether CO₂ emissions from the seabed and subsequent acidification can disturb the ecosystem and the behaviour of invertebrate benthos. Among other things, we have studied green crab, ocean quahog and prawns. The initial results indicate that the benthos react to low pH values. The project also investigates the limit at which changed behaviour occurs. This is a collaborative project with UK and German research communities.

There is little previous research in this area. Studies of environmental effects are important when storing large volumes of CO₂ under the seabed. Establishing projects that look at environmental effects is therefore some of the most important work IRIS has achieved within CCS.



INTERNATIONAL

“Through CLIMIT we also receive support to participate in international cooperation and information exchange. This e.g. relates to the European Energy Research Alliance (EERA), a research alliance where we participate in the joint CCS programme. We also gain access to extensive knowledge through this network.”

CO₂GeoNet, a European network of excellence, was initially a project under the EU's sixth framework programme, but was established as an association under French law in 2009 with NIVA, IRIS and SINTEF as partners from Norway. IRIS will head the board in CO₂GeoNet for the next two years. We also participate in a European cooperation project, CGS-Europe, under the EU's seventh framework programme with 34 participants from 28 countries.

Through EEA (the European Economic Area), Norway has allocated research funds for nations with weaker economies, and we have taken part in projects or are planning projects in countries such as the Czech Republic, Estonia, Poland and Hungary.

CHALLENGES AHEAD

“IRIS will continue to conduct research on the environmental effects of CO₂ emissions. Our goal is to increase the knowledge about effects on the marine environment and contribute to development of methods to monitor the marine environment. It is important to establish knowledge about this so we can operate within safe boundaries,” says the research director.

We could also mention that IRIS-Biomiljø is developing a seabed infrastructure that can be used to study CO₂ storage (detection of CO₂ leakage, understanding environmental impact and monitoring technology based on biosensors). IRIS has developed the first operational biological sensor that provides direct information on how environmental

changes impact mussels. The technology is being commercialised by IRIS' subsidiary Biota Guard AS.

We also make active contributions together with FME SUCCESS (Norwegian research centre in CCS) and CLIMIT to realise the vision of a central storage facility for CO₂ on the Norwegian shelf. Further development of simulation tools, sound well solutions and an improved understanding of what happens when we inject CO₂ is necessary to realise such a store.

LONG-TERM

“A long-term perspective is important to find good answers to difficult challenges. This also characterises many of our projects. They also provide valuable lessons for IRIS.”

Kristin Flornes is excited that the European Association of Geoscientists & Engineers (EAGE) will hold next year's CO₂ workshop on geological storage in Stavanger. This is a vote of confidence to the Norwegian research communities.

IMPORTANT COLLABORATIVE ARENA

“Cooperation is important to achieve nationwide improvement in this area. CLIMIT provides guidelines that promote openness, mutual respect and trust in the research communities involved in this work.”

This contributes to the establishment of valuable networks and arenas for national and international collaboration through the numerous initiatives.



LONG WAY FROM START TO FINISH

There is widespread agreement that the research work on CO₂ capture and storage is important, but there is also frustration about the political world that, in global terms, is unable to agree on concrete goals. We know a lot about what we need to do, but can see that things get bogged down. The industry has also, to a considerable extent, adopted a wait and see attitude.

The manager of the Institute for Energy Technology's (IFE's) CO₂ Centre, research director Harald Johansen, expresses some of the frustration the research communities feel due to a lack of binding international agreements to bring about sufficient reductions in greenhouse gas emissions.

SUCCESS

Harald Johansen from IFE is also a key part of FME SUCCESS. This is a Norwegian research centre that works on CO₂ questions related to storage.

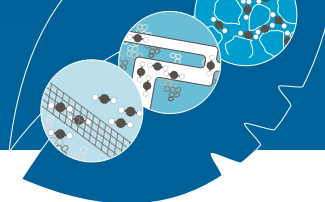
"There is a long way from start to finish in the type of projects we work with. In the end, results must be reported. The conclusion frequently involves a need to keep going and close knowledge gaps in important areas. We have a long way to go," says the research director.

CO₂ capture and storage has been an important discipline for about a decade, and really took off after the Norwegian Government declaration in 2005. IFE started its integrated activity in the field at the same time, even though most issues have been on the agenda for several decades.

BACKDROP

The background for the focus from IFE and other research communities is obvious. The climate challenge is one of the most important we will face in this century. Solving it will require development and application of CO₂ capture and storage technology.

"The research provides results in the form of new knowledge, patents and laboratory development, to mention just a few. While in the past capture received the greatest focus, there is now a greater push for CO₂ storage," says Harald Johansen.



The North Sea could become a CO₂ storage area (NPD's FactMaps on Googlemaps)

In this field we have knowledge and experience from drilling and recovery of oil and gas, but there is still a considerable lack of actual knowledge about storing CO₂ in the subsurface. This knowledge is necessary if we are to reach the goals for annual deposition.

INTERNATIONAL COOPERATION

"The climate challenge is global, and international cooperation is both natural and necessary," says the research director. We cooperate with expert environments in countries including the US, Canada, the UK and Germany. At the same time, we have companies such as Statoil, Lundin and Store Norske on the sponsor and network side.

Cooperation with the UK follows naturally since we share a border in the North Sea. The best storage possibilities may lie across the border!

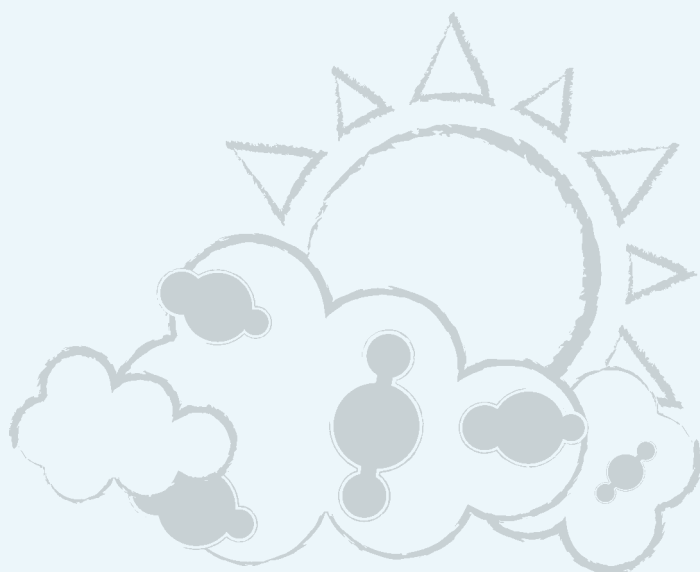
"We have a broad-based international network where IFE has been assigned a key role. The application of CCS will be different and adapted to the various needs and conditions found in the US, China and India, to mention some".

IMPORTANT INTERACTION

"The establishment of Gassnova and CLIMIT has been very important. This particularly applies to the people working there. They have been insightful and easy to cooperate with in the dialogue regarding progressing projects and developing new ones."

The interaction between the research communities, industry and CLIMIT is important for prioritisations and future commercialisation. The pilot storage project in Longyearbyen on Svalbard and the pilot capture project at Norcem in Brevik are good examples of this, excellent arenas to develop and practice knowledge.

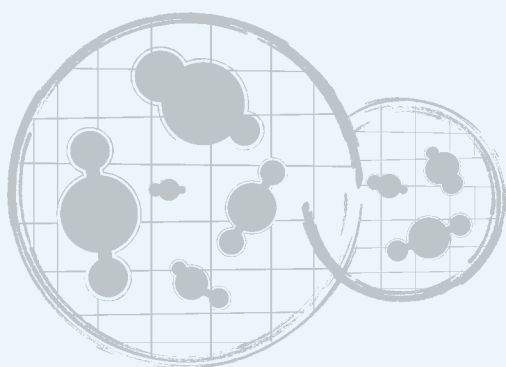
"It is important that we have visions and projects that point the way for coming years. We need to find mechanisms from our research that result in decisions that are necessary for actually making progress. This might be the biggest shared challenge we face," says research director Harald Johansen.



PROGRAMME BOARD

- NEW STRATEGY AND PROGRAMME PLAN 2012-2020

CLIMIT carried out a strategy process in 2012 to meet market development. Technological innovations in projects supported by CLIMIT will hopefully push market development in coming years.



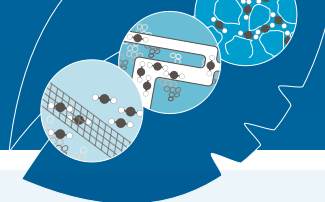
PROGRAMME BOARD 2012

In 2012, the programme board was composed of the following members:

- Kjell Bendiksen, IFE – chair
- Marit Larsen, Tel-Tek – vice-chair
- Olav Kårstad, Statoil
- Randi Viksund, Gassco
- Marianne Holmen, Statkraft
- Niels Peter Christensen, Vattenfall – *resigned March 2012*
- Nils Røkke, Sintef
- Guttorm Alendal, University of Bergen
- Kristin M. Flornes, IRIS
- Jürgen Mienert, University of Tromsø

Ingar Steinsvik represents the Ministry of Petroleum and Energy (MPE) as an observer on the programme board.

There were six programme board meetings in 2012.



NEW STRATEGY PLAN 2012-2020

CLIMIT's long-term goal is to contribute to significant reduction in CCS costs. This requires new research to provide fundamental insight into and testing of processes in small pilots and in broad-based cooperation with industrial players who find investments in such solutions profitable.

The strategy highlights areas with commercial potential:

- Oil and gas industry as driver for CCS
- Need for own CCS in industry
- Norwegian technology suppliers that can create new and competitive solutions
- Innovation through cooperation and a multidisciplinary approach
- Established infrastructure and innovation arenas
- Opportunities in relation to pre-commercial demonstration facilities

A weak market and lack of "demanding customers" constitutes an "incentives gap" which entails a risk of not reaching political ambitions. To help fill parts of this gap, the strategy points to the need for more powerful policy instruments and a more clear indication of future development needs within the area. CLIMIT will emphasise innovation in a broad technology portfolio to contribute to reduced costs over time. The strategy indicates that research is a continuous and underlying activity to achieve fundamental insight into the processes, to increase overall safety and contribute to cutting-edge technologies.



During the strategy period, CLIMIT will contribute to:

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

Projects supported by CLIMIT will contribute to:

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

CLIMIT'S NEW PROGRAMME PLAN (2013-2020)

The programme plan is directed at the applicants to the CLIMIT programme so they can easily identify the areas prioritised by CLIMIT. The programme plan will also form the basis for upcoming calls for proposals and announcements in the programme.

The programme plan identifies three strategic focus areas and CLIMIT will prioritise projects within these areas:

- New innovative solutions that can yield considerable cost reductions and increased safety
- Areas where Norway or Norwegian players have advantages in CCS
- CCS in Norwegian industry for major CO₂ point sources

The programme plan also provides an overview of strategic prioritisations within the areas of capture, transport, storage and the environment.

There are currently no clear technology winners within the capture area. CLIMIT will emphasise innovation in a broad technology portfolio to contribute to reduced costs over time.

Pilots are necessary within transport and storage to demonstrate safe handling and storage.

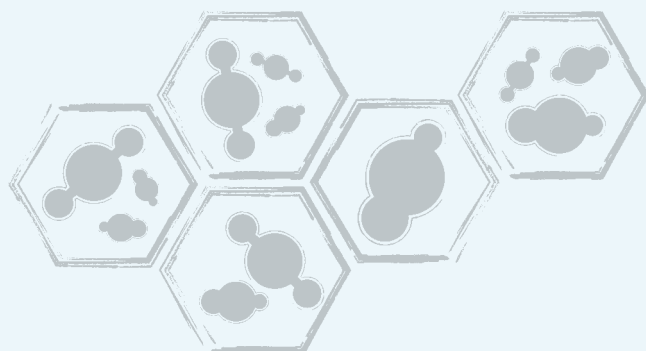
The strategy was approved by the programme board in April 2012 (Item 29/12) and stipulates guidelines for a detailed programme plan and action plan for the programme.

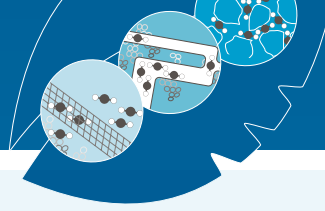
SUMMARY OF THE MOST IMPORTANT PROJECT RESULTS

The technological challenges related to CCS are mainly development of cheaper and more effective CO₂ capture technology, as well as increasing our expertise on how CO₂ flows and reacts in a CO₂ storage site.

The projects in CLIMIT's portfolio help address these challenges. Even though no revolutionary innovations were made in the past year, the projects make continuous contributions with gradual improvements. Within capture, work is ongoing on new innovative solutions with the potential for lower costs and less energy consumption. Considerable fundamental research is also underway on several concepts to increase knowledge and expertise, as well as to close technological gaps.

The on-going industrial projects at Sleipner and Snøhvit have proven that CO₂ transport and storage are feasible. However, the Snøhvit project also shows that there are considerable knowledge gaps. The CLIMIT projects continuously generate new knowledge, and the researchers are delving steadily deeper into the details to understand more about geomechanics and geochemistry related to CO₂ storage. New technology is also being developed to monitor CO₂ storage, which is very important in order to document storage safety.





THE PROGRAMME BOARD

From left to right:

Kim Dam-Johansen
Kjell Bendiksen (Chair)
Per Reidar Ørke
Marianne Holmen
Olav Kårstad
Eva Halland
Nils Røkke
Per Aagaard

Not present:

Anita Utseth
Elisabeth Rose
Ingar Steinsvik (Observer)
Klaus Schöffel (Head of CLIMIT secretariat)

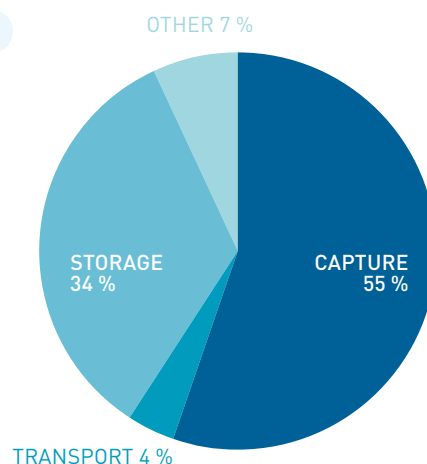
KEY FIGURES

CLIMIT must have a diverse project portfolio within:

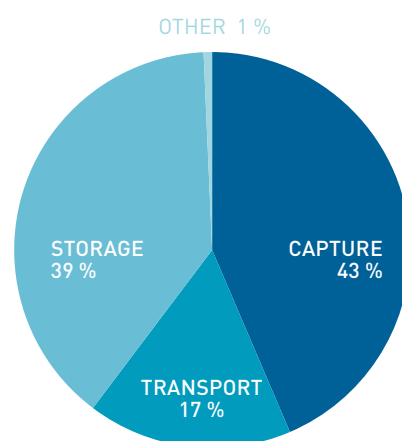
- Technology areas (capture, transport, storage)
- The development chain (research, development and demonstration)

The diagrams show good balance 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.

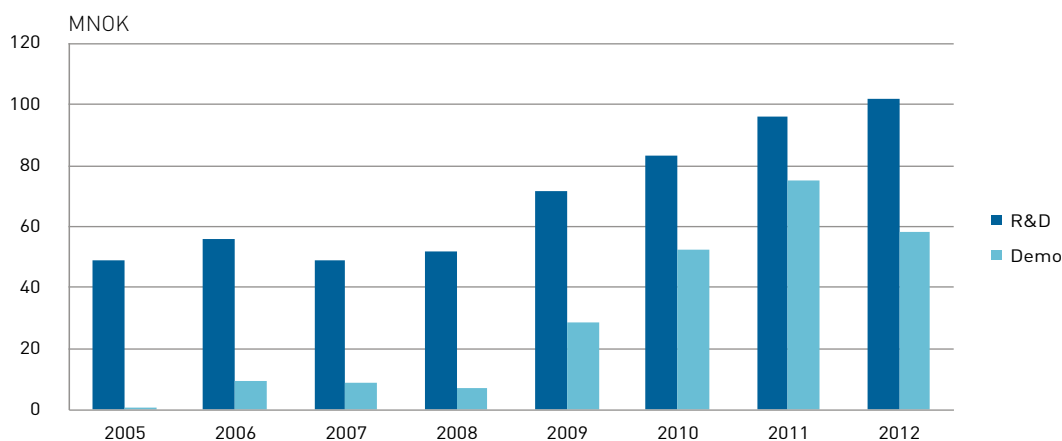
The diagrams for the programme's distribution along the development chain show that, within CLIMIT R&D, nearly 80% of the allocations in the active portfolio are related to projects where the industry is involved, while approx. 22% of the allocations in the portfolio are related to pure research projects. KPN projects (expertise projects for businesses) include both basic research and applied research, while IPN projects (innovation projects for businesses) target applied research. Within CLIMIT Demo, the projects generally fall within the "development" category.



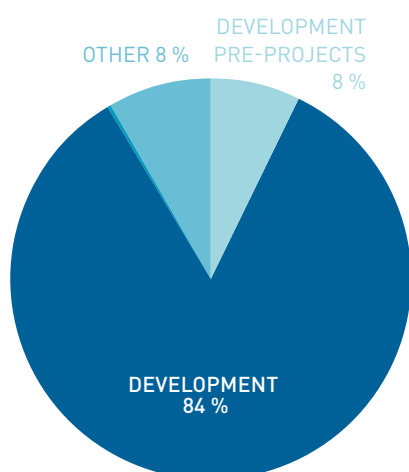
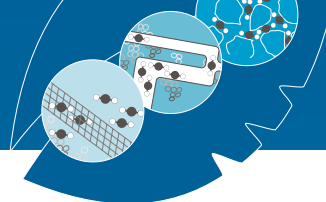
CLIMIT Demo: Distribution by area
Ongoing projects 2012, allocated



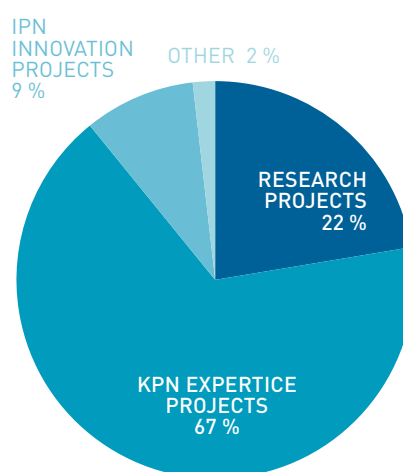
CLIMIT R&D: Distribution by area
Ongoing projects 2012, allocated



Disbursements CLIMIT.



CLIMIT Demo: Per development stage
Ongoing projects 2012, allocated



CLIMIT R&D: Per development stage
Ongoing projects 2012, allocated

Demo projects, which are projects considerably closer to commercialisation, are still comparatively rare. This is because the market is still a ways away from what could be called “commercially functioning”, as well as the fact that the support intensity offered from CLIMIT in this phase is very low (typically 25%).

Since the start of CLIMIT in 2005, disbursements have increased gradually.

Disbursements have increased for CLIMIT R&D, despite reduced budgets in 2011 and 2012. It is important to ensure a steady level of support to maintain a high level of activity. Despite the budget reductions, extensive calls for proposals were carried out both in the autumn of 2011 and 2012. 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. The disbursements in 2011 are in line with annual allocations from the MPE. The disbursements in 2012 show a minor decline from 2011, despite record funds being allocated to Demo projects. This is because several of the approved projects in 2012 have not progressed far enough to receive disbursements by the end of 2012.

The high activity level 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 utilise the entire 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 very long. Unless the market receives significant new investment signals for CCS, this trend will continue.



STATE IMPETUS IMPORTANT TO MAINTAIN MOTIVATION!

The financial crisis coupled with difficult times for the industry in large parts of the world has a negative effect on the work to develop technologies for carbon capture and storage. Low CO₂ quota prices have the same effect. Strong Norwegian political involvement through Gassnova is therefore extremely vital in pushing technology development.

The head of Alstom's CCS involvement in Norway, Arne Ellestad, works with exciting challenges for carbon capture in one of the world's leading industrial technology companies in the area. Alstom works within power production, transport infrastructure and power grids. The company is represented in nearly 100 countries and has more than 92 000 employees.

UNIQUE RESEARCH PROJECT

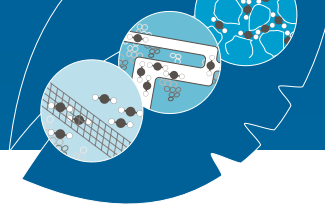
The CO₂ Technology Centre Mongstad (TCM) is the world's largest test facility for CO₂ capture technologies. TCM has two demonstration plants for two different capture technologies, and Alstom's chilled ammonia process is one of them.

"It is important that we also test in a gas-fired power plant. In order to reach the two-degree goal, we need to develop and optimise solutions for various types of power plants and for industry. The solutions must be sellable; there must be a demand for them from industry and power producers. The way it looks now, we could hope for a commercial market from around 2020," says Arne Ellestad.

IMPORTANT ROLE FOR NORWAY

"We have several new ideas – one of them is FIRCC (Fully Integrated Regenerative Calcium Cycle). The funding commitment from CLIMIT allows us to progress in the work on this promising process, which has the potential for substantially reduced energy consumption compared with the technologies available today. We will cooperate with Tel-Tek, Telemark University College, the Institute for Energy Technology (IFE), University of Zurich (ETH) and our sister company in Wiesbaden.

The work being carried out in Norway is important. We are accumulating knowledge



Alstom's facility at the CO₂ Technology Centre Mongstad (TCM).

and expertise that will contribute to future value creation.

CLIMIT also supports a project for Norcem for the cement industry, where we will participate with feasibility studies. We are also planning improvement projects for the chilled ammonia process with future utilisation of the facility at TCM in cooperation with SINTEF.

LONG EXPERIENCE

Since the 1970s, Alstom has worked on technology for SO₂ cleaning for power plants and cleaning/recovery processes for the aluminium industry, and we are currently world-leading within these technologies. The development was driven by strict environmental requirements in Norway, interested Norwegian clients and our technical expertise – these

technologies went on “conquer” the world. The conditions are right for a corresponding development for CO₂ capture technology.

THE ROAD AHEAD

“The CLIMIT projects and the full-scale facility at Mongstad (CCM) are very important to maintain the level of interest in further development on the part of technology suppliers such as Alstom. While we are waiting for a commercial CCS market, we are looking at utilisation of CO₂ for industrial purposes, for example for production of urea, methanol and improved oil recovery (IOR). This will not significantly reduce CO₂ emissions, but it will sustain technology development and expertise,” says Arne Ellestad.



EUROPE'S FIRST FOR CEMENT INDUSTRY:

CO₂ CAPTURE PROJECT IN A LEAGUE OF ITS OWN AT NORCEM

"Gassnova and the CLIMIT programme have been essential in order to get the CO₂ capture project at Norcem in Brevik started. It is the first of its kind in Europe and is planned to run for three and a half years. However, I hope that, as early as 2015, we will be able to learn more about whether this is a realistic, future-oriented solution for the cement industry."

The head of alternative fuel in Heidelberg Cement Northern Europe, Per Brevik, is enthusiastic about the carbon capture project that will soon commence at the cement factory in Brevik.

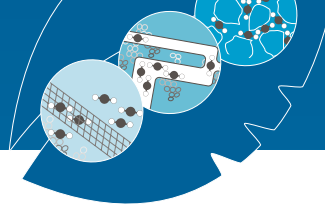
CONSIDERABLE SOURCE OF CO₂

"Globally, the cement industry is responsible for about 3-5 per cent of global CO₂ emissions. We have a responsibility to look at the possibilities of reducing our emissions," says Brevik. So far, research has focused on development of capture technology from power production based on fossil fuels.

Land-based industry is something entirely different. It is therefore ground-breaking that we can now start up a test centre for different technologies, both existing and new. The results of this project will benefit our entire industry.

MAJOR PROJECT

Per Brevik is optimistic with regard to finding answers to the technology challenges. The test facility could also support additional smaller projects. The project will benefit the entire cement industry through cooperation with the European Cement Research Academy (ECRA).



Norcem Brevik.

ENERGY EFFICIENCY

“An important factor will be how much CO₂ we can capture based on the surplus energy available at the plant in Brevik. Based on our preliminary calculations, capturing 30-40 per cent of CO₂ emissions could be possible. Increasing the capture rate to 85-90 per cent would require additional energy production. For us it will be a very important element to assess the different technology solutions with regard to energy efficiency,” says Per Brevik.

THE PROJECT PERIOD

The project at Norcem in Brevik is planned to last until the end of 2016. We will gather a lot of knowledge from the test centre during this period.

“I hope that, as early as 2015, we will be able to learn more about how close we are to a realistic, future-oriented solution. Then we will know much more about whether there is a basis for looking into building a full-scale facility. However, this will require us to go many rounds within the company and with our partners and supporters,” says Per Brevik.

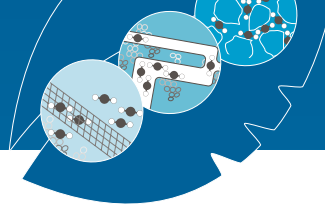
HEALTH AND ENVIRONMENTAL EFFECTS IN CONNECTION WITH AMINE-BASED CO₂ CAPTURE

Since 2008, CLIMIT has supported studies of possible health and environmental effects of amine and amine degradation products. So far, this has resulted in 11 projects with a total budget of more than NOK 60 million.

The projects cover chemical conversion in the capture plant, emissions to air and measures to reduce these emissions, dispersion and further conversion of emissions in the atmosphere, as well as final ultimate concentrations in soil and water. This work e.g. includes the first systematic review of literature to collect data for dispersion calculations. This study was led by NILU and pointed to insufficient data for conversion of amines in the atmosphere. This was followed up with three projects led by the University of Oslo where atmospheric conversion of a number of amines was studied. The results, published in scientific forums, have also been quoted in newspapers and were used in the emission permit application for the CO₂ Technology Centre Mongstad (TCM).

The CLIMIT programme has also supported fundamental work regarding conversion of amines in the actual capture plant and this work has been continued in the amine qualification programme for the full-scale project at Mongstad. Together with the industrial sponsors, the CLIMIT programme has played an important role in starting these studies, which have subsequently been used and further developed by TCM and CCM. Through all these activities Norwegian research organisations have become leading in this area.

All of this extensive work has provided insight and understanding of what takes place when amines are released in the atmosphere. So far, this knowledge has not revealed new insurmountable challenges.



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