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Exploring paths and innovation in Norwegian carbon capture and storage policy

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Abstract

Norway, a significant petroleum producer and exporter, has been a frontrunner within policies for carbon capture and storage (CCS). As CCS is recognized as a key technology for achieving the Paris climate policy targets, there is a clear need for more knowledge about how to design successful projects. Norway's first CCS policy initiative, the ambitious Mongstad project, was the result of a political compromise that was imposed from above, basically with one single company in control. The project was largely seen as a failure and was terminated in 2013. However, instead of dropping ambitions for developing CCS projects, the authorities launched a new policy soon afterwards. This policy evolved with the differently organized Longship CCS project as its core. Using a path-dependency perspective, we find that established institutional structures from the Mongstad project, combined with national interests and expertise, help to explain the fundamental continuity of CCS policies in Norway. This explanation is supplemented by a policy-learning perspective, which helps to explain policy changes and differences between the two flagship CCS projects. The Longship project developed gradually 'from below'; linked project responsibilities close to competences and interests; dealt with key risks separately to reduce the inherent complexity; and organized clear requirements up front. We hold that this way of designing CCS projects is of relevance to other countries considering CCS projects. Furthermore, by placing the Norwegian case in context of the development of EU and international climate policy we contribute a theoretical framework relevant also for subsequent research.

KEYWORDS
carbon capture and storage, CCS, climate policy, Longship, Norway, path dependency, policy learning

1 | INTRODUCTION

Carbon Capture and Storage (CCS) is recognized as a key technology for achieving the Paris climate targets (IPCC, 2014, 2018; Nordic Energy Research, 2021), but national initiatives have had limited success. In 2020, there were 26 commercial CCS facilities operational worldwide, and three under construction (Global CCS Institute, 2021). However, these involve a range of different technologies and purposes, and most of these plants concern petroleum-sector activities (Global CCS Institute, 2021). Such plants are usually designed to remove CO_2 from natural gas in order to improve its quality: climate-change concerns are not necessarily the main motivation. In addition come plants in sectors like chemicals, ethanol, fertilizer and hydrogen production worldwide.

After several unrealized projects in countries like the Netherlands, Norway, Poland and the UK in the years 2005 to 2015 (Inderberg & Wettestad, 2015), a quiet period ensued. Since around 2018, the tide appears to have turned in Europe. Whereas the focus had been on the electricity sector (gas and coal thermal power plants in particular), more recent projects target energy-intensive industries and the waste sector. However, few studies have examined the lessons learned from the previous wave of projects, to analyze whether the new national CCS policies might have better chances of success.

As a major producer and exporter of fossil fuels, Norway was a keen supporter of and participant in the initial European CCS drive, with the national petroleum company Statoil (Equinor from 2018) having conducted CCS successfully at the Sleipner gas field since 1996. The ambitious Mongstad project, launched in 2007, was hailed as a 'moon landing' venture (Boasson, 2015; Roettereng, 2016; Tjernshaugen, 2011). Initial CCS policy targeted the power sector, aiming to achieve commercial-size ('full-scale') capture at the Mongstad gas power plant, with further ambitions for developing emissions-reductions technologies globally (Roettereng, 2016; Swensen, 2012). As later documented, the actual results were far more modest than hoped for, and the project was largely seen as a failure. That might have been expected to end the Norwegian CCS drive. Instead, however, soon after the termination of Mongstad in 2013, there followed a revised Norwegian CCS policy, with the 'Longship' project (*langskip*: an old Viking boat) – encompassing the 'Northern Lights' (NL) transport and storage element – as a key component.

In this within-case comparative study of Norway's internationally focused CCS projects and policy, we ask the following key research questions: first, why did Norway initiate a new, ambitious national CCS policy despite the failure of its first CCS initiative? Second, what can explain the changes from the first CCS policy to the new one, especially as regards the different design of the flagship Mongstad and Longship projects? Third, what wider analytical and political lessons can be derived from the Norwegian case?

Norwegian CCS policy has seen significant developments, including reorganization of project responsibilities, different risk sharing, and a new economic model. Concerning interaction with the external environment, there has been a reorientation from the electricity sector to a European cross-border trade in CO_2, and hence different external linkages. Whereas the significant prevalence of the CCS strategy may be explained in terms of path-dependency, we investigate how external events and learning theory can explain the changes in CCS policy. These insights are likely to have implications for the likelihood of success not only for the Norwegian CCS strategies, but for similar projects in Europe and beyond.

2 | ANALYTICAL FRAMEWORK AND METHOD

2.1 | Explaining continuity and change in CCS policy: Path dependency and policy learning as key perspectives

How can we explain persistence as well as change in the Norwegian CCS policy over the past 20 years? In the slowly developing and maturing policy field of CCS a key element of policy is the design of successful demonstration projects. Here we understand 'policy success' not as influence and catering to the interests of various actors (McConnell et al., 2020), but as related to the official goals of the policies in question. Drawing on earlier studies of CCS policies (Boasson, 2015; Roettereng, 2016, 2018; Tjernshaugen, 2011, 2012), we identify four key design features.

- **The official goals for the CCS policy**: These are the main goals of the CCS policy pertaining to project design, and include constructing demonstration projects, as well as full-scale CCS pilots; creating chains of capture, storage and transportation; establishing infrastructure for transport and storage; and the development and spread of CCS technologies.
- **Policy scope**: A first distinction here is between projects that focus solely on CO_2 storage, and those that cover the whole chain from capture to transportation and storage. A second distinction is between projects that target a specific industry (such as the petroleum industry, or energy-intensive industries), and more comprehensive projects that may cover a range of energy producers and energy users.
- **Distribution of competence**: This concerns how the relationship between governmental agencies and industrial actors is organized. Projects may vary regarding, for instance, the types of public and private actors responsible for various parts of the capture–transport–storage chain, the fit with their core competencies and traditional activities, and risk distribution between the public and private actors involved.
- **Funding**: A basic distinction here is whether projects are funded by public or private actors, or some combination of this.

To explain persistence and change in the Norwegian CCS policy, and the role of societal actors and drivers at the sub-national, national and international levels, we apply path-dependency and policy-learning perspectives. Further, we account for the main changes in the international context that have affected Norway's CCS ambitions and measures.

We draw on theory of *path dependencies and lock-in effects* generated by previous policy programmes and established interest structures. Here we aim not to explain the *genesis* of the Norwegian CCS policy – that has been done elsewhere (Tjernshaugen, 2012; Tjernshaugen & Langhelle, 2009). The Longship policy is rooted in established structures, institutions and interests in the Norwegian economy and public administration; and, as policy is still evolving, there is reason to expect that established institutions and interests will also assume their own dynamics, based on positive feedback.

Under certain conditions, path dependencies create lock-in effects that constrain and influence policy choices (Eikeland & Inderberg, 2016; Pierson, 1993; Pierson, 2004). Pierson (2004) sees positive feedback (in the form of 'increasing returns') as a key feature of path dependency: policy choices gradually become more stable and increasingly difficult to change. This path-dependency perspective takes a long-term approach to explaining stability and (primarily) incremental change. Initial policies and institutions structure commitments to specific interest groups that favor and advocate particular policies, rather than actors with conflicting preferences and interests – or with few stakes in the policy in question (Fagerberg et al., 2009). Exogenous shocks may disrupt such a policy path, but institutions and industrial complexes can lead to lock-in that favors certain types of policies (Unruh, 2000).

The Norwegian CCS policy was not discarded after it failed to achieve the main ambition of a 'full-scale' operational plant: it was put on hold for several years, later resurfacing in a new guise with the Longship policy. We employ a policy-learning perspective to explain these policy changes in perspective (Armitage et al., 2018; Boasson & Wettestad, 2013; Gerlak et al., 2018; Jordan & Matt, 2014; Jordan & Moore, 2020).

Policy learning may operate through the effects of policies on actors' interpretation of those policies (Moyson et al., 2017). This can be seen as 'cognitive learning': 'changes in understanding of social/or ecological conditions' (Armitage et al., 2018, p. 4). As Rietig and Perkins (2018, p. 492), 'if learning is responsible for policy change, it is logical that actors should have altered their behaviors, choices and actions in response to and reflecting on new information, experiences and insights, or sought to do so'. Such cognitive policy learning, which can be observed as *change in policy*, is likely to interact with other factors that influence interpretation, including actors' pre-existing policy frames and influential policy ideas pre-dating a policy, or external events. This relates to the wider literature on policy change, including policy streams (Kingdon, 1995), and the Advocacy Coalition Framework (Sabatier & Jenkins-Smith, 1993). Typically, this literature understands learning as 'relatively enduring alterations of thought or behavioral intentions which result from experience and which are concerned with the attainment (or revision) of policy objectives' (Sabatier, 1988, p. 133). Inspired by Rietig and Perkins (2018), we focus on the policy output and apply a more tangible operationalization, where we observe policy change that can be traced to learning effects by involved actors.

Policy learning may be simplistic and limited to direct copying of policies or practices that have been shown to work earlier or for other issue-areas, but it will often be a more sophisticated process. Such sophisticated learning involves careful probing and efforts to correct choices made earlier – because they have failed, or have proven flawed under certain conditions (Finnemore & Sikkink, 1998; Gilardi, 2010; Underdal et al., 2015). This can be seen as 'relational learning', that is, changes in the perceptions of others and cooperative relationships (Armitage et al., 2018: 4), although the distinction regarding 'cognitive learning' is not sharp and clearcut. Learning here is a matter of active engagement in acquiring and perhaps further developing new knowledge and innovative ideas that can help governments and other actors to improve policies, cooperative practices and institutional design. We understand this instrumentally, as negative or positive lessons about how to design a policy or programme, often rooted in dissatisfaction or policy failure (Rose, 1991). This is clearly the case with Norway's Mongstad CCS policy. Here we investigate the learning points and to what degree and how such learning can explain modifications of this policy.

However, the combined path-dependency and policy-learning perspective cannot exhaust the range of possible factors that might explain continuity and change in Norway's CCS policy. Although these perspectives do include factors of long-term established structures, interest constellations, and experiences with policy design and their effect and challenges, we do not see them as working in isolation. As highlighted by the literature on policy learning (Rietig & Perkins, 2018), a given outcome may come about regardless of learning. Particularly for an open economy like that of Norway, changes in the external context may well prove significant for the resulting policies. Roettereng (2016, 2018) highlights the importance of viewing the Norwegian CCS dynamics in a national-international interaction perspective, with the CCS drive seen not least as a way to demonstrate norm adherence towards the international climate regime.

We seek to account for these more 'exogenous' factors inductively, emphasizing their independent effects, but particularly how they interact with the factors that feature in the path dependency and learning perspectives. Thus, our interview guide included questions about the influence of the international environment; where interviewees identified key developments of relevance also outside Norway, these were incorporated into our empirical account and analysis. Factors relevant here include policy signals from the global climate regime, like the outcomes of negotiations under the UN Framework Convention on Climate Change, UNFCCC; the London Protocol under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter; and the role of EU policies and carbon prices under the EU Emissions Trading System (EU ETS).

2.2 | Case selection and methods

The case of Norway has characteristics that enable wider lessons regarding CCS success. With a track record of high CCS ambitions, accessible storage facilities, political commitment, and a proven willingness to invest heavily in CCS technology development, Norway stands as a frontrunner in CCS policy – while also being part of the wider European and international ambition to develop successful capture plants, transport systems, and storage, as a full value chain of international ambition (Global CCS Institute, 2021).

Through process tracing (Bennett & Checkel, 2014) we can identify the connections between decisions, initiatives and their linkage over time. Process tracing is particularly relevant for this study, as the policy in question has involved gradually developing and shifting initiatives. Using this method enables closer investigation of the formal and informal links over time, as well as comparison of the two initiatives in the context of Norway and the links to developments abroad. As such, our approach here can be considered as within-case analysis (Norway) of different outcomes (policy design) over time, to assist in producing contextually grounded yet generalizable findings (Ayres et al., 2003). This design allows for identification of key factors that have changed – providing an explanation for the case, as well as linking it to the theoretical literature on learning and path dependency.

Our analysis is backed by data from technical and policy documents, combined with data from interviews with key stakeholders. The documents are primarily publicly available, referenced documents issued by the Norwegian government, like white and green papers, national budgets, research literature and national auditor reports. In addition, come reports from the Mongstad and Longship projects, from the public company Gassnova and from Statoil/Equinor, as well as NGO assessments and publications, and independent reports and scholarly publications. An advantage here is that information is more open than is usual with industrial projects: because of their large share of public funding, the Mongstad and Longship projects are required to publish most of the information they develop, much of which would probably otherwise have been withheld for reasons of competition.

In addition, we conducted eight interviews. Informants were strategically selected from key public entities, companies, and organizations; they included representatives from the government (the Ministry for Petroleum and Energy (MPE) and Gassnova), industry (Equinor, Fortum and Norcem) and the NGO sector (Zero Emissions Organization; independent energy analyst). See Appendix A.

3 | TRACING CCS DEVELOPMENTS FROM MONGSTAD TO LONGSHIP

3.1 | The Mongstad project: A failed ‘moon landing’?

CCS in Norway has a fairly long history, starting in 1996 with catchment and storage from the Sleipner field (and later Snøhvit). This was because of the high CO_2 levels in the gas itself, which would require ‘gas sweetening’ – reduction in CO_2 levels – of the extracted natural gas in any case. However, the direct trigger for CCS in the Sleipner case was the Norwegian carbon tax on petroleum from 1991. Almost all our interviewees considered the CCS experiences from Sleipner crucial for the later development of CCS in Norway.

The question of new gas-fired power plants had been controversial from the mid-1990s onward. Both the Labour Party and the Conservative Party were basically in favor, with the other parties in the center and to the left rather skeptical to such new plants, particularly if they were to be built without specific plans for abatement measures.

As highlighted by one NGO interviewee, the role played by the environmental movement was unique in a European perspective (interview 3). Elsewhere in Europe, the environmental movement was generally deeply opposed to CCS, whereas in Norway some environmental NGOs were central in forging a politically feasible CCS compromise (Boasson, 2015). Relevant here was the fact that Norway has no coal-fired power plants.

Initially, the aim was to capture the CO_2 from the recently constructed gas power plant Kårstø in southwest Norway. A first key political compromise involved requiring that the Kårstø facility be constructed with CCS facilities. In 2004, the Norwegian Parliament established the Gas Technology Fund, to fund R&D for environmentally friendly gas-power technologies. ‘Gassnova’ was initiated as a subsidiary agency of the MPE in January 2005 for the purpose of facilitating the CCS process. A research programme on CCS in gas-power plants – CLIMIT – was established under the auspices of Gassnova. Under the new Labour-led government from 2005, Gassnova was established in 2007 as an official state-owned company.

Gassnova, in cooperation with the gas transporter Gassco, and the state-owned petroleum giant Statoil, set about investigating the feasibility of CCS at Kårstø, through pre-FEED (Front-End Engineering & Design) studies between 2007 and 2009. These indicated that CSS was technically, but not economically, feasible (interviews 4, 8).

However, in 2005 the state petroleum company Statoil had applied for construction of a gas-fired power plant – the Mongstad facility – *without* specific abatement technology. The focus now shifted to this project, which we see as constituting the core of the initial Norwegian CCS policy. This was a result of a top-level political compromise that emerged between the gas-friendly Labour Party and the gas-skeptic Centre Party and Socialist Left Party after the new Red–Green, Labour-led government took office in 2005: permission to build such a plant would be granted – contingent on CCS technology being used (Tjernshaugen & Langhelle, 2009).

The agreement on a full-scale CCS project at Mongstad was signed between Statoil and the MPE in 2006 (Gassnova, 2020), framed as an innovative demonstration project with European and global implications. This grand vision was officially launched as a Norwegian ‘moon landing’ in Prime Minister Stoltenberg's 2007 New Year's Day speech – which also noted the high risk and ambitions of the initiative. The idea of a gas plant with CCS had come from the political level; the 2007 Soria Moria Declaration of the new Labour-led Government stated that any new licenses for gas-power plants must include CCS facilities. According to our informants, Statoil was rather skeptical from the beginning (interviews 2, 3).

The main goal of the Mongstad initiative was to construct a full-scale CO_2-capture pilot, as well as a test facility. As noted in the MPE/Statoil agreement, ‘the parties have a common objective to create a CO_2 solution within 2014 with concern for common industry practice for safe and national execution of such projects’ (Boasson, 2015). The organizational model included an agreement between the MPE and Statoil on the construction of a CO_2-capture pilot plant and a test center: the Technology Company Mongstad (TCM). As to participation, on the industrial side it was solely Statoil. From the governmental side, the MPE ministry was central. Gassnova was to take charge of carbon capture.

The bulk of the funding was to come from governmental sources. The MPE agreed to finance construction of the plant and running costs – highly advantageous for the industrial actors involved. Statoil was to contribute what the company would have paid for ETS allowances if no cleaning/CCS had been installed. In the budget for 2009, two billion NOK (approx. 200 million euros) were set aside for this purpose. Over time, Statoil came up with an estimated budget of NOK 25 billion (approx. 2.5 billion euros). In the EU, the revenues from selling 300 million ETS allowances were set aside for support to CCS projects (Boasson & Wettestad, 2013). However, Norway had been included in the EU ETS only recently (in 2008) and drawing on EU funding had not been discussed.

Aligning with the international framing at the time, the target group for the CCS at the Kårstø and Mongstad projects was the power sector. European debates were primarily concerned with this sector. Perceptions differed between proponents of cutting emissions within the electricity sector (who often argued that other industry gases were more difficult to catch), and opponents, often environmental organizations but also some industries, who questioned the logic of prolonging the life of fossil-based power against the development of renewable power. The focus was on the capture element of the CCS chain: transport and storage received less attention. It was common at the time to assume that the storage element was covered through the EU Storage Directive (interviews 1, 3, 8). In 2011, the IEA issued a report on opening up for transport of CO_2 across boundaries and options to allow such transport under the London Protocol – a development that proved important for events almost a decade later (IEA, 2011).

The Technology Centre Mongstad (TCM) opened in 2012. Initially, the investment decision for the full-scale plant with CCS was to be taken also in 2012, but was postponed due to uncertainties around the amino-based technology applied for capturing CO_2, and investigations concerning cancer danger. The TCM itself – the world's largest test center for CCS – was constructed at Mongstad between 2009 and 2012 (Gassnova, 2020). Gassnova, Statoil, Shell and South African Sasol were partners, but the center would be open for other actors as well. As a result, the test facility has remained in operation, whereas the Mongstad full-scale project was ultimately terminated by the Labour government in 2013 (Mildenberger, 2020). Official reasons were 'high uncertainties and risks', including risks concerning the transport and storage elements, which had received far less attention than the capture aspects (Gassnova, 2020).

3.2 | Northern Lights and Longship: 'Rising from the ashes'?

The Northern Lights project, which gradually became an integral part of the more comprehensive Longship initiative, can be traced to the momentum emerging primarily within the governmental bodies MPE and Gassnova. This new initiative became official in late 2014, with the launch of the 2015 national budget. Norway's new Conservative-led government aimed at identifying measures that would lead to technology development and cost reductions (OED, 2014). Although it was acknowledged that 'CCS is complicated', the official ambition was to have a full-scale catchment plant by 2020, with Gassnova as the primary coordinator and driver.

According to our interviewees, the process of starting NL/Longship came from a governmental initiative, where the MPE and Gassnova initiated talks with likely major partners about a new CCS initiative, starting with Statoil. Here the initial focus was on creating a market for storage, by demonstrating the feasibility of this through what later became the Northern Lights project (interviews 1, 2, 4, 5, 6, 7).

In winter 2015, the Norwegian government announced the ambition of achieving 40% emissions cut by 2030, in collaboration with the EU. Somewhat paradoxically, a development was then started which entailed an increasing need to be more specific about *domestic* emissions cuts, as this collaboration also came to entail linking up to the EU Effort-Sharing system, with annual emissions budgets (European Commission, 2022).

In spring 2015, Gassnova delivered an initial feasibility study to the MPE, with 21 industrial facilities included in the list of potentially feasible catchment sites (Gassnova, 2015). In the summer of 2016, the MPE issued a follow-up feasibility study for full-scale and full-chain CCS (OED, 2016). Here, three catchment sites were short-listed: the Yara plant for ammonium production in Porsgrunn; the Norcem cement factory in Brevik; and the Fortum waste incineration plant in Oslo (Fortum Oslo Varme AS). All three were granted contracts for further study of their respective locations in 2017. Statoil (renamed Equinor in 2018) conducted a feasibility study for storage.

In autumn 2018, the government decided to proceed with the full-scale strategies. Fortum and Norcem received preliminary contracts, with no guarantee of ultimate project funding, whereas Yara discontinued its plans for shifting to green hydrogen. Interviews confirm that the Fortum and Norcem projects were considered mature and feasible, whereas Fortum CCS was more expensive, primarily because of more complicated emissions for catchment, and the need for both land and sea transport (interviews 1, 4, 8). In 2019, Equinor, Shell and Total partnered up and received contracts for studies of the transport and storage parts – *the Northern Lights project*.

The IEA, 2011 report on CCS had indicated several options as to ratification under the London Protocol (IEA, 2011). In October 2019, one of these options, 'Provisional Application', was adopted as an amendment. Although provisional, it opened the possibility for creating an international business case related to transport and trade of CO_2 emissions. Our interviewees emphasize this as a crucially important development for the Longship initiative. Without this amendment, the vision of creating a truly transnational project – with other countries using the Northern Lights storage capacity – would have been a dead end (interviews 1, 4, 5, 8).

As to the general Norwegian climate-policy context, in the winter of 2020 the government adopted a more ambitious 2030 target: 'at least 50% and towards 55%' emissions reductions to be achieved by 2030, mainly by abatement measures undertaken in Norway.

In September 2020, the White Paper 'Longship' was submitted to the Norwegian Parliament (OED, 2020). It presented the complete governmental strategy of CCS in Norway, with Northern Lights as well as one or two full-scale industrial catchment sites, with the cement company Norcem and Fortum CCS as the finalists. When the national budget was announced later that year, it became clear that Norcem would receive full funding according to contract. Fortum received 3 bill NOK (ca. 300,000 euro) in partial funding and was requested to acquire additional funding (ca. 3.8 bill NOK) from EU sources (Fortum, 2021).

In March 2021, it was announced that Fortum's project was one of the 70 shortlisted in the first round of project applications to the

EU Innovation Fund. When the final decision was made in November 2021, Fortum did not succeed (Fortum Oslo Varme, 2021). However, four of the approved projects were CCS projects, and the majority of these projects pointed to Northern Lights storage. As to Fortum, this brought additional uncertainty; once again, the policy-making ball was in the Norwegian government's court regarding additional funds. Then, in the spring of 2022, the City of Oslo and partners came up with up to six billion NOK, ensuring economic backing of the project (Oslo Municipality, 2022). Fortum sold its 50% stake in energy provider Fortum Oslo Varme to a consortium comprising the municipality-owned Hafslund Eco, the Swedish investor Infranode, and the private equity firm HitecVision. In early 2023, the project, under the new name of *Hafslund Oslo Celsio*, made a final investment decision and received approval for catchment and temporary storage of CO_2, by the Norwegian Environment Agency (NTB, 2023).

In March 2022, Northern Lights was designated as an EU 'Project of Common Interest' (PCI): that meant that it could benefit from simplified permission regulations as well as being entitled to apply for EU funding from the Connecting Europe Facility. The NL PCI links project promoters in seven European countries (Norway, Belgium, Finland, France, Germany, the Netherlands and Sweden) (Northern Lights, 2021). However, the winter of 2022 saw dramatic changes in European politics. The Russian attack on Ukraine led to higher energy prices. The exact implications for CCS have yet to be determined, but there are few signals that it will weaken political commitment in Europe and Norway. On the contrary, it is more likely to increase interest in hydrogen with CCS (i.e., blue hydrogen).

The Northern Lights project consists of a transport network, a terminal, and a storage site off the southwestern coast of Norway. According to the official statement, '[i]t will be the first ever cross-border, open-source CO_2 transport and storage infrastructure network and offers companies across Europe the opportunity to store their CO_2 safely and permanently underground' (Northern Lights, 2021). Project Phase One is set for completion by 2024, with a projected annual storage capacity of ca. 1.5 million tonnes of CO_2. The official goals are as follows (Northern Lights, 2021):

- Demonstrate the whole chain of capture, transport and storage of CO_2 with acceptable costs
- Show that CCS is possible, and safely implemented
- Spread the technology
- Establish infrastructure for transport and storage of CO_2
- Contribute to cost reductions of future projects
- Contribute to business development

Asked what it would take to deem Longship a success, our interviewee from the MPE responded that it should be considered as such if it: (a) completes Phase One (one or two catchment plants); (b) establishes 5 million tonnes of storage with increasing economies of scale; and (c) leads to CCS diffusing faster in Europe than the case without Longship (interview 8). Further, interviews indicated changing perceptions and interests and the developing dynamics involving Equinor, Shell and Total as important (interviews 1, 4, 5, 8). For Equinor, the importance of establishing a market for CO_2 storage has changed significantly over the past 10 years, with the focus now on industrial emissions and on storage in Norway. With the 2019 changes to the London Protocol, Equinor's interests now involve establishing a European market for CO_2; and subsequently possibly also a blue hydrogen market.

For the Norwegian government, risk management has been central. According to our interviewees, the 'Mongstad failure', also referred to as the 'Mongstad ghost', made itself felt throughout the development of the Northern Lights project. Interviewees describe the initiation process of NL/Longship as 'completely different' from Mongstad (interviews 1, 4, 5, 8). As a central design principle, the Norwegian government, through the MPE, has split up responsibilities according to core competencies of the companies involved – catchment at the plants; transport by Gassco; and storage by the large petroleum exporters – and has taken charge of company support, requirements for tenders, and not least the budgeting and deadlines in a significantly tighter way, according to interviewees involved in these processes (interviews 1, 4, 5, 6, 7, 8).

The target focus of Longship is still primarily the ETS sector (although waste incineration is not yet included in the ETS) – but not the petroleum sector or coal based electricity generation. With Longship, energy-intensive industries such as cement and steel, as well as ammonium and waste, have moved into the spotlight, although there are also strong material interests for the petroleum/gas industry in a potential future market for blue hydrogen, as well as for prolonging the life of oil and gas exports. This has been better-received elsewhere in Europe than earlier CCS initiatives, which were mainly seen as prolonging the life of the coal industry. As one key industry interviewee noted, it is much easier to get support for an initiative that deals with difficult-to-cut emissions from the production of necessary goods and materials (interview 6). Petroleum companies are still involved, but primarily by holding key competence for offshore storage and having business interests in development of the necessary technology.

The overall project horizon for Longship extends far beyond Norway, as potential Norwegian catchment sites are too few. European customers are seen as crucial. Most interviewees held that the project can be seen as an attempt to overcome the 'chicken and egg' coordination problem for large infrastructure developments, where the government in conjunction with industry seeks to guarantee available storage and infrastructure, to make it feasible for other heavy emitters in Europe to develop catchment solutions for their own plants (interviews 1, 2, 3, 5, 6, 7, 8).

As to financing, the Norwegian state has a role as project guarantor. Before an investment decision can be made, a well must first be drilled – estimated to cost some 45–54 million euros. Estimated full-scale Longship project costs are currently some NOK 25 billion (approx. 2,5 billion euros) for the first 10 years. This includes investments as well as 10 years of operational costs. The Norwegian government will cover some two-thirds of these costs.

Summing up, in the 'Mongstad model', commercial interest within industry was no driver of the CCS policy. On the contrary, the core

TABLE 1 Main CCS policy differences and similarities.

	Official goals	Policy scope	Distribution of competence	Funding
Initial CCS policy – 'The Mongstad model'	Main goal: construct an operational full-scale CO_2 capture pilot and CCS test facility (primarily a domestic ambition)	Power sector (gas power) Capture technology	Agreement between the government and one company (Statoil) Statoil in control	Mainly governmental. No EU funding
New CCS policy – 'The Longship model'	Six goals: • Demonstrate whole chain of CCS at acceptable costs; • Show that CCS is possible and safe; • Spread technology; • Establish transport and storage infrastructure; • Contribute to CCS cost; • Develop CCS business	Energy-intensive industries Waste incineration Capture, transport, storage, proof of concepts at all levels	Agreement between Gassnova and three companies Longship involves also Norcem and Fortum Separation of capture, transport and storage	Initially €45–54 million covered by the government Attempt to achieve EU Innovation Fund contribution to Fortum Full costs: 25 bill NOK (mainly covered by the government)

company Equinor was pushed into the CCS project – without having to take the financial risks, which were taken by the state. Second, with one sole, large industrial actor, this reluctant actor was placed in a position of power, very much in control of expenses and project implementation speed. As the Norwegian state was taking the financial risk, this represented a challenging position for the government. Third, this core industrial actor had responsibility for the entire capture–transport–storage chain, essentially without having to bear the financial burdens of the project. That led to a precarious financial situation for the Mongstad project.

By contrast, the Longship model places industry in a strikingly different position. First, core industrial actors such as Equinor now see considerable business opportunities in the Northern Lights storage project and in blue hydrogen (from natural gas with CCS). Second, there are several core industrial actors involved, with roles far more carefully matched between their interests and responsibilities than with the Mongstad initiative

Table 1 sums up key similarities and differences between the initial CCS policy with the Mongstad project – and the new CCS policy, with the Longship project.

4 | ANALYSIS: PATHS AND LEARNING CENTRAL – BUT NOT THE SOLE FACTORS

4.1 | The central role of path dependency and policy learning

What can explain overall continuity in policy, with initial failure not completely halting the CCS venture but still inducing significant changes? When the process that became the Longship project started back in 2014, a new Conservative–Progress Party government under the leadership of Erna Solberg had taken over. This new government was less troubled by the 'Mongstad ghost' and initial policy failure, which had been a Red–Green political compromise.

However, we find that change of government cannot explain the setting in motion of the process that eventually became the Longship project. The key driving forces have been located in central bodies in the bureaucracy, subsequently negotiated 'up' to the political level. Our interviewees single out the MPE in collaboration with Gassnova as the key Longship entrepreneurs (interviews 2, 3, 4, 5, 6, 7, 8). These actors initiated a process involving knowledge production and mapping of industrial perceptions and interests. Importantly, Northern Lights and Longship took shape gradually. They were not imposed 'from above' – and this can be seen as relational learning from the experience of the failed Mongstad project. The government and MPE realized that there would have to be a business case for CCS beyond the petroleum sector – and, with that in mind, they designed a policy that evolved into Northern Lights and Longship. This was achieved by working with key industry players to spur interest in CCS, and by deliberately splitting the responsibilities for carbon capture, transportation, and storage among several sectors and companies (interviews 1, 2, 3, 4 5, 6, 7, 8).

To qualify as 'learning', something should lead to some sort of *change*, and we here can observe elements of both cognitive and relational learning. The cognitive change includes a change in perspectives in what role CCS could serve – from the electricity sector to more general emissions abatements from industry. Relational learning includes a significant change of organizing principles of organizational competencies, roles, and responsibilities, as well as anchoring needs beyond merely implementing 'top–down' political decisions.

The MPE did not need to start from scratch here. Several elements from the Mongstad initiative contributed to a certain CCS path-dependency. Important insights into the complex task of getting the CCS technology off the ground had been acquired through the CLIMIT research programme, and the hard-won experience of the bureaucratic and industrial actors involved. Gassnova was there as a key body to develop solid new ideas for taking CCS forward; and the TCM at Mongstad was in operation. All these elements represent a positive heritage from Mongstad that should not be overshadowed by the 'ghost' image. In our view, these factors help to explain the fundamental path dependency involved, and why CCS was *not* shelved as a policy option.

However, the 'Mongstad ghost' also demonstrates *negative* relational learning. A key lesson has been to focus on reducing the central coordination problem of demonstrating and developing a value chain and market that can reduce the risk for both potential catchment plants and the transport and storage infrastructure. The coordination problem – the 'chicken and egg problem' of CCS – is a well-known challenge as regards securing commitment in projects that require participation from several actors. Essentially, the problem here is that a company may not be willing to invest in CCS capture facilities unless there is a reliable solution for transportation and storage of CO_2. Similarly, an actor considering whether to develop a storage site may not be willing to invest until there is assurance of clients with captured CO_2 requiring storage.

Concerning the role of central industrial actors in the organizational model, we note significant differences. Industry is placed in a strikingly different position in the Longship model. These changes of the organizational model are additional examples of relational policy learning, as indicated by the critical lessons noted in policy documents as well as by several interviewees (interviews 3, 4, 5, 6, 7).

The incremental, low-key, 'bottom–up' and technical approach to the business case for CCS also shows clear indications of both cognitive and relational MPE learning from the Mongstad project and the initial CCS policy (interviews 4, 5, 6, 7). There has been – and will continue to be – debate as to the costs and risks associated with Longship. However, this discussion is more 'technical' and less heated than that surrounding the Mongstad project. CCS is now only one among several issues in the debate on how to achieve a low-carbon transition in Norway.

4.2 | Changes of exogenous factors

Several significant developments, which cannot be deemed policy learning or path dependency have also driven and shaped Norway's new CCS project policy.

First, within Norway, we can note in public opinion a changed perception of CCS projects, which does not really fit the 'learning' category. The Mongstad project emerged from a heated debate about gas-fired power stations, and the whole process was deeply tinged by this debate. Northern Lights/Longship has evolved in isolation from specific national industrial controversies – spurring spurred greater interest and public support. This has enabled greater public acceptance of Longship – indeed, constructive interest – and project development in a more deliberate and practical way.

Furthermore, national climate policy ambitions have been increasing: from the 40% emissions cut by 2030 target launched in 2015, up to the 50%–55% cut adopted in 2020, which includes the goal of achieving these cuts domestically (Gulbrandsen & Hermansen, 2022). These climate ambitions – in line with similar developments internationally – have helped to strengthen the case for CCS in Norway. In addition, as highlighted by Roettereng (2016, 2018), this can also be seen as a globally-oriented strategy, with the new CCS drive demonstrating norm adherence to the Paris Agreement and the international climate regime.

As to the overall policy signals from the EU, we note significant changes. In 2007/8, the EU aimed to become a global CCS frontrunner. The focus was on the power sector, and the goal was to have at least 12 pilot plants in operation by 2015. That ambition was politically dead by 2013/2014. In the European Commission's 'Clean Planet for all' Communication from 2018, the role of CCS is clearly downplayed: the focus on the power sector is dropped, replaced by a focus on CCS in energy-intensive industries (EU, 2018). This shift can be seen as a result of hard lessons learnt by central EU-policymakers: first with an EU CCS drive targeting the power sector, and then CCS failures in several member-states.

The idea for a new CCS drive in Norway was influenced by these international developments. The bureaucratic CCS entrepreneurs realized that CCS, if perceived as being linked to the coal and electricity power sector, was unlikely to receive support in the EU and elsewhere in Europe. This was also due to the rise of renewables in countries like Germany, the Netherlands and the UK. The way forward for CCS entailed a shift of sectoral focus, to avoid the framing of 'saving coal' among CCS skeptics, and emphasizing solutions for the energy-intensive industries, waste incineration, and other 'hard-to-abate' emissions from industrial processes.

Another key EU development that may have influenced Norwegian CCS policy was the carbon price in the EU Emissions Trading System (ETS). A robust carbon price is important to the business case for CCS (European Commission, 2013). The ETS experienced increasing troubles post-2009, with a surplus of allowances accumulating related to effects of the financial crisis – leading to a depressed, low carbon price (Wettestad, 2014). Basically, given the huge investment costs in infrastructure for carbon capture, transportation, and storage, there was no business case for CCS. But, following the adoption of the Market Stability Reserve in 2015 and further tightening reforms in 2018 have come significantly increasing carbon prices, in 2022 approaching the 100 euros threshold (Carbon Pulse, 2022; Wettestad & Jevnaker, 2019). Although this development is too recent to shed much light on changing policy design, our industry interviewees confirmed that an increasing and reliable future carbon price has become a major factor in the new CCS drive, strengthening the business case for reducing carbon emissions (interviews 1, 5, 6, 7, 8).

In addition comes the more specific interaction with the funding mechanisms generating EU-level support for project development. In 2009, the EU established the European Energy Programme for Recovery, with co-funding for six CCS demonstration projects, at 1 billion euros. Furthermore, in the revised EU ETS adopted in 2008, 300 million allowances were set aside for funding CCS and renewables projects – the NER 300 Fund (Boasson & Wettestad, 2013). As noted, however, this fund was not considered relevant for the Mongstad project. Moreover, as other CCS initiatives stranded for various reasons, in practice the NER money came to fund only renewables projects.

In the 2018 ETS Directive determining the rules for the phase 2021–2030, a new fund was established – the Innovation Fund. This sets aside 450 million allowances; CCS projects are included in the range of projects to be supported by the revenues raised by sales of these allowances (Wettestad & Jevnaker, 2019). Concerning Longship, the ambition had been that money from this Fund could make it possible to get the Fortum project (now Fortum Oslo Celsio) up and running. These hopes were crushed in the autumn of 2021. However, as the City of Oslo invested in the project in spring 2022, the project now seems set for realization.

The 2019 amendments to the London Protocol (LP) solved some of the key challenges to full-chain CCS as a truly *European* endeavor, by enabling transboundary cooperation (of transport and storage of CO_2) as well as competition between these. Fundamentally, the amendments enabled a shared interest among the main actors to start building a European market for CCS, where CO_2 and storage services can be developed in a reliable way. Not least because suitable storage sites are very unequally distributed, this change would enable actors needing storage in one country to utilize the storage services in, say, the Netherlands, Norway or the UK – all well placed to offer such services. This emerging competition between storage sites, in combination with a higher, more reliable price on the same CO_2, means a significant boost to the business case of European CCS. This is why the LP amendment is one of the most significant factors strengthening the new Norwegian CCS policy, according to our interviewees (interviews 1, 5, 8). Although the formal decision was not taken until 2019, it played a facilitative role even in the early days of Longship, as it was well known that Norwegian negotiators had worked hard to get this amendment adopted.

5 | CONCLUDING REFLECTIONS

We have analyzed why Norway initiated a new and ambitious national CCS policy following the failure of its first grand CCS initiative, and what can explain the changes from the first CCS policy to the new one. Following up initial studies (Roettereng, 2018, 2016; Tjernshaugen, 2012; Tjernshaugen & Langhelle, 2009), our study is among the first to offer a systematic analysis of important developments on Norwegian carbon capture and storage policy, all the way from the Mongstad project to recent developments in Longship. We find that the path dependency and policy learning perspectives provide helpful assistance in accounting for both the interesting continuity and change witnessed, although this framework cannot fully explain the new CCS policy and its design features. In particular, they link with international and EU developments – factors that will influence CCS policies in all of Europe. While acknowledging some challenges in making a precise demarcation between learning factors and 'exogenous' ones, we also highlight interactions likely to be relevant for CCS policy in other countries.

The path-dependency perspective helps to explain how established institutional structures – from the top–down organized Mongstad policy, including public administrative units in the MPE and advisory bodies such as Gassnova – contributed to keeping CCS on the national agenda in Norway. This – in combination with the expertise developed and persistent structural national interests for continuing with petroleum extraction and enabling for a future the oil and gas sector – helps to explain why CCS reappeared on Norway's political agenda so soon after the failure of the Mongstad CCS project.

The policy-learning perspective helps to explain the policy changes over time and the more specific differences between the two flagship projects – Mongstad and Longship. Cognitive learning includes the importance of focusing on energy-intensive industries and hard-to-abate emissions, rather than the use of fossil fuels in the electricity sector and 'saving coal' and linking Longship to European needs for industry. The dominant relational learning includes strategic work with international coordination for enabling CO_2 trade (the London Protocol), linking more clearly to international climate policy developments.

There have also been some crucial relational lessons for the internal Longship project organization, which may serve as more general learning insights likely to be valid also in other key CCS initiatives internationally. Key among these have been linking project responsibilities closer to competences and interests; dealing with key risks separately, to reduce the inherent complexity and amplified risks; and organizing clear requirements up front. Several of these include a mix of lessons of what *not* to do, as well as building on what has worked and on established competence. The complete reach of these insights will have to be followed up by country comparative studies.

Finally, several external factors have been involved. These include international facilitation and removal of legal barriers with the adaptation to the London Protocol, indirect support of the CCS business case with increasing EU ETS prices and heightened forecasts. We find less support for direct facilitation from the Paris Agreement – although, as highlighted by Roettereng (2016), this has arguably had an important indirect role.

As to the main implications of the changes in project design for the likely success of CCS in Norway and beyond, we find that prospects generally look better for the Longship organizational model than for the Mongstad model. Interest from central German industries could be noted in the autumn of 2021, and European interest, gradually increasing throughout 2022, including the designation of Northern Lights as an EU 'Project of Common Interest'. However, in 2021 it was announced that the Norcem/cement industrial part of Longship would cost 100 million euros more than planned. Although this increase was apparently due to the COVID pandemic and other unforeseen developments, it is important for project success that other such shocks do not follow. Then the 'Mongstad ghost' might well return to haunt the scene.

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APPENDIX A: Interview list (anonymized)

Interview no.	Date	Role	Company/Sector
1	16 January, 2020	MPE representatives	Ministry for Petroleum and Energy (MPE)
2	6 February, 2020	Policy analyst	Independent policy analyst
3	26 January, 2021	Advisor	Zero
4	3 February, 2021	Agency representative	Gassnova
5	16 February, 2021	Industry representative	Equinor
6	7 May, 2021	Industry representative	Fortum Oslo Varme
7	27 May, 2021	Industry representative	Norcem
8	5 November, 2021	MPE representatives	Ministry for Petroleum and Energy (MPE)