ZERO

Zero Emission Resource Organisation

Diagnosing CCS

Where are we today and how do we move on from here?

Front page: *Boundary Dam capture plant (source: SaskPower)*

Acknowledgments

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Please visit our CCS database at
www.zeroCO2.no for more information about CCS policies and projects.

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– Where are we today and how do we move on from here?

WHY DO WE NEED CCS?

The latest UN climate report says that it is possible to limit the global warming to two degrees, but it will take extensive changes in all industries. The International Panel on Climate Change (IPCC) based its analyses on research results from 900 scenarios that show how the world might develop if we adopt new climate measures.

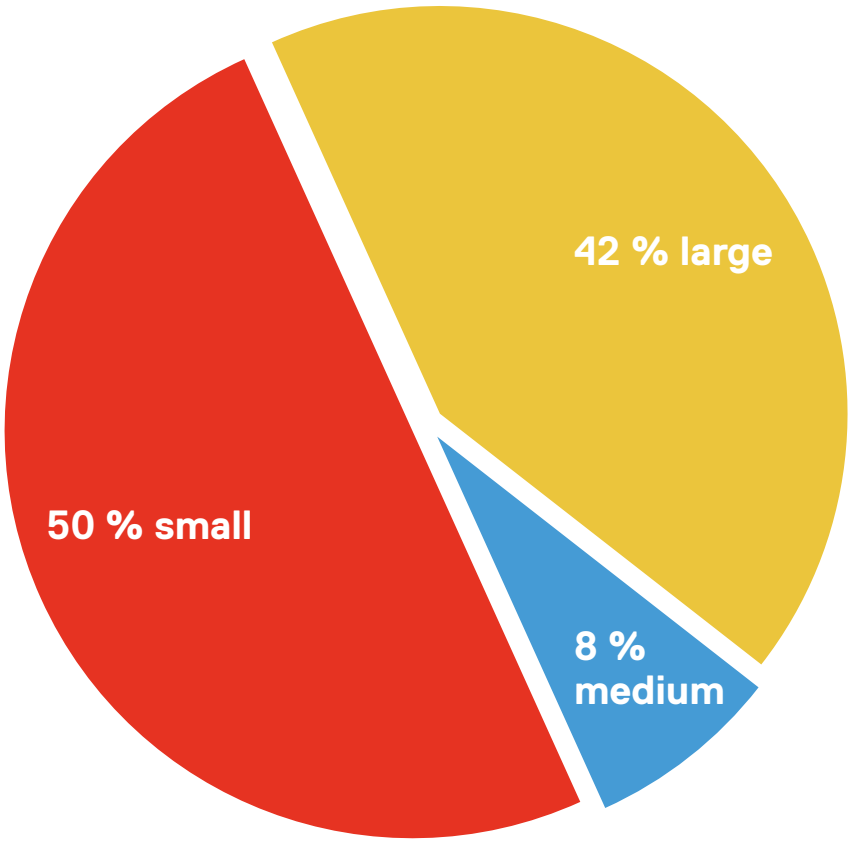
Most of these scenarios show that one must develop a substantial amount of Carbon Capture and Storage facilities, in addition to extended use of renewables and improving energy efficiency, to reach the two-degree goal, and not just on fossil fuel or industrial sources. Most of the IPCC's scenarios assume a comprehensive use of carbon negative solutions, i.e. solutions that remove CO2 from the atmosphere.

One example is producing energy from biomass where the CO2 emissions are captured and stored. The carbon negative solutions are crucial for reaching the two-degree goal based on where the world stands today. The faster we reduce emissions, the less we have to rely on carbon negative solutions.

This report looks at the development of CCS during the past year, both looking at actual projects and at policy developments around the world. Why are some projects succeeding and others cancelled? How can we encourage the development of more CCS?

We also take a close look at Norway and what has happened after the cancellation of the full-scale CCS project at Mongstad last year. Finally, we offer possible ways to encourage more CCS, based on previous recommendations, but also in light of recent developments.

Operational CCS projects in the world



THE STATUS OF CCS TODAY

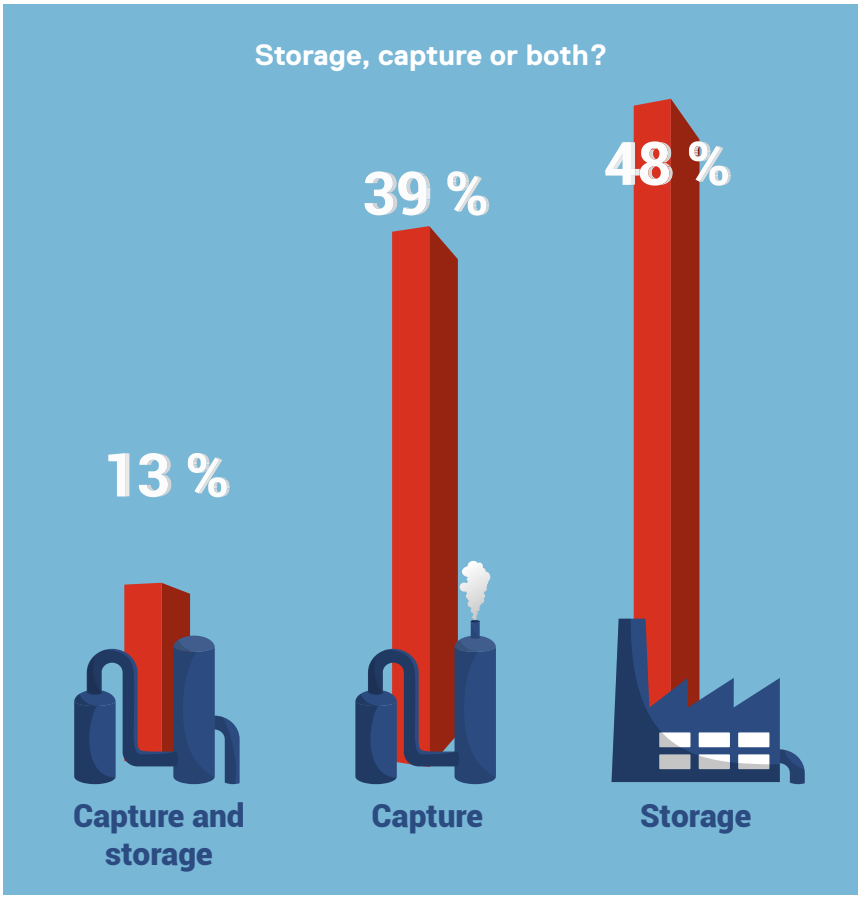
ZERO has identified 52 operational CCS projects around the world. Half of the projects are small-scale projects, which indicates smaller test and research facilities. A small portion of the projects is medium-scale, which commonly are demonstration projects. There are 22 large-scale projects in the world today, and this report will focus mostly on these projects, including the ones that are under construction and large-scale projects in the planning phase.

The majority of the large-scale projects are both capture and storage projects. The remaining projects are either capture projects, which store CO2 in separate storage locations, or storage projects, where there is no capture, but where the projects receive CO2 from capture projects. We found no capture and release projects among the large-scale CCS projects.

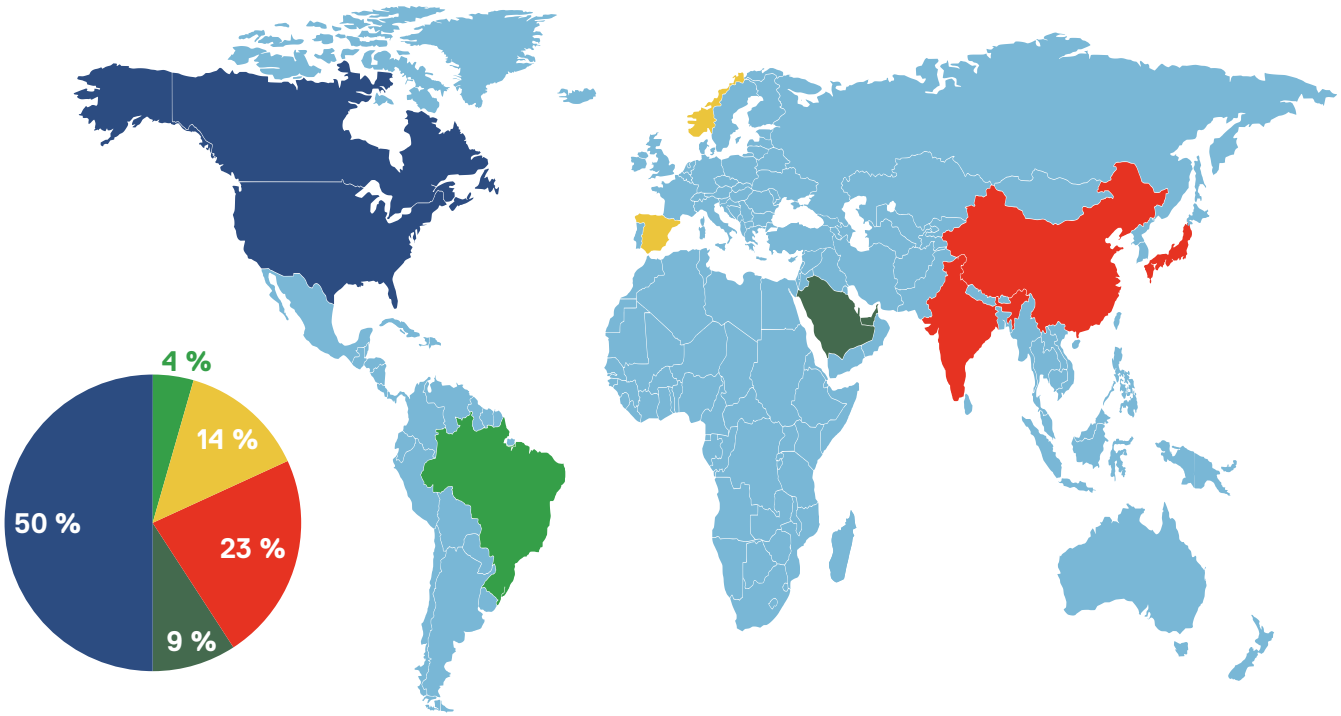
WHERE IS CCS DEVELOPED?

Europe only has three operative large-scale CCS projects, of which two are large storage projects in Norway, Snøhvit and Sleipner. The third, Hontomin, is a large-scale storage pilot for the now cancelled Compostilla CCS project in Spain.

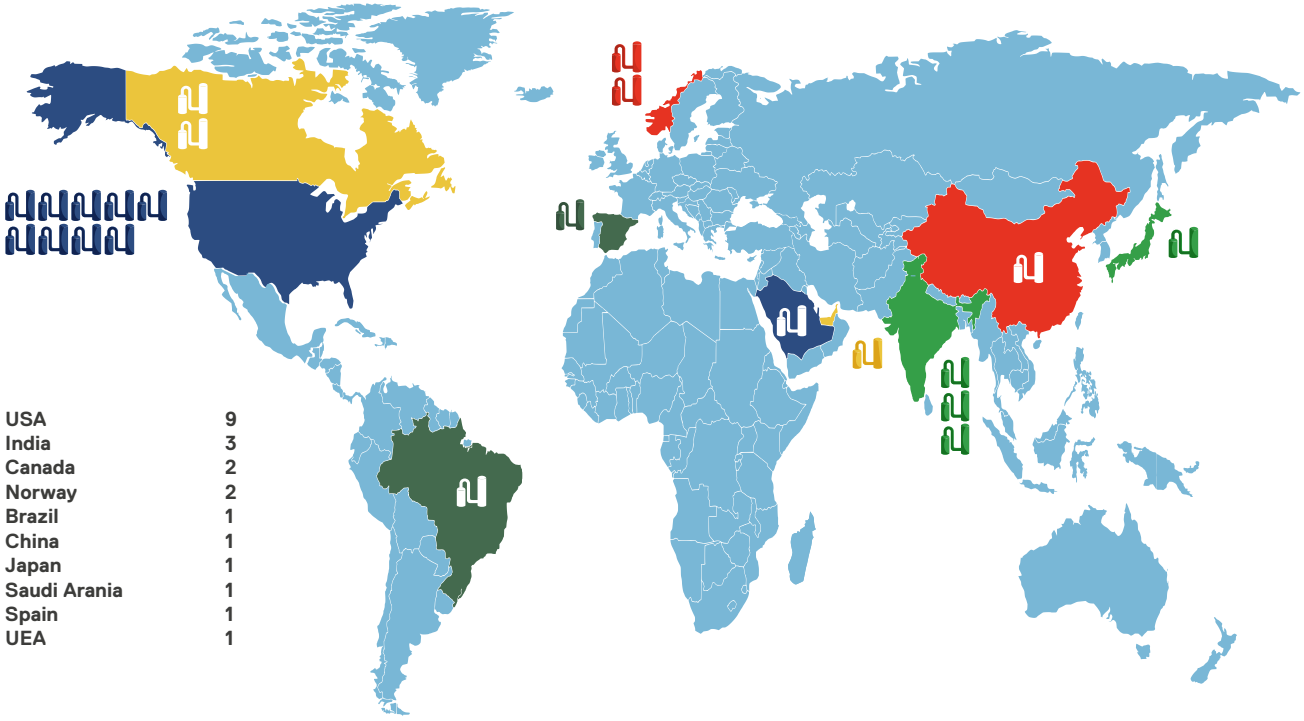
A majority of the projects can be found in North America, with nine operative large-scale projects in the U.S. and two in Canada. One of the major reasons for the development of CCS in North America, and especially in the U.S., is because CO2 is used for enhanced oil and gas recovery (EOR) in the oil and gas processing industry.



Large-scale CCS projects by region

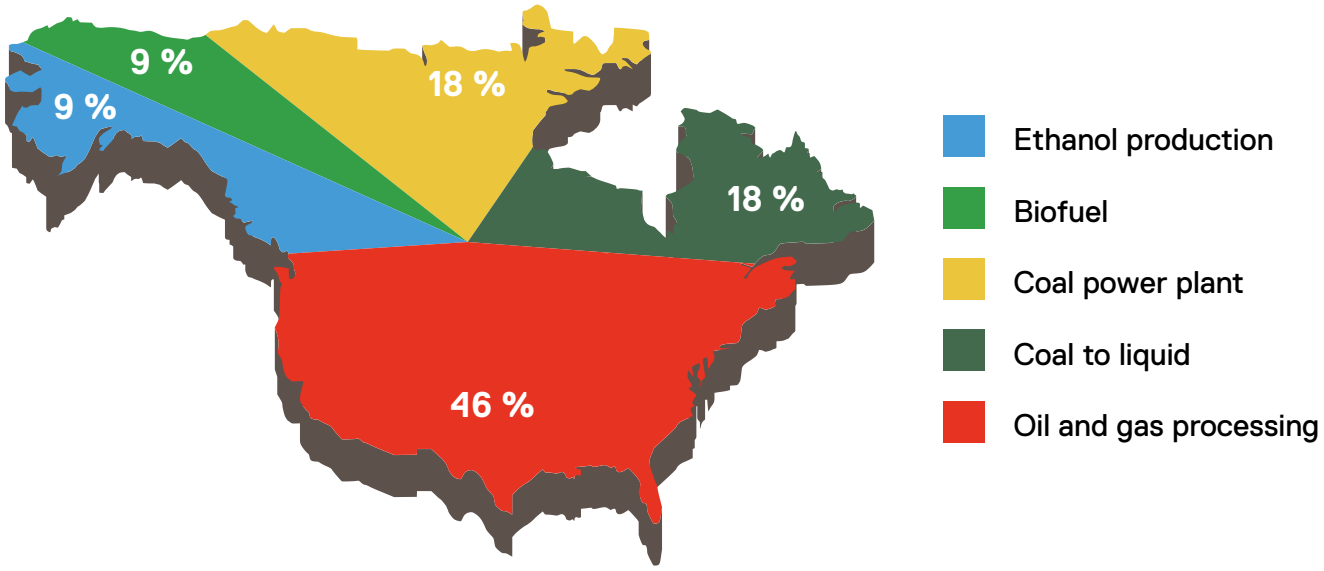


Large-scale CCS projects by country



USA	9
India	3
Canada	2
Norway	2
Brazil	1
China	1
Japan	1
Saudi Arania	1
Spain	1
UEA	1

Large-scale CCS in North America by industry

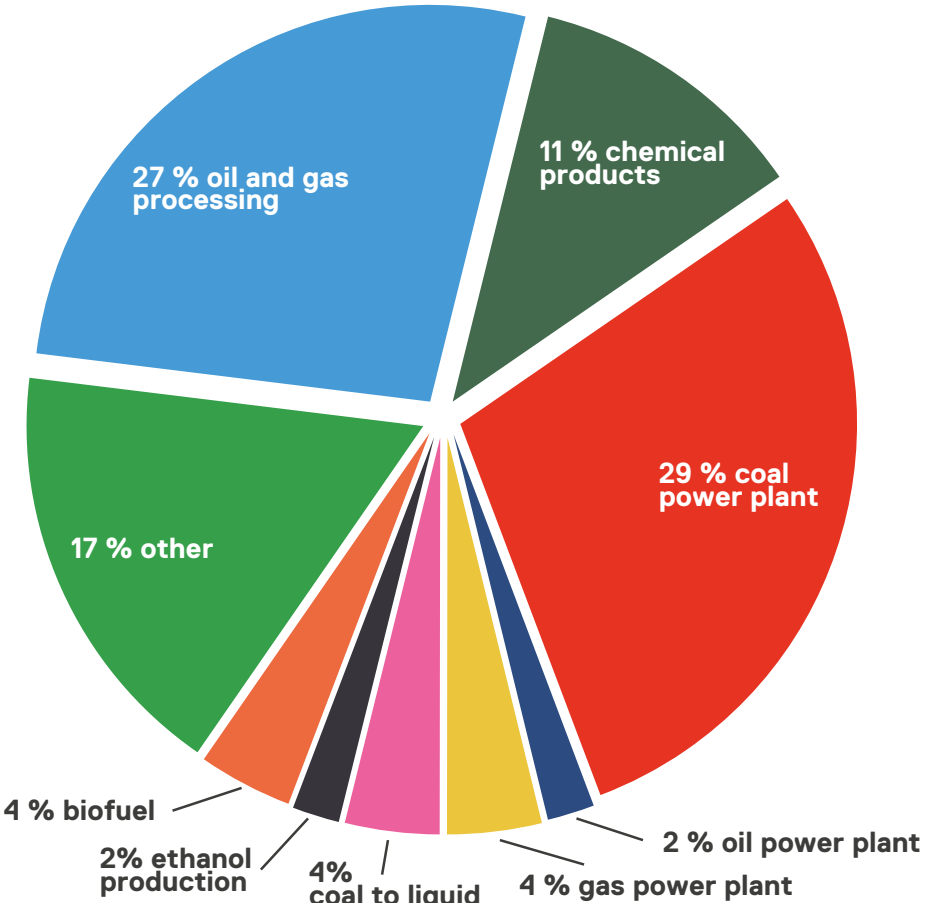


Unsurprisingly, given the amount of large-scale operational projects in North America, we find the largest amount of CO2 captured in this region. The numbers are based on the projected annual amount of CO2 captured, but they clearly show that one region is miles ahead of the others. The annual capture rate for Europe is probably especially surprising, given the number of projects that have been in planning stages until recently. However, these columns clearly show that the only thing that counts is finished and operational projects.

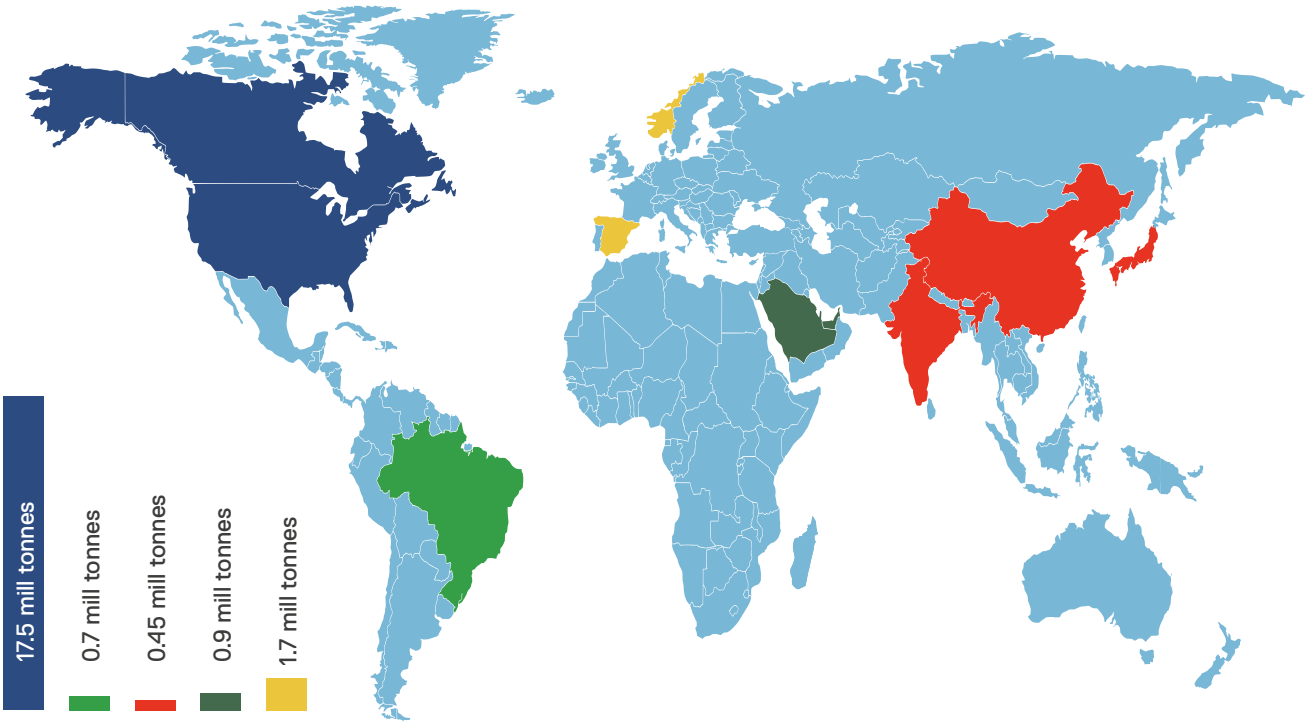
PROJECTS BY INDUSTRY

The vast majority of CCS projects in the world is either in oil and gas processing or coal power plants. Captured CO2 can be used for enhanced oil and gas recovery (EOR/EGR) in the oil and gas processing industry, which explains the investment in CCS in this industry. The coal industry is under pressure in many regions of the world, which has lead to new CCS projects in coal plants in these regions.

Operative CCS projects by industry



Amount of CO2 captured annually by large-scale projects by region



Kemper Country IGCC CO2 absorbers. (Source: Mississippi Power)

New and Notable Projects

BOUNDARY DAM

Boundary Dam in Saskatchewan, Canada, is the first commercial-scale project in the world combining post-combustion CCS with coal-fired power generation, and the project had its grand opening on October 2, 2014. Boundary Dam has been a very successful project from the start, especially due to the quick execution of the project. Building the project took only three years from the provincial government approved the plans in 2011, and the project was fully operational in October, 2014.

How do you realize a project in only 3 years in a world where most CCS projects seem to struggle to find political and financial will for development?

Success factors for Boundary Dam

- Low cost:
  The CCS plant had an estimated cost of 600 million Canadian dollars, and received financial support from both the national and provincial governments.
- Strict organizing
- Choose the right technology at an early stage.
- Tight project management.
- Requirements for profitability led to a strong focus on keeping costs low.
- National and local policymakers use the law to reduce CO2 emissions:
- The new emission standards in Canada and Saskatchewan are stricter than before.
- The project was a result of Canadian laws that limit emissions.
  Coal power plants in Saskatchewan will have to close within 10-20 years if they do not comply with the new regulations.

KEMPER COUNTY IGCC

The Kemper County IGCC project is another promising full-scale CCS under construction. The project will, when finished, capture 3.5 million tons of CO2 annually from the coal-powered plant. Critics point out that the Kemper County project might not be the best example of successful full-scale CCS plants.[1] One reason is the enormous budget, which has more than doubled, from $2.4 billion to $5 billion. Another reason is the time delays. The project was scheduled to be operational in May 2014, but the opening date has been pushed back to May 2015 since then. Despite the criticism, the project has sparked a great deal of enthusiasm, as it will help ensure the future of coal under the upcoming EPA coal power regulations.

1 Science News, September 6, 2014: https://www.sciencenews.org/article/carbon-capture-and-storage-finally-approaching-debut

Success factors for Kemper Country IGCC

- One of two selected projects in the second round of the U.S. Department of Energy's Clean Coal Power Initiative
- Received $270 million in funding from the initiative.
- It has also received $412 million in investment tax credits from the revenue service.
- A successful example of a project where the emitter has to develop CCS and pay it themselves to comply with future emission regulations.

QUEST

The Quest project is another CCS project, which is due to start operating in 2015. The Shell-led Quest project in Alberta, Canada, is the first commercial-scale CCS project to tackle emissions from oil sands extraction. It aims to capture and store up to 1.2 million tons of CO2 per year from the Scotford Upgrader, the facility at Fort Saskatchewan which produces synthetic crude oil from bitumen derived from the Athabasca Oil Sands extraction project.

The project was made possible by direct financial support from the government of Alberta, which is a very different financial structure than in Europe. In June 2011, Shell signed official agreements for part-funding of C$745 million from the Alberta government's $2-billion CCS fund and C$120 million from the federal government's CCS fund - funding awards that were made in October 2009. The total cost of the project is estimated at $1.35 billion. Shell also negotiated a two-for-one carbon credit deal with the province, which will help the company balance the higher cost of CCS against the $15 per ton carbon price.

Success factors for Quest

- The government has used a "per milestone-funding" system, rather than paying the full amount all at once. This has given the incentive to develop the project in a timely manner.

CANCELLED PROJECTS

The full-scale CCS project at Mongstad was probably the largest and most prestigious project to be cancelled last year. The Mongstad project was cancelled after the Norwegian auditor general released a report, which criticized the poor project management and cost control. The main developer Statoil did not have the proper incentives in the agreement with the Norwegian government to finish the project in a timely and cost effective manner. The report sparked a discussion about how one could ensure a better execution of the project, and the government's cancellation a few weeks later came as a surprise to many. However, the government argued that it was no longer a feasible project with costs that spun out of control.

Several of the projects financed by the European Union's European Economy Recovery Plan (EERP) have struggled to receive further economic support, and are either cancelled or dormant until the financial situation has been sorted out. The only EERP project left is the ROAD project in the Netherlands, which is ready to enter the FEED phase. However, low CO2 prices has generated less funds for the project than expected, and the ROAD project currently has a funding gap of > €150 million. The project managers at ROAD are still optimistic and believe that they will be able to raise a sufficient amount of funds to move on with the project. Continuing the ROAD project would also be important to spark more CCS development in the Euro zone.

There is not one single answer to why projects are cancelled, but one common denominator seems to be the lack of secure and stable financial solutions, or the lack of long-term investment from policy makers and the industry itself.

The European Trading System (ETS) has not generated sufficient funds to build enough CCS within the EU due to low carbon prices, mainly because the EU member states issued too many emission permits. The Clean Development Mechanism, which was funded under the Kyoto Protocol, has struggled with the same issues; little funding due to low carbon prices.

The Norwegian Mongstad project received government funding, but the incentives to build inexpensively and efficiently were not there. The "per milestone" funding used by the Canadian government for the Quest project, seems to be a much more efficient way of government funding. The project has to fulfill certain milestones and obligations in order to receive all the funding.

Competitions have also proven unsuccessful so far, but the second rounds of NER300 and the UK CCS Commercialisation Programme seem to have sparked more CCS than the previous rounds. However, none of the projects have started construction yet, so it is to soon to evaluate the competition system. Competitions could still be an efficient way to initiate more CCS projects, but the ground rules and the format of competitions could be improved compared to NER300 and the UK competition.

The technology for CCS is mature, has been used for decades and will, in the long run, get less expensive and less energy intensive. The barriers and challenges are, in most cases, funding, legislative issues or a lack of political will, or a mix of these factors. This is why ZERO highlights the need for an efficient, permanent and sufficient framework for CCS on all levels; nationally, within EU and globally.

POLICY CHANGES AND FINANCIAL SUPPORT MECHANISMS AROUND THE WORLD

EPA Rule on Coal Plants

We have seen some policy changes regarding CCS the last year. The change that was most debated, was probably when the Environmental Policy Agency (EPA) in the US proposed a new rule on coal plants designed to cut carbon dioxide emissions from existing coal plants by as much as 30 percent by

2030, compared to 2005 levels.[2] The proposal is expected to be finalized in 2015. The individual states can meet the set emission targets in many different ways, but the plans have to be implemented within a year after the proposal has been finalized.

NER300 Second Award Decision

NER300, the EU's funding program for innovative low-carbon energy demonstration projects, made its second award decision in 2014 and awarded funds to the White Rose CCS project in the UK. This is the first CCS project to receive NER300 funding.

EU legislation

The EU has started the process to review its CCS policies, and the European Parliament released a resolution about CCS in January this year that motioned for strengthening CCS in Europe. The Parliament is expected to vote on this resolution in early February. However, it is not expected that the legislation will be passed until late 2015.

UK CCS Commersialisation Programme

The UK also has its own competition, the CCS Commercialisation Programme. The Commercialisation Programme decided to move forward with two preferred bidders in 2013, the White Rose and the Peterhead projects, and in 2014, both these projects were awarded funds for FEED studies. The final decision is expected in 2015.

The UK government has received some internal criticism for the competition, because it has not generated enough CCS in the UK.[3] However, other projects can apply for funds through the Contracts for Difference system. The UK government is signaling that at least £50 million is planned for an auction round in 2015, with a total of £1 billion potentially being available for further projects, including Carbon Capture and Storage.

The combination of the NER300 funding to White Rose, an upcoming decision in the Commercialisation Programme, and other funding mechanisms might allow the UK to take the lead on CCS in Europe.

WHAT IS HAPPENING IN NORWAY?

The cancellation of the Mongstad CCS project in Norway in 2013 left Norway without any new full-scale CCS projects. The following Mongstad hearing and the report from that hearing which was released in March 2014, revealed fundamental issues that should be taken into consideration when launching another full-scale CCS project in Norway. The main learning points for further projects was to ensure cost-efficiency and tight project management.

The election of a new government in the fall of 2013 sparked a hope that there would be funds for new CCS projects in their revised national budget, which was presented in June 2014. Unfortunately, there were no signals in the budget that the government would allocate funds for developing full-scale CCS, despite the ambitions to build a full-scale CCS plant by 2020.

However, the government did commit to NOK 100 million in support to the ROAD CCS project in the Netherlands to assist the project in meeting the financing gap. The EU has asked its member states to provide a minimum of € 40 million to release additional € 20 million from the EU. The ROAD project is currently on hold awaiting more funds to move on to the FEED part of the project, so this funding is crucial for the development of the project. The Norwegian Petroleum Minister Tord Lien underlined that this support comes in addition to, not instead of, a Norwegian full-scale CCS project.

The Norwegian national budget for 2015 also suggests contributing NOK 125 million to Horizon2020/ERA-NET, where an applicable European CCS project can apply for funds. ROAD is the most developed CCS project in Europe at the moment and is the most likely candidate to receive such funds. However, such funds will not be available until 2017 or 2018.

Despite the lack of commitment towards CCS from the government, there is one industry in Norway that has taken the matter into its own hands. The cement plant NORCEM has started a study on industrial CCS in cooperation with Norwegian R&D institutes and Aker Solutions. The project will examine to what extent excess energy from the production of cement can be utilized for capturing CO2. The study will also establish important knowledge about individual challenges for the cement industry and evaluate how different capture technologies can be fitted to cement plants. [4]

2 Washington Post, June 2, 2014: http://www.washingtonpost.com/national/health-science/epa-will-propose-a-rule-to-cut-emissions-from-existing-coal-plants-by-up-to-30-percent/2014/06/02/f37f0a10-e81d-11e3-afc6-a1dd9407abcf_story.html

3 House of Commons Energy and Climate Committee , Carbon Capture and Storage, Ninth Report of Session 2013-2014, May 13, 2014: http://www.publications.parliament.uk/pa/cm201314/cmselect/cmenergy/742/742.pdf

4 Norcem, zeroCO2.no: http://www.zeroco2.no/projects/norcem-cement-plant-in-brevik-norway

ZERO recommends

The Norwegian government released the national budget for 2015 in October 2014, and there was some hope to see a follow-up of the Parliamentary Climate Settlement from 2008 (and the updated version from 2012), and also signals from the government about building a Norwegian funded large-scale CCS plant by 2020, either in Norway or in Europe. However, the budget, and the CCS strategy included in it, does not include any concrete plans for how to fund and realize such a project by 2020.

The lack of concrete plans for funding a full-scale plant for 2020 brings forward the question of how one can realize a full-scale CCS project funded by the Norwegian government within the next 5-10 years. One way to do this could be to divide the responsibility for the deployment of CCS in Norway between the state bodies Enova and Gassnova. Enova has the experience and organization needed to evaluate and support the development of such a project, especially with earmarked funds from the government. Gassnova should be in charge of developing appropriate transportation and storage options to support such CCS projects. A shared effort for the whole chain of CCS, with clear and realistic criteria for financial support and close follow-up of the project management, could initiate CCS projects. This is a way of sparking the first Norwegian full-scale projects, which also will need more built-in market mechanisms for operation in the long run.

There is a need to cover operation costs after developing full-scale projects, to secure competitiveness for industries and energy projects with CCS. ZERO's suggested certificate system is a good long-term solution; others could be a strict EPS or tax incentives. There is also a need to find short-term solutions for projects built before the certificate system or similar functioning policy-instruments are implemented. There are several methods to achieve this; one solution could be to hand out 5-year guarantees by the Norwegian government to support operational costs. The government should also take responsibility for developing storage sites, and for long-term liability for these sites.

The government's CCS strategy mentions the potential for a large storage projects in the North Sea to cover the European need for storage space. The Norwegian Petroleum Directorate's CO2 Storage Atlas, and also the work done by the North Sea Basin Task Force, shows that there is great potential for storage both at the Norwegian continental shelf and in the North Sea. The government argues that the cost of storing CO2 in the North Sea is high, and the need for new storage space at the moment is low. The suggestion is to find storage opportunities for each individual CCS project until there is a need for larger storage options. However, ZERO finds it crucial to start working on the legislative implications of North Sea storage and moving CO2 over borders now, to be able to develop the necessary storage capacity in time when needed. There is a need to be offensive about storage opportunities, to ensure that a lack of storage sites is not what stands in the way of the development of CCS.

CERTIFICATE SYSTEM AND OTHER POLICY INSTRUMENTS

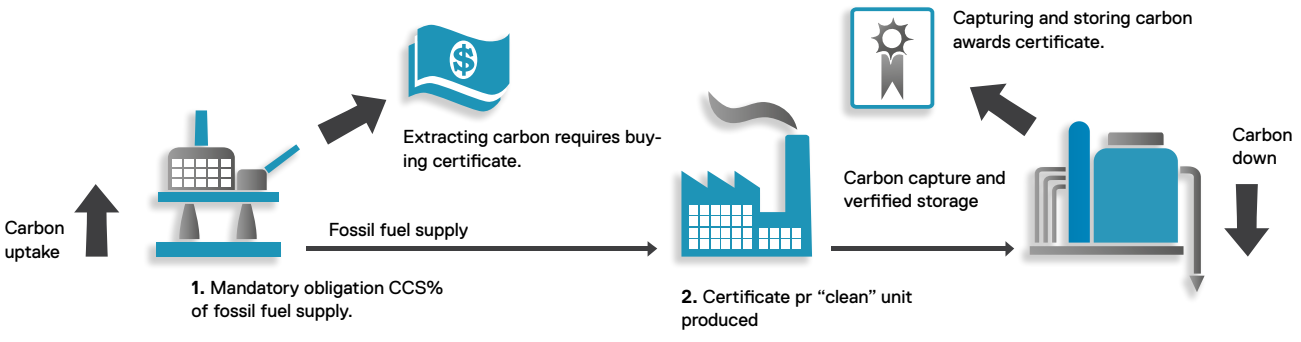
In 2013, ZERO released a report on policy instruments for large-scale CCS, which evaluated seven possible policy instruments. A mix of instruments to promote CCS is indispensable, and the industry needs long-term and predictable frameworks to be willing to invest in CCS.

General CCS instruments are preferable to sector-specific instruments, covering emissions beyond power production to give competition for reduced CCS cost across all sectors. And policy instruments for the whole CCS chain are preferable to separate instruments for each part of the chain in the long-term perspective.

Based on a thorough evaluation of the possible policy instruments, ZERO made the following recommendations in its report:

A mandatory certificate system

The basis of the certificate system is that if you make profit on taking carbon up, you have to make sure that



A simple illustration of a CCS certificate system.

the carbon is put back. This means that companies will have a legally binding obligation to buy - or "produce" - certificates as a share of their production/supply

The volume of CO2 will be politically decided, and the market will set a price to fulfill the obligation

A certificate system is a cost-sharing instrument, distributing the extra cost to all fossil value chains, and creating a potentially minimal effect on carbon leakage issues. It is more likely to receive political acceptance when costs are covered by the industry and included in the product price for fossil fuels, rather than if the cost is passed on directly to consumers.

- Obligate suppliers of fossil fuels to do CCS as a share of their supply
- Certificates given for production of clean products with CCS
- Flexibility for suppliers to do CCS themselves or to cooperate and trade CCS certificates from other projects.
- Possible cooperation between countries, both developed and emerging countries.

EPS

An output emissions performance standard (EPS) is a benchmark for production, which sets a restriction of maximum allowed emission per produced unit. EPS can be used for both power plants and other industry sectors, such as cement, steel, etc. EPS can also be set not on the specific plant, but on the total company portfolio or for a market portfolio. ZERO suggests:

- EPS regulation for new and existing power plants and industry, in combination with the certificate system.

Storage

- The government should take the post-storage, long-term liability for CO2, de-risking storage cost for all CCS projects. In the short term a special government involvement and funding focus is important to establish sufficient early stage storage capacity.

ZERO recommends using a combination of the certificate system, EPS and taking charge of storage.

COMPETITION OR A CCS FUND

ZERO has previously launched the idea of a CCS competition in order to generate good full-scale CCS projects, built either in Norway or outside Norway, but funded by the Norwegian government. Even though there are no plans for executing such a competition at the present time, there will be a need for a concrete plan and a funding structure, like this, for CCS in a short-term period. If the government should opt for a competition model, it would be crucial to look at previous competitions, such as NER300 and the UK CCS Commercialisation Programme, and learn how to improve the process to secure faster award decisions. The previously mentioned government body Enova could be the administrator of this.

It is necessary to have solid government funding to attract an appropriate number of projects to choose from. ZERO has created a set of premises and criteria that should be fulfilled in order to receive government funding for a full-scale CCS plant:

- Existing sources of emission should be prioritized, or emission sources that will be developed despite of government funding.
- The CCS plant should use the most accessible and relevant technology.
- The experiences from the CCS plant have to be transferable to plants in similar industries.
- The plant must capture at least 300,000 tons within the set timeframe.
- One should consider whether it might be expedient to build the first plant outside Norway.
- The grant must include investment and operating expenses.
- Industrial process emissions that cannot be eliminated by using renewable energy should be taken under extra consideration when choosing a grant recipient.
- The developer is responsible for planning, building and the operation of the plant.
- The government is responsible for developing transportation and storage solutions.

NORWAY'S ROLE INTERNATIONALLY

The new Norwegian government, lead by Prime Minister Erna Solberg, has recently discussed the option to finance CCS projects outside Norway. Choosing a project in Norway might not give most GHG reductions per NOK spent, which has opened up the discussion about funding CCS abroad.

The only concrete suggestion for supporting and developing CCS with funds from Norway in the EU, is further contributing to ROAD through Horizon2020 funds. The added funds to the ROAD project are supposed to cover operation costs, and come with certain restrictions that means they will not be made payable until 2017. In practice this means that there is no funding for large-scale CCS projects in Europe or internationally in the national budget for 2015.

The government has also suggested that some of the NOK 200 million funding through The Green Climate Fund (GFC) could be earmarked for CCS projects, and also to strengthen support to CCS projects through the World Bank and their CCS fund. These instruments are not securing any development of CCS today, but could be crucial for the development of CCS in developing and emerging economies in the future, as long as some of the funds are earmarked for CCS.

First Quest CO2 injection well (Source: Shell)

CONCLUSION

Governments have a pivotal role to play in enabling CCS deployment through predictable, efficient and durable policies that include carbon dioxide limits, a price on emissions, incentives for early deployment and performance standards for specific types of facilities.

To move CCS forward we need to look beyond the limits of the current bureaucratic imagination. Politicians and policy makers need to realize that CCS on industrial emitters, coal and gas is essential as we move to a low carbon society.

To make that vision a reality, we need to see new policy instruments brought forward and investments in infrastructure enabling CO2 transport and storage.

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