The is the accepted version of the article eventually published as:
Tor Håkon Inderberg and Jørgen Wettestad
Carbon capture and storage in the UK and Germany: easier task, stronger commitment?
Environmental Politics, Vol 24, No 6, 2015, pp. 1014-1033.
DOI: 10.1080/09644016.2015.1062592

Carbon Capture and Storage in the UK and Germany: easier task, stronger commitment?

Tor Håkon Inderberg and Jørgen Wettestad,
The Fridtjof Nansen Institute, Lysaker, Norway

Corresponding author: Tor Håkon Inderberg

Email: thin@fni.no

Abstract

A successful carbon capture and storage (CCS) policy and programme is widely considered essential to curbing carbon dioxide emissions. What explains the strikingly different policy outcomes in two key EU political heavyweights and coal economies, the UK and Germany? The UK has decided to contract two specific CCS projects, with explicit timelines for realization; Germany has made no such decisions. From scrutiny of official documents and in-depth high-level interviews, we find that the UK has more favourable structural capacity, including offshore storage capacity (which evokes less conflict) and significant oil-industry expertise, and thus an easier task. Moreover, this structural capacity has interacted with a solid political commitment to bring CCS forward in the UK, including specific, multi-stage funding and a high-level drive to develop CCS, especially after 2009. In Germany, by contrast, CCS has encountered increasing local and central opposition since 2009, with the *Energiewende* and renewables being accorded priority.

Keywords: *CCS, climate change mitigation, environmental policy, energy sector*

Introduction

The EU sees carbon capture and storage (CCS) as essential for achieving its long-term decarbonization targets (European Commission 2013). The goal of 12 demonstration plants in operation by 2015 was adopted in 2007, accompanied by policy initiatives – not least in the two key political heavyweights and coal economies, Germany and the UK. Both have positioned themselves as green frontrunners in the EU, and both are amongst the major EU countries (prior to Poland's accession) that rely most heavily on coal in their energy mix. CCS has been seen as necessary if coal is to continue to be used in the long run. This is coupled with high ambitions for decarbonization of the power sector in both countries.

The main policy decisions regarding material governmental support to CCS demonstration plants are strikingly different in Germany and the UK, which justifies choosing these cases for further investigation and a fruitful starting point for analysis of CCS policy. In Germany, politicians and industry have largely abandoned CCS; in the UK, there is political determination to bring two demonstration projects into operation by 2020, with specific financial support. We seek to explain the different policy outcomes by systematically comparing social dynamics and developments in these two countries whose outcomes matter considerably for EU climate-policy progress.

One difference concerns storage options: the UK has significantly higher potential for offshore storage of carbon dioxide (CO_2). As offshore storage generally entails fewer user conflicts than onshore storage, CCS might be politically easier for the UK. Previous studies indicate differing political commitment to CCS in the two countries (Meadowcraft and Langhelle 2009, Scrase and Watson 2009, Praetorius and von Stechow 2009, Jänicke 2011, Rayner and Jordan 2011, Hughes 2012, Shackley and Evar 2012), yet none compares developments in these two countries systematically and in-depth.

We find that the striking difference in policy outcomes is partly because the UK has a more favourable structural capacity and hence easier task than Germany. This includes differences in storage capacity and significant industry expertise, which has interacted with a solid political commitment to bring CCS forward in the UK, including specific, multi-stage funding, especially after 2009. In Germany CCS encountered increasing local and central opposition after 2009, with the energy sector transformation programme *Energiewende,* and renewables moving into the driver's seat.

Analytical framework

The ultimate evidence of CCS progress is concrete realization of CCS plants. As there currently are no fully developed demonstration plants in the UK or Germany, our dependent variable is *governmental contracting of specific CCS projects with realization timelines*.

Three main explanations can be offered for the presence or absence of specific governmental contracts. The first is based on basic national structural conditions and problem characteristics (Bailey *et al.* 2012), which shape an easier or more difficult road to realizing CCS. The second explanation recognizes these conditions, but emphasizes how national dynamics have led to a further shaping of such differences. With structural conditions basically frozen, the main policy interest lies in the dynamic factors – political commitment to CCS. Whereas the first explanation is suited for exploring how embedded factors lead to bounded policy decisions, the second focuses on how these can be influenced by political decisions and what room exists for them (Bailey *et al*. 2012). These two perspectives are unlikely to be fully isolated from each other, but represent analytically distinct and complementary accounts of climate-policy decisions. The third explanation highlights interaction with the EU.

Elaborating these three perspectives, the *structural conditions explanation* focuses on stable, slow-changing factors and fundamental conditions that can influence CCS realization. Although the factors grouped under this headline are diverse, they are all stable or even static. The distinction between factors that can be politically influenced and those that cannot is important for informing national policy, and is the main reason for such grouping of the variables.

First, a country with access to feasible offshore storage is likely to stand a better chance of developing low-conflict CCS projects than one with storage possibilities only onshore, entailing the likelihood of land-use conflicts. We measure offshore storage by analysing official estimates of storage potential and locations.

Second, a country already possessing relevant technological expertise, such as a petroleum exploration/extraction industry, is likely to provide more fertile ground for CCS than one without such expertise. This can be qualitatively assessed though interviews and economic activity.

Third, in a country with previous political conflicts over similar issues there is a greater risk that CCS may re-activate old conflict lines and resistance than in one with no such political conflicts (Fischedick 2009). This is difficult to establish objectively, but we asked interviewees to reflect on relevant potential or real issue linkages, leaving them to make connections. This approach involves minimal influence on interviewees, and enables comparisons of differences between the two cases.

Fourth, some elements of the national polity stand out as basically structural and not amenable to political 'manipulation'. A striking feature is the significant difference regarding the organization of the polity, including its degree of centralization: the German federal polity includes regional competence; the UK is a more unitary state. As the multi-level governance literature (Hooghe and Marks 2001, Bache and George 2004) suggests, federal states may present barriers to or even veto national-level policies to a greater extent than in more unitary states. Thus we hypothesize that *differences in specific CCS contracting are caused by one country having a more favourable structural starting point than the other, in terms of natural, technological and political characteristics.*

The *national dynamics perspective* includes factors subject to 'political will'. Firstly we map and analyse the degree to which CCS has figured as a central theme on the agenda of important governmental agencies, qualitatively assessed on the basis of official documents and interviews. We expect that the degree to which specific organizational units and capacity have been established or dedicated to promote CCS will influence the ability to realize CCS projects. A further central factor is how national funding has developed – including the level of funding of CCS development and the main characteristics of relevant public–private partnerships. We measure national funding by mapping and comparing public financial support and relevant framework conditions, through official sources and interviews. Summing up, in line with the national dynamics explanation, we hypothesize that *differences in specific governmental CCS contracting are due to one country devoting more agenda-related, organizational, and financial commitment to CCS than the other.*

Finally, the third perspective highlights the role of the EU. We focus on three central EU processes, beginning with interaction with the EU Emissions Trading System (ETS). A robust carbon price is important in forming the business case for CCS (European Commission 2013), although the EU-ETS has experienced increasing troubles post-2009 (Wettestad 2014). Second, in spring 2009 the EU established the European Energy Programme for Recovery (EEPR), with co-funding of €1 billion for six CCS demonstration projects. Third, in the revised EU emissions trading system (ETS) adopted in 2008, 300 million allowances were set aside for CCS and renewables projects – the NER 300 Fund (Boasson and Wettestad 2013). Focusing on differing engagement with the funding mechanisms as a potential explanation, we hypothesize that *differences in specific governmental CCS contracting are due to one country having a more active engagement with EU funding mechanisms than the other.*

The explanatory factors are unlikely to work in isolation from each other, so our analysis will discuss interactions. For instance, access to offshore storage may have a ‘double positive effect’ – directly as storage opportunities, as well as a petroleum industry with experience relevant to CCS. Such natural conditions may in turn influence other factors, like public motivation for investing in CCS and administrative and political salience. We build on empirical data from formal documents (official budgets, national white and green papers, official reports, and press releases), as well as secondary sources, including interest organization/research reports.

To triangulate written sources and get under the surface of official policy, we conducted 14 semi-structured interviews. Interviewees were chosen on the basis of broad representation (official governmental representatives, interest organizations, industry partners and otherwise involved individuals), and approached by email, with follow-up. Most were specifically targeted, but some were identified through ‘snowballing’. While a snowball approach can lead to empirical ‘blind spots’, our interviewees represented diverse actors, and with triangulation of sources no indications of substantial empirical gaps were found. All interviewees were asked specific questions about ambitions, political rhetoric, CCS-drive, effects and possible traps of policy choices, as well as encouraged to reflect freely about related issues, to allow new factors to be brought in.

CCS politics in Germany and the UK: chronological overview

Germany: snail’s pace and old wounds re-opened?

Germany is a federal parliamentary republic, with strong jurisdictional powers vested in the states *(Länder)*. Local political bodies and the Federal Council *(Bundesrat)* have become central foci for political action in the field of environmental issues (Schreurs 2003).

Pre-2005

CCS entered the research agenda in Germany in the late 1990s. Coal (particularly lignite) accounted for around half of electricity production, with renewables and 19 nuclear power plants accounting for around 7% and 30% respectively. Nuclear was at a standstill, as no new plants had come into operation since 1988. Natural gas accounted for the rest (13%) (Duffield and Westphal 2011). Research and debate on CCS were coupled to heated earlier debate going back to the 1970s about transport and storage of nuclear wastes, and the planned nuclear reprocessing plant in Wackersdorf (Spiegel Online 2010b, 2010a). From the mid-1990s, controversies increasingly focused on the transport of such waste.

There were significant 'Wall-fall' emissions-reduction effects when Germany became reunited (Hasselmeier and Wettestad 2000). Ambitious emissions reduction goals were agreed: the EU target-sharing agreement adopted in 1998 obliged Germany to reduce its GHG emissions by 21% by 2008–2012, which made it necessary to explore climate-policy options. The Social Democrats (SPD) won the 1998 elections and governed, in alliance with the Greens, until 2005. In 2000 this coalition adopted a comprehensive National Climate Protection Programme (Schafhausen 2002, Wurzel *et al.* 2003) – with no mention of CCS. Further development of renewable energy was a major element in the Programme, and this '*Energiewende'* became an increasingly important factor shaping the German climate and energy debate.

Two central research programmes with CCS as components were established after 2000: the GEOTECHNOLOGIES programme set up in 2000 to explore aspects of storage, co-funded by the Ministry for Education and Research (BMBF) and the German Research Foundation (GEOTECHNOLOGIEN 2013); and COORETEC (CO2-Reduktions-Teknologien), initiated in early 2002 by the Ministry of Economics and Technology (BMWi), which aimed to develop power-plant technology, with the CCS part focusing on capture (Praetorius and von Stechow 2009, COORETEC 2014). However, analysts and interviewees alike hold that CCS remained a political non-issue in Germany prior to 2005 (Praetorius and von Stechow 2009, p.139).

2005–2008: a certain CCS drive, several projects initiated

Our interviewees generally emphasize that the EU drive from about 2005 contributed to the growing interest in CCS in German industrial and political circles.

The energy giant RWE became involved in several CCS projects from 2005/2006 onwards. As its flagship project, RWE announced the development of an 'Integrated Gasification Combined Cycle' (IGCC) coal- or lignite-fuelled power plant (the Goldenbergwerk) in Hürth, North Rhine-Westphalia, in 2006, with which, according to our interviewees, CCS politics in Germany really 'took off'. The plan involved transporting 2.6 million tonnes of captured CO_2 annually via pipeline to storage in Schleswig-Holstein, at a cost of €2 billion (RWE 2013). The idea of locating the large-scale plant and the storage in different regions became controversial, and interviewees indicate that RWE did little to involve stakeholders. RWE's framing and initiative set the German CCS debate off on a bad note. Fears of pipeline leakage and groundwater acidification grew, with political conflict lines reminiscent of earlier controversies around nuclear waste; Greenpeace used identical wording and language as in its earlier battle against the transport and disposal of radioactive waste, talking about ‘time bomb CO_2 disposal’ (Roehrl and Toth 2009).

The energy giant Vattenfall launched a flagship project with its Oxyfuel ‘Schwarze Pumpe’ in Brandenburg, a 30MW pilot plant located near Vattenfall’s existing lignite-burning power station. Investment costs were initially estimated at €60 million (ZERO 2013). The plant began operation in 2008, with initial reports of successful CO_2 separation, with storage planned for 350 km away, in the large Altmark gas-field in Lower Saxony.

In 2005, the conservative CDU led by Angela Merkel won office, and entered coalition with the SPD. No significant changes were made to climate policy. The government launched an ‘Integrated Energy and Climate Programme’ in 2007 (BDU 2007), one of whose 29 proposed ‘actions’ focused on CCS. Germany adopted a ‘no regrets’ strategy for CCS, signalling only moderate spending and aiming to enable CCS technologies to achieve market status by 2020, with ‘rapid moves to organize the legal framework for the capture, transport and storage of CO_2’ (BDU 2007, p.12). The technical, environmental and economic feasibility of CCS technologies was to be confirmed by demonstration plants. Germany’s ministries of the environment, economics and research – all with responsibility for CCS – were to develop a ‘roadmap’ for its development (BDU 2007, pp.12–13), but CCS was not actively pushed politically. The environment ministry was sceptical about CCS. The economics ministry was split, with some officials open to CCS (and coal) because ‘you cannot run a society only on renewables’, as several interviewees put it. Almost no environmental organizations accepted CCS.

In 2008 Vattenfall initiated its Oxyfuel and post-combustion demonstration plant near Jänschwalde, Brandenburg, the largest coal-fired power station and point-source CO_2 emitter in Germany (25 Mt/Yr). Estimated annual CO_2 capture was around 1.7 Mt, at a cost of €1.5 billion. Probable storage sites were sandstone areas in the eastern part of the North German Basin (Vattenfall 2013, ZERO 2013). In 2008, the GFZ German Research Centre for Geosciences began storing CO_2 in aquifers near Berlin, as part of the European research project CO2SINK, with a first phase 2004–2010, which includes capture, transport and storage with a budget of €14 million.

At this stage, an Act on CCS (the KSpG), transposing the 2008 EU CCS Directive, was being developed by the German government. The initial draft made no mention of the possibility of local vetoes of CCS projects, or specific limits on the amount of CO_2 to be stored.

2009 and after: CCS grinding to a halt

However, in June 2009 the CCS draft law was withdrawn due to opposition in Chancellor Merkel's CDU, mainly from representatives of constituencies where storage-site exploration was proposed. This withdrawal can be seen as a tactical move prior to upcoming elections in September, indicating that CCS was not seen as a 'winning cause' (Helseth 2011). Our German interviewees agree that the postponement can be seen as a key turning point for CCS in Germany; thereafter, things became increasingly difficult. CCS was rapidly becoming a 'skunk issue' with which most politicians did not want to be associated.

At this stage the EU established its programme EEPR, which included co-funding six CCS demonstration projects. RWE and Vattenfall competed, and Vattenfall's Jänschwalde was awarded €180 million. Vattenfall also applied for the specific EU ETS funds, the NER 300 Fund. The application was later withdrawn – according to industry interviewees, in response to increasing turmoil over CCS.

In July 2010 a CCS compromise was proposed in the Bundestag. Now as a 'research law', it included a maximum storage limit of 3 Mton/year per storage site, a country-wide 8 Mton/year limit, and co-decision on storage sites for the German states. The Bundestag postponed debate on the law several times. Lack of local public acceptance was increasingly becoming a critical issue. In September the government announced national energy policy to 2050 with its Energy Concept plan. Here CCS technology was presented as offering attractive export opportunities for German industry, and the government endorsed 'the testing and where appropriate the use of CCS technology in Germany' (BMU 2010). Based on the CCS Act, two demonstration projects were envisaged by 2020 (BMU 2010, pp.16–17). By March 2011 the government had decided to phase out nuclear power within 10 years, stepping up the *Energiewende* and the turn to renewables (Beveridge and Kern 2013).

The watered-down CCS Act was adopted by the Bundestag in July 2011. It effectively granted the *Länder* veto rights over CO_2 storage within their borders, while also effectively excluding commercial use of CCS by limiting storage to 3 million tonnes per site. It was hardly coincidental that this corresponded to the planned annual volume of storage from Vattenfall's Jänschwalde project (Helseth 2011). No review of the Act was planned until after 2017. Three key *Länder* have been particularly involved in the storage debates. Niedersachsen (Lower Saxony) and Schleswig-Holstein, governed by the government partners CDU and FDP, have continuously worked against CCS locally, regionally and federally. Brandenburg, governed by SPD and *Linke* (the Left Party), has wanted to see the Jänschwalde project realized, co-funded by the EU (Helseth 2011).

After adoption in the Bundestag, however, the CCS Act was rejected by the Federal Council (Bundesrat) in September 2011, mainly because of disagreement about the local storage veto provision. Vattenfall and RWE then mothballed their CCS projects. In July 2012, a compromise was struck between the Bundestag and Bundesrat, and the Act on the Demonstration and Use of the Technology for the Capture, Transport and Permanent Storage of CO_2 (KSpG) was adopted in August. Maximum annual storage capacity per site was reduced to 1.3 million tonnes CO_2, with a nationwide annual maximum limit of 4 Mt (IEA 2013). The *Länder* hold a veto power on CCS storage that does not exist for nuclear power and waste incineration.

All major industrial actors have now given up on CCS in Germany. In addition to the specific German dynamics, the financial crisis, the low European carbon price and insurance issues have undermined the business case for CCS for the foreseeable future (European Commission 2013). However, the Ketzin storage project is progressing as planned, is claimed to enjoy high acceptance, and is seen as the main German CCS project success story – although it is not commercialization, but rather a research project. The German fuel-mix for electricity production in 2012 was coal 45%, renewables 24%; nuclear 16%; biogas 9% and natural gas 6%.

The UK: struggle, but also progress

The UK political structure is both centralized and unitary, generally dominated by majority cabinets through the bicameral parliamentary system. There is a relatively strong central government, albeit weakened through devolution to the national governments of Wales, Northern Ireland and Scotland in recent years.

Pre-2005: gradual awareness and research

Before the 2000s there was a gradual growth of awareness about CCS in isolated parts of British industry and public administration. In this phase, most efforts involved pushing CCS in the EU and elsewhere. Early official mentions of CCS, as in the 1993 Coal White Paper, did not regard it as a likely future solution (Scrase and Watson 2009); however, it gradually rose on the agenda after 2000. The 2003 UK Energy White Paper mentioned CCS positively albeit noncommittally, including discussions of North Sea storage potential and Oil Enhanced Recovery with CO_2 (UK Energy White Paper 2003), but CCS was not followed up in the Energy Act of 2004 (Shackley and Evar 2012).

Identifying specific figures for British R&D on CCS is difficult, as funding has gone under various names and funding bodies. The earliest research scheme was the 1994 Clean

Coal Technologies Programme, funded by the Department of Trade and Industry (DTI), but with limited attention to CO_2 reduction (Scrase and Watson 2009). In 1999 another DTI programme addressed efficiency improvement for coal plants as a means of reducing carbon emissions (DTI 1999, Shackley and Evar 2012). CCS was formally put on the research agenda in 2004/2005, and rose thereafter, coinciding with actions in Norway, the USA and elsewhere (Shackley and Evar 2012).

According to Haszeldine (2012, p.441), the UK is 'uniquely well provided with CO_2 storage potential' offshore. Storage can also provide synergies with traditional petroleum activities, and the UK is claimed to hold hundreds of years of storage for its own emissions, and possibly also for Europe (Senior CCS Solutions LTD 2010, p. 14); more concretely, in the 2010 'One North Sea' study, medium and high case scenarios for CCS deployment in the UK were 15 and 60 Mt CO_2/year by 2030 (Element Energy 2010).

Conflict over CCS has been low in Britain, with proponents outnumbering explicit opponents. Proponents are often coal- and gas-based electricity producers, petroleum companies and heavy-emissions industry. British NGOs have generally been pragmatic about CCS (Littlecott 2012), with few critical voices. There is a large industry with interests and expertise relevant for developing CO_2 transport and storage; not solely UK-owned, it consists of large companies such as National Grid, BP, Shell, Statoil and other petroleum majors, as well as sub-suppliers.

Later, academics began showing interest in CCS. In 2005 the UK invested only £0.1 million in R&D explicitly directed to CCS (Tjernshaugen 2008), but investments have since risen significantly. Several research networks have been established, initially based in London, later with Edinburgh as a hub, with UK and Scottish funding, including social and natural scientists, with a focus on the entire CCS chain. CCS has been an important issue for the Scottish government.

2005–2009: First commercialization competition; Climate Change Act

CCS has featured increasingly in the media since 2004/2005. However, opposition has been fairly muted, and public discourse is less polarized than in many other countries, probably because of 'the minimal invasion and minimal impact presented by planned and costed projects', in particular offshore storage (Haszeldine 2012, p.438). NGOs such as Sandbag and E3G regard CCS as important, even necessary, for curbing emissions.

Originally, most interest in CCS involved the petroleum industry (Boasson and Wettestad 2013). Our academic and NGO interviewees describe the rise of CCS in the UK as connected to the Miller petroleum field off Scotland and the Peterhead gas power plant in Aberdeen, which Shell in 2005 proposed be converted into a CCS test plant with government support. Arguing public procurement rules, the government decided to conduct a competition for tenders in 2007. Nine bidders entered, but eligibility was subsequently limited to coal-based, post-combustion power plants; five bidders were not eligible according to these new criteria (NAO 2012), including Peterhead, a gas power plant. Some interviewees feel strongly that excluding Peterhead was a missed opportunity that set British CCS back several years. In 2008 four projects were announced as winners of the competition. Three soon withdrew; the one remaining, Longannet, was mothballed in 2011.

The UK has implemented several acts and schemes relevant to CCS feasibility. The Climate Change Act 2008 made it the duty of the Energy Secretary to ensure that the net UK carbon target for 2050 remains at least 80% below the 1990 baseline, with binding five-year carbon budgets along the way. Interviewees hold that the Act and subsidiary regulations have implications for CCS: in particular, the general goals for long-term and binding emissions reductions serve to improve the CCS business case.

In 2008, energy and climate responsibilities were merged into the Department of Energy and Climate Change (DECC), a restructuring that acknowledged the central position of the energy sector in UK emission reductions. Part of the restructure involved establishing the DECC Office of CCS, a public administrative office dedicated to the development of CCS.

2009 and after: UK CCS progress drive

The 2009 launch of the EU EEPR programme, with its €1 billion budget, provided a potential external funding source for UK CCS. In December 2009, the programme granted the Don Valley Project (formerly known as Hatfield) €180 million for a CCS demonstration project. The grant was insufficient to trigger funding in the national competition, and Hatfield – the only UK project to win funding through this mechanism – was not realized. Most of the €1 billion made available for CCS pilot projects through the EEPR has remained unspent and will not be reallocated, according to Chris Davies, MEP (European Parliament 2014).

Prior to the 2010 elections, the Labour government proposed a CCS levy to fund more CCS test plants. The levy received strong support from CCS proponents. Although initially supported by the Conservative/ Liberal Democrat coalition, it was dropped in March 2011.

Instead, a Carbon Price Floor mechanism was introduced, adding a UK-specific carbon tax to British electricity generators to compensate for the low EU ETS allowance price. Parts of the revenues are to be used to support low-carbon technologies. The UK fuel-mix for electricity production in 2012 was 46% gas, 29% coal, 16% nuclear, and 16% renewables (IEA 2012). The use of coal for electricity generation is down significantly since 1990, from almost 70%, but the share of CO_2-emitting generation has remained high.

The Climate Change Act also prepared the ground for the Energy Market Reform (EMR), proposed in 2010, with significant potential for low-carbon structural change. An important CCS-relevant element of the reform is the 'Contracts for Difference' scheme (CfD), an adjustable feed-in premium system scheduled to start in 2017. Supported technologies (including CCS) will sell electricity and heat in the market, and CfD will cover the difference between the estimated market price and the long-term price needed to promote investments in a given technology – the 'Strike Price' (DECC 2012c, 2012b).

In 2012, the National Audit Office concluded that the 2007 CCS commercialization competition had suffered from insufficient planning, and lack of financial clarity and recognition of commercial risks, resulting in unsuccessful project realization and ultimately the withdrawal of the competition (NAO 2012); the lack of financial clarity delayed the early stages of the competition, and when a capital budget was eventually decided in October 2010, there was no agreement on government funding for operational costs.

In addition to the 2009 EEPR funding, the second EU-based support scheme, NER300, was relevant for British CCS plants. As of winter 2012, five UK CCS plants were eligible and shortlisted for funding, with differing technical solutions: Don Valley, Teesside, UK Oxy CCS demo, and C.GEN in North Killingsholme, with Peterhead as a reserve option (European Commission 2012).

UK governments have consistently declared their support for CCS, through progress reports on capture technology, storage technology, public acceptance and private funding. A new national CCS roadmap was released in April 2012, presenting the larger framework and policy statement of the government on CCS (DECC 2012b). Here, the main goal is described as being for commercial UK deployment of CCS in the early 2020s to be seen as a shared challenge for government and industry. This general goal includes the power sector and industrial emissions. In December 2012, the government published a database of UK CO_2 storage capacity, the first of its kind. The second CCS Commercialization Programme competition, announced the same day (DECC 2013b), included the £1bn not distributed in the previous round. Opening in April 2012, it closed in July 2012. Eligible CCS projects were to be ‘full chain’ or with prospects of becoming so. Candidate plants should be located in the UK with storage offshore, be operational at the latest by 2020, with abatement on a commercial scale (DECC 2012a). The criteria for eligibility and funding were now clearer and more consistent.

Furthermore, EU NER funding hinged on active national support. The Don Valley Project in particular, shortlisted for funding in the UK national and the NER300 competitions, was expected to win financial support from both sources. However, in December 2012, the project received formal endorsement from the government, but only after the first deadline had passed and UK co-funding could no longer be guaranteed. Our DECC interviewee noted that EU funding was not very significant in the larger picture, and that supporting the ‘wrong’ project could come at a higher cost than the potential gains. Don Valley subsequently failed in the national competition as well.

By October 2012, four full-chain projects had been shortlisted in the national competition. Revised proposals were submitted in January 2013; in March, the government announced support for the Peterhead gas-fired power station in Aberdeenshire and the White Rose Project involving a coal-fired power station at Drax in North Yorkshire. The Peterhead proposal involved a 340MW post-combustion capture retrofitted to part of an existing 1180MW combined-cycle gas-turbine power station, with partners Shell and SSE – a project that built on the original Peterhead project from 2005. White Rose was an Oxyfuel capture project at a proposed new 304MW coal-fired power station, led by Alstom and involving Drax, BOC and National Grid Carbon, with storage 90 km offshore**.**

These projects are planned to be constructed on existing plants. Front End Engineering and Design (FEED) contracts with DECC have been signed, with FEED phases expected to last into 2015, and the projects expected to become operational between 2016 and 2020. The two other bidders – the Captain Clean Energy project in Grangemouth and the Teesside Low Carbon Project – are ‘in reserve’. In the second round of NER300 announcements launched in April 2013, there was only one CCS project (as opposed to 32 RES projects) EU-wide: White Rose. Although welcome, NER support does not seem vital to the project.

Alongside commercial developments, significant research efforts have been underway in the UK since 2005 – notably, a committed governmental funding structure in a grand research programme of £125 million for CCS R&D between 2011 and 2015. This has resulted in a large number of projects, mainly basic research but also some on the applied and pilot levels (DECC 2013a). All this is indicative of the consistent political commitment of both Labour and the Conservative parties to CCS (Geels 2014).

Explaining differing CCS outcomes: interplay of structural and dynamic factors

Both Germany and the UK have struggled to bring CCS forward, with the result that in 2015, the main deadline in official EU policy, neither has a full-scale demonstration plant in operation. Yet the UK has announced support for two demonstration projects – and Germany none. Why?

Different national structural conditions?

Our hypothesis was that differences in specific CCS contracting are caused by one country having a more favourable structural starting point than the other, in terms of natural, technological and political characteristics. We found some support for this. Clearly, Germany and the UK have had very different CCS-relevant initial conditions as regards relatively static factors like natural endowments. Access to CO_2 storage is the most striking structural difference, UK access to large offshore areas with good storage capacity contrasting with Germany's opportunities mainly limited to land-based storage, which has proven neither politically nor practically easy.

This basic difference is important, as it tends to interact with and lead to several other issues and differences further along the causal chain. The existence of offshore oil and gas fields – the reason for the UK's large storage potential – also explains why an interested and competent petroleum industry is present on the national scene. Large companies like BP and Shell have been proactive in pushing CCS in the UK, whereas in Germany the number of planned and initiated projects has been moderate, and the petroleum industry has a much more limited presence.

Another striking difference lies in fundamental political/administrative structures. Compared to the UK's relatively centralised and unitary government, the German federal system entails various obstacles to CCS development. Concerned about environmental issues, several key *Länder* have been restrictive, as seen in the development of the German CCS law, with strict volume limitations to storage, which have been significant impediments to the realization of full-scale CCS plants.

Different national dynamics?

We hypothesized that differences in specific governmental CCS contracting are due to one country devoting more agenda-related, organizational, and financial commitment to CCS than the other. There are clear differences in how CCS has been framed and placed in the public debate. In Germany we find a stricter 'green' focus, with CCS seen by central governmental and non-governmental actors as merely contributing to 'business as usual', instead of underpinning the preferred and 'real green' *Energiewende*, with its major focus on renewables. The narrow 'green' focus is further indicated by the near-absence of environmental NGOs that accept CCS as a viable solution, a striking difference with the UK, where attitudes to transformation to a low-emissions energy sector have been more pragmatic, and CCS is an accepted technology at elite level, with the general public less informed but offering little opposition. In Germany, CCS has become associated with earlier controversies related to transport and underground storage of nuclear waste, which has tainted CCS technology's reputation, leading to low political feasibility; no larger NGOs or political parties express strong support for CCS.

Before 2008, national efforts were not so different. Relevant research was funded in both countries, although the UK had a more specific CCS funding structure in place. But 2008/2009, and particularly the adoption of the UK Climate Change Act (CCA), marked a turning point. Precise figures are difficult to obtain, but since 2011 the UK has spent significantly more on CCS research than has Germany. Even if the CCA had little to do with CCS specifically, it has already had a substantial influence on factors important for CCS. In particular, producing emission budgets has highlighted what has been interpreted as the necessity of CCS as part of the UK energy portfolio. A similar institutional mechanism has not been developed in Germany, where 2009 marked rather 'the beginning of the end'.

Furthermore, the CCA contributed to the establishment of DECC and the subsidiary specific office for CCS (OCCS). Opinion differs as to how well coordinated UK CCS policy has really been, but the establishment of OCSS has put the responsibility on the organizational map. Germany lacks a similar office or organizational node for CCS. Generally, the UK governmental apparatus seems more united in its perceptions of CCS than is the case in Germany, where there is a major split in and between the relevant ministries.

Differences in national CCS target-setting are another factor. The UK CCS Roadmap states the goal of a viable commercial CCS industry by the end of the 2020s. This has slipped slightly, with a delay from the early to late 2020s, but the goal is clearly expressed, and measures have been enacted to achieve it. Germany, by contrast, has had more diffusely stated official ambitions regarding CCS, with 'demonstration plants' to be realized by 2020.

The specific instruments have been weaker in Germany, and there are substantial differences in funding for research on CCS. Both major research programmes in Germany have included governmental funding, but they pale in comparison with Britain's. The UK programme of £125 million has funded most British CCS-relevant research and, ranging from basic research to concrete applied-science test projects on the verge of commercialization, has contributed to developing CCS and possible commercialization.

The differences are even starker as regards funding support for commercialization. Whereas Germany has not yet developed a concrete commercialization scheme, the UK has put in place £1bn, with goals for the industry to be commercially functioning by the mid-2020s. While final realization of the UK funding for commercialization is pending, the White Rose and Peterhead projects are well-positioned: FEED contracts have been signed, and the projects are currently being developed.

We find relevant differences also in other political framework conditions for CCS phase-in, especially for energy market structuring. Germany has a more open tradition and is less reluctant to support specific technologies. However, it has not yet developed specific conditions for facilitating the phase-in of CCS into the German energy system to improve the business case. The UK, although generally favouring a more narrow and 'technology-blind' approach (Mitchell 2010), has made important changes that influence the CCS business case; the changed support scheme with CfD contributes to realization of specific CCS projects.

Leadership by politicians to guide their publics towards acceptance of CCS has been more vigorous in the UK than in Germany. In Germany, CCS has become a complicated, burdensome issue from which politicians have increasingly sought to distance themselves. Knowledge about CCS among the public may be quite low in both countries and fundamental hostility towards the technology may not be much greater in Germany, but the room for organized opposition and mobilization has been allowed to develop more freely in Germany, with no supporting NGOs, high public resistance, and little political backing. Our evidence shows that politicians have more actively championed CCS technology in the UK than in Germany, the two largest political parties supporting it continuously by similar explicit goal statements as well as economic support schemes and regulations.

Different engagement with the EU?

We hypothesized that differences in specific governmental CCS contracting are due to one country having a more active engagement with EU funding mechanisms than the other. Does bringing in EU-level factors significantly enhance our understanding of the differences between the two countries? Not very much, although they are not totally irrelevant. First and foremost, EU factors can help to explain why CCS project activity in both countries increased considerably from 2005 onwards, and why the business case for CCS has deteriorated over time, in line with ETS problems and the low carbon price. But EU-level CCS funding has played a somewhat more important part in CCS politics in the UK than in Germany, and the effect of an overall low carbon price has been less detrimental for CCS dynamics in the UK than Germany due to the introduction of the British Carbon Price Floor. Table 1 sums up the key comparative differences.

Table 1: Key differences in the main explanatory factors for Germany and the UK

	Germany	**UK**
Structural conditions	• Mainly onshore storage • Marginal oil industry • Coal industry highly controversial • Decentralized system, with many veto points	• Good offshore storage possibilities • Significant oil-industry expertise • Coal industry less controversial • Relatively centralized system
National dynamic factors (political effort and framing)	• *Energiewende,* with renewables at the core • CCS a 'skunk issue' • Diffuse, moderate CCS funding • No specific CCS office • Little high-level support for CCS projects after 2009	• Pragmatic decarbonization • CCS 'just another technology' • Specific CCS funding, in several stages • Specific, governmental CCS office • High-level drive after 2009; plus CCA

Conclusions

Structural and stable factors like storage options, presence of relevant industry, status of coal industry and polity structure all emerge as important factors that influence the likelihood of realizing carbon capture and storage. As seen in Germany, when many unfavourable structural conditions are present, they can interact in ways that amplify the obstacles to developing commercially viable CCS. Moreover, the room for more dynamic factors that influence CCS – funding, national attitudes, administrative dedication and high-level political support – is shaped by structural conditions. In Germany, difficulties in storage options, coupled with heavy political influence from the *Länder* and issue-linkage to nuclear waste, have meant low commitment to CCS, whereas the UK has significant offshore storage potential and fewer complicating linkages to previous and controversial environmental issues such as nuclear storage. Furthermore, the relatively unitary polity structure of the UK favours national efforts, unlike Germany's complicated de-centralized and veto-based decision structure.

The UK has emplaced more significant policy measures for developing CCS, and political leadership on CCS matters has been more apparent and stronger than in Germany. Elite British politicians and bureaucrats have embraced the issue, in rhetoric and in practice; more funding has been allocated to research and specific project development, resulting in an active public–private partnership. In Germany, by contrast, leadership basically evaporated together with the reputation of CCS; both among the public at large and politicians it became a 'skunk issue' and an 'election loser'.

Initial differences in structural conditions do matter for the likelihood of developing CCS. However, these structural conditions are not necessarily the sole explanation for lack of progress – storage issues, for example, are in principle solvable. There appears to have been substantially stronger political will in the UK to take CCS technology forward, which, interacting with more favourable conditions, has contributed to a different outcome from that in Germany. Thus we conclude that while structural conditions establish the broader framework and room for politics to unfold, ultimate realization of CCS depends on political will.

Acknowledgements

Our research was funded by the Norwegian Research Council under the research centre Strategic Challenges in International Climate and Energy Policy (CICEP), of which the Fridtjof Nansen Institute (FNI) is part. We thank Arild Underdal and members of the European Programme at the FNI for helpful comments in the research design and writing, as well as two anonymous reviewers for constructive input that contributed to improving the quality of this work.

Interviews:

Heinz Bergmann, IZ Klima, Berlin, 1 July 2013

Matthew Billson, DECC OCCS, London, 26 November 2013

Mark Burnett, British Embassy Oslo, 25 January2013

Jeff Chapman, CSS Association, London, 26 November 2013

Wolfgang Dirschbauer, Vattenfall, Berlin, 25 June 2013

Stuart Haszeldine, University of Edinburgh, 29 May 2013

Peer Hoth, Ministry of Economics and Technology, Berlin, 5 July 2013

Matthias Kopp, WWF Germany, Berlin, 10 July 2013

Chris Littlecott, E3G and SCCS, Oslo, 5 November 2013

Indira Mann, ZERO and SCCS, Edinburgh, 29 May 2013

Damien Morris, Sandbag, London, 25 November 2013

Guido Oberschernikat, RWE, Berlin, 2 July 2013

Camilla Svendsen Skriung, ZERO, Oslo, 25 October 2012

Mervyn Wright, National Grid (previously DECC), London, 27 November 2013

References

BDU, 2007. *Key elements of an integrated energy and climate programme: decision of German Cabinet on August 23rd/24th 2007 at Meseberg*. Berlin: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Bache, I. and Flinders, M., 2004, eds. *Multi-level governance*. Oxford: Oxford University Press.

Bailey, I., MacGill, I., Passey, R. and Compston, H. 2012. The fall (and rise) of carbon pricing in Australia: a political strategy analysis of the carbon pollution reduction scheme. *Environmental Politics* 21(5), 691–711.

Beveridge, R. and Kern, K. 2013. 'The Energiewende in Germany: background, developments and future challenges. *Renewable Energy Law and Policy,* 4 (1), 3–13.

BMWi, 2006. *Up-date on carbon capture and storage activities in Germany.* Powerpoint presentation in New Delhi: German Federal Ministry of Economics and Technology.

Boasson, E.L. and Wettestad, J. 2013. *EU climate policy: industry, policy interaction and external environment*. Farnham: Ashgate.

COORETEC, 2014. *Info about COORETEC,* http://www.cooretec.de/index.php?index=21. Accessed 6 January 2014.

DECC, 2013. *CCS competition launched as government sets out long term plans*. Department of Energy and Climate Change 2012a [accessed 26 November 2013]. Available at: https://www.gov.uk/government/news/ccs-competition-launched-as-government-sets-out-long-term-plans.

———, 2012b. *CCS Roadmap: Supporting deployment of Carbon Capture and Storage in the UK*. London: Department of Energy and Climate Change.
———, 2012c. Electricity Market Reform: policy overview. London: Department of Energy and Climate Change
———, 2014. *Cross-government Carbon Capture and Storage R&D Programme 2011–2015: list of projects*. Department of Energy and Climate Change 2013a [accessed 12 February 2014]. Available at:https://www.gov.uk/government/publications/cross-government-carbon-capture-and-storage-r-d-programme-2011-2015-list-of-projects.
———, 2013. *UK carbon capture and storage: government funding and support*. Department of Energy and Climate Change 2013b [accessed 13 December 2013]. Available at: https://www.gov.uk/uk-carbon-capture-and-storage-government-funding-and-support.
Devine-Wright, P., 2011. Reconsidering public acceptance of renewable energy technologies: a critical review. In: M. Grubb, T. Jamasb and M. Pollitt,eds, *Delivering a low carbon electricity system: technologies, economics and policy.* Cambridge: Cambridge University Press.
DTI, 1999. *Cleaner coal technologies: future plans for research and development.* London: HMSO.
Duffield, J.S. and Westphal, K. 2011. Germany and EU energy policy: conflicted champion of integration? In J.S. Duffield and V.S. Birchfield,eds, *Toward a common European Union energy policy – problems, progress, and prospects.* London: Palgrave, 169–187.
Element Energy, 2010, *'One North Sea': A study into North Sea crossborder CO2 transport and storage.* Draft Report for the Norwegian Ministry of Petroleum and Energy and the UK Foreign and Commonwealth Office on behalf of the North Sea Basin Task Force.
E.On. *Web site CCS info* 2013. http://www.eon.com/de.html
European Commission, 2012. NER300: Moving towards a low carbon economy and boosting innovation, growth and employment across the EU In *SWD(2012) 224 final*, edited by European Commission. Brussels: European Commission.
———, 2013. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the future of carbon capture and storage in Europe.* Brussels.
European Parliament, 2014. *On implementation report 2013: developing and applying carbon capture and storage technology in Europe (2013/2079(INI))*. European Parliament 2014 [accessed 12 February 2014]. Available at: http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&mode=XML&reference=A7-2013-0430&language=EN#top.
Fischedick, M.E A., 2009. Stakeholder acceptance of carbon capture and storage in Germany. *Energy Procedia,* 1, 4783–4787.

Geels, Frank W., 2014. Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. Theory, Culture & Society, 31, (5), 21-40.

Geotechnologien, 2013. *Goals, organisation* 2013. Available at: http://www.geotechnologien.de/index.php/en/.

Hasselmeier, G. and Wettestad, J., 2000. *German climate policy ambitiousness: just a side-effect of reunification?* FNI Report 2/2000. Lysaker: Fridtjof Nansen Institute.

Haszeldine, S., 2012. UK carbon capture and storage, where is it? *Energy & Environment* 23 (2), 437–450.

Helseth, J. 2011. *CCS in Germany – is it game over?* [accessed 10 October 2011]. Available at: http://www.globalccsinstitute.com/insights/authors/jonashelseth/2011/10/10/ccs-germany-it-game-over.

Hooghe, L. and Marks, G., 2001. *Multi-level governance and European integration*. Oxford: Rowman & Littlefield.

Hughes, C., 2012. CCS in the UK: fears may be liars – or may be not. *Energy & Environment* 23 (2&3), 413–416.

IEA, 2012. *Energy policies of IEA countries. The United Kingdom: 2012 review.* Paris: International Energy Agency.

———, 2013. *Energy policies of IEA countries: Germany – 2013 review*. Paris: International Energy Agency.

Jänicke, M., 2011. German climate change policy: political and economic leadership. In: R.K.W. Wurzel and J. Connelly, eds, *The European Union as a leader in international climate change politics.* Abingdon: Routledge, 129–147.

Kraeusel, J. and Möst, D., 2012. Carbon capture and storage on its way to large-scale deployment: social acceptance and willingness to pay in Germany. *Energy Policy* 49C, 642–651.

Littlecott, C., 2012. Stakeholder interests and the evolution of UK CCS policy. *Energy & Environment,* 23 (2 & 3), 425–436.

Meadowcraft, J. and Langhelle, O., 2009. *Caching the carbon: the politics and policy of carbon capture and storage*. Cheltenham: Edward Elgar.

Mitchell, C., 2010. *The political economy of sustainable energy*. New York: Palgrave Macmillan.

NAO, 2012. *Carbon capture and storage: lessons from the competition for the first UK demonstration.* London: National Audit Office.

———, 2013. *The levy control framework.* London: National Audit Office.

Praetorius, B. and von Stechow, C., 2009. Electricity gap versus climate change: electricity politics and the potential role of CCS in Germany. In: J. Meadowcroft and O. Langhelle, eds, *Caching the* *carbon: the politics and policy of carbon capture and storage.* Cheltenham: Edward Elgar, 125–157.

Rayner, T. and Jordan, A., 2011. The United Kingdom: a paradoxical leader? In: R.K.W. Wurzel and J. Connelly, eds, *The European Union as a leader in international climate change politics.* Abingdon: Routledge, 95–111.

Roehrl, A.R. and Toth, F., 2009. A critical comparison of geological stprage of carbon dioxide and nuclear waste in Germany: status, issues and policy implications, 8th Conference on Applied Infrastructure Research, Berlin, 9–10 October 2009.

RWE, 2013. *CCS info* 2013. http://www.rwe.com/web/cms/en/8/rwe/

Schafhausen, F., 2002. *Germany's climate protection programme – a step by step approach*. Berlin: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Scrase, I. and Watson, J., 2009. CCS in the UK: squaring coal use with climate change? In: J. Meadowcraft and O. Langhelle,eds, *Caching the carbon: the politics and policy of carbon capture and storage*. Cheltenham: Edward Elgar, 158–185

Senior CCCS Solutions Ltd., 2010. *CO2 Storage in the UK: industry potential*. London: Department of Energy & Climate Change.

Shackley, S. and Evar, B., 2012. Up and down with CCS: the issue attention cycle and the political dynamics of decarbonization. In: N. Markusson, S. Shackley and B. Evar (eds), *The social dynamics of carbon capture and storage: understanding CCS representations, governance and innovation*. Abingdon: Earthscan/ Routledge.

Spiegel Online, 2010a. *The curse of Gorleben – Germany's endless search for a nuclear waste dump* [accessed January 15]. Available at: http://www.spiegel.de/international/germany/the-curse-of-gorleben-germany-s-endless-search-for-a-nuclear-waste-dump-a-672147.html.

———, 2010b. *A timeline of the anti-nuclear power movement in Germany* [accessed 6 November]. Available at: http://www.spiegel.de/flash/flash-24362.html

Tjernshaugen, A., 2008. Political commitment to CO2 capture and storage: evidence from government RD&D budgets. *Mitigation and adaptation atrategies for global change*,13 (1), 1–21.

UK Energy White Paper, 2003. *Energy White Paper: Our energy future – creating a low carbon economy*, edited by Department for Trade and Industry. London.

Vattenfall, 2013. *Web site info about CCS.* http://corporate.vattenfall.com/

Wettestad, J. 2014. Rescuing EU emissions trading: mission impossible?', *Global Environmental Politics*, 14 (2), 64–81.

Wurzel, R.K.W., Jordan, A., Zito, A.R. and Brückner, L., 2003. From high regulatory state to social and ecological market economy? ‘New’ environmental policy instruments in Germany. In: A. Jordan, R.K.W. Wurzel and A.R. Zito eds, *‘New’ instruments of environmental governance? National experiences and prospects*. London: Frank Cass, 115–137.

ZERO, 2013*. Web site info about CCS.* http://www.zero.no/