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► **To cite this version:**

Sébastien Chailleux, Xavier Arnauld de Sartre, Régis Briday. Ecological modernisation wanderings: ambivalent framing and unstable coalitions in the development of Carbon Capture, Utilisation, and Storage (CCUS) in France. *Journal of Environmental Policy and Planning*, 2023, 25 (4), pp.400-412. 10.1080/1523908X.2022.2162865 . hal-03919746

HAL Id: hal-03919746

<https://hal.science/hal-03919746>

Submitted on 3 Jan 2023

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Ecological Modernisation Wanderings: ambivalent Framing and unstable Coalitions in the Development of Carbon Capture, Utilisation, and Storage (CCUS) in France

Sébastien Chailleux, Sciences Po Bordeaux, Centre Emile Durkheim (*lead author*)

Corresponding author: s.chailleux@gmail.com

Xavier Arnauld de Sartre, UMR TREE (Pau, France)

Régis Briday, CNAM (Paris, France)

Abstract:

Ecological modernisation tends to dominate institutional definitions of low-carbon transitions in industrialised countries. While most works study the market solutions and the technological innovation constraints of Eco-Modernist (EM) projects, this article analyses them at a micro level through the study of the development of an EM coalition supporting industrial Carbon Capture, Utilisation, and Storage (CCUS) in France. Drawing on interpretive policy analysis and the sociology of innovation, and focusing on the building and erosion of a common frame within the coalition, we highlight the ambivalence of the framing of the solution and the instability of the coalition supporting it. First, we show that, like most EM innovations, almost all CCUS projects in France have been co-constructed between public and private actors. Second, we argue that the ambivalent frames developed by French promoters of CCUS initially legitimated the deployment of the CCUS technologies but led to a misalignment of actors in the long term. We conclude by encouraging scholars in more micro-observation of EM coalitions in order to gain a better understanding of their internal conflicts and of their heterogeneity, and to document the general, now dominant, discourse of EM in the field of environmental policies.

Keywords: CCUS (Carbon Capture, Utilisation, and Storage); France; Ecological modernisation; coalition building; framing

7974 words without keywords and abstract

1. Introduction

Industrial Carbon Capture, Utilisation, and Storage (CCUS) aims to prevent CO₂ emissions from reaching the atmosphere by capturing it on industrial sites and then either burying it underground or reusing it for industrial purposes. First experimented with during the 1990s, and mainly developed since the mid-2000s thanks to the support of industrialists, public research centres, and State support (USA, Australia, European Union, etc.) (O'Neill & Nadaï, 2012), CCUS suffered a dire time in the early 2010s linked to the post-2008 economic crisis and the lack of social acceptability of several projects (Brunsting et al., 2011; Markusson et al., 2012; Ha-Duong & Chaabane, 2010; Kuijper, 2011). Nevertheless, it was put back on the agenda with the 2014 IPCC report and COP21 as a solution for the further decarbonisation of the industry and the development of negative carbon emissions thanks to BECCS (Bio-Energy with Carbon Capture and Storage) (Aykut et al., 2018; IPCC, 2014). Beyond the usual factors found in the literature (economic model, storage availability, social acceptability, and political support (Hansson et al., 2022; Minx et al., 2018; IEA, 2016; Chailleux & Arnauld de Sartre, 2021; Bertrand du Chazaud et al., 2018)), we focus here on the internal dimensions of the French coalition supporting CCUS. This leads to a better understanding of what contributed to limiting the development in of CCUS in France, and how reframing processes within the coalition limited the ability to convince external stakeholders about making CCUS an option in fighting climate change.

The Global CCS Institute describes France as a second-tier actor, with a lower domestic 'inherent interest' in CCUS than countries such as the USA, Germany, the UK, and the Netherlands. France's 'propensity towards fossil fuel' is lower (mainly because of the massive use of nuclear power) and the country has undergone important deindustrialisation. Only one middle-scale CCUS facility was implemented in Lacq (south-west France), storing 51 ktCO₂ (vs 30 MtCO₂ worldwide in 2017).

However, ‘the overall strength of [the] government’s policy stance on CCS’ is higher in France compared with most other Western European countries with a similar (Spain, Italy) and even a higher ‘inherent interest’ (Germany) (Global CCS Institute, 2017, pp. 37 & 29). French companies and research centres did develop CCUS technologies, with the help of European and national grants (INERIS, 2017, pp. 39-44; Pigeon, 2016), and CCUS became integrated into the 2020 National low-carbon strategy as a contribution to the 2050 carbon neutrality goal (MoE, 2020; Chailleux & Arnauld de Sartre, 2021; O’Neill & Nadaï 2012). This constitutes a seeming French paradox which we analyse in this paper: why did French actors invest, and why are they still investing, in CCUS despite low domestic prospects and so few outcomes? This question has not been tackled yet in the few studies of French CCUS (with almost all of these analysing the pre-COP21 sequence (O’Neill & Nadaï, 2012; Pigeon, 2016), rather than how the following ‘renewal phase’ transformed the CCUS narratives and coalition).

This empirical question is coupled with a wider theoretical question about how coalitions promoting Ecological modernisation work and about their internal strategies. The CCUS coalition displays the attributes of an Eco-Modernist (EM) coalition, we argue. The promoted solution is an endogenous renewal arising from actors and industries criticised for their contribution to climate change. The solution is part of a tradition of carbon management and backed by market instruments, particularly the EU Emission Trading Scheme (ETS) in this case. These are two main features of Ecological modernisation which is now dominating institutional definitions of low-carbon transitions in industrialised countries (Mol et al., 2009). As a political programme, Ecological modernisation tends to depoliticise transitions and favour the development of standard technologies as global solutions (Bidone, 2022; Aykut & Evrard 2017; Newell & Mulvaney 2013). It has long been criticised at the expense of a broader understanding of politics and complexity

(Paterson et al., 2021; Rudolf 2013; Avelino et al. 2016; Kenis et al., 2016). While systemic analysis favours external explanations for failed EM agendas, such as the role of public opinion, network and coalition studies provide complementary analysis focused on the internal dynamics (Jorgensen, 2012; Kenis et al., 2016). Showing the internal politics of the EM coalition supporting CCUS in France, our article stresses the heterogeneity of EM coalitions and the internal struggles and limitations involved in supporting the nonetheless dominant frame for ecological transition.

Our argument is threefold. First, we explain the sustainability of CCUS in France despite low interest and constraints arising from the particular characteristics of the coalition. We show that CCUS is built within public and private partnerships rather than being an exogenous innovation that could be ‘captured’ by economic incumbents (Pel, 2016). Second, we explain the failure of the up-scaling of CCUS projects arising from the instability of the coalition and its framing. We argue that the ambivalence of the objectives (Walker & Shove, 2007) worked to the point that this remains ‘consistent’ both within the coalition and between it and other coalitions. Third, we describe the heterogeneity of the coalition, and the ability of one solution (CCUS) to be reframed to fit various problems (clean coal, carbon leakage, carbon neutrality, etc.). We highlight how the identities of actors were tied to the narratives that they developed. Drawing on interpretive policy analysis (Fischer et al. 2017; Dodge & Metze 2017; Metze 2017) and the sociology of innovation (Callon 1986; Latour 1992), we study the framing processes within a coalition, its political dynamics, and how the common objectives and discourse are defined. We show that, in the long term (1993-2021), the ambivalent frames led to a misalignment of actors, with the strategy of industrialists diverging broadly from that of public planners and some experts.

In a first, theoretical section, we explain why the CCUS case exemplifies the importance of analysing technological framing. Second, we briefly expose our methods. Then, we analyse the

strategies of the three main types of actors supporting CCUS. Finally, we discuss the instability of their coalition and the ambivalence of their framings.

2. Theoretical Approach: analysing an Eco-Modernist Community from the Sociology of Innovation and Interpretive Policy Analysis Perspectives

‘Transition studies’ are mainly focused on how a radical niche transforms the existing regime (Geels, 2005). More recently, they have also analysed how incumbent actors develop an innovation to maintain their hegemonic position (Köhler et al., 2019; Turnheim & Sovacool, 2020). Ecological modernisation (Avelino et al., 2016), and CCUS development, mainly take place in this framework, with actors ‘greening’ their sector inside the fossil-fuel regime. While many social science publications have addressed the ambivalences of the EM discourses and the limits of the implementation of EM agendas (Kenis et al., 2016), we want to refine the study of transition in stressing the need to open the black box of coalitions, particularly EM coalitions, in order to highlight the conflicting goals of actors and how these challenge ecological transition (Avelino & Wittmayer, 2016).

Based on discourse coalition analysis (Hajer, 1993), we look at the enlistment processes around CCUS to show the core role of narratives and frames within the coalition (Callon, 1986; Latour 1992; Zittoun et al., 2021). Framing encompasses the production of the way in which CCUS is interpreted outside the core set of actors who build it, defining the conditions in which it can prosper. Building on the coupling process between a public problem and its solution (Kingdon, 1984; Zittoun et al., 2021; Cohen et al., 1972), we analyse CCUS as a policy proposal (Zittoun, 2014 & 2016). While a public problem encompasses causalities between a public of victims, a tragic future, and the villains to blame (Gusfield, 1981; Stone, 1989), a policy proposal is composed of causalities between a public of beneficiaries, a bright future, and the heroes involved

(Zittoun, 2014). The policy proposal ‘tames’ a public problem, addressing some of its aspects and not others, generating beneficiaries and scenarios for the future (Zittoun, 2016).

Furthermore, proposals may bear different meanings in different arenas, notably between private spaces and public fora. This does not mean that the actors lie to the public to defend hidden goals, but rather that a solution can have different goals at the same time in different arenas. Nevertheless, these goals have to be clear enough, since ambivalence can slow the politics of transition (Walker and Shove, 2007). As observed with solar or biogas technologies, coalitions between strategic actors and their subsequent alignment are often critical to the success of a technology. Several authors stressed the inconsistencies appearing between their strategies and narratives (Markard et al., 2020; Bohnsack et al., 2016; Planko et al., 2016). In this paper, we show that, despite a seemingly homogeneous frame from the outset, CCUS promoters defended contrasting goals for CCUS, thereby making this solution ambivalent.

Stressing the links between a coalition and its narratives also questions the role of actors’ identities. The ‘owners’ of a solution (cf. Gusfield [1981]’s ‘owners’ of a public problem) not only define it so that it fits their expectations, they also shape it to demonstrate their legitimacy to participate to governmental action and to assert their ability to rule over and settle public issues. Ownership of solutions redefines the ties that bind proposals and problems, as it reflects the owners’ vision of the world; *at the same time*, the proposal builds the group identity by becoming part of this identity as the group gains a reputation (Carpenter 2010), professional opportunities, or political influence. The study of the political construction and maintenance of the coalition leads to an examination of how actors argue, adapt, and define their identities and interests, and of how they convince other actors to agree with them (Zittoun et al., 2021; Hajer & Wagenaar, 2003).

3. Methodology: a Field Study of the Promoters of CCUS in France

Our study combines different types of data gathered in France between 2017 and 2020. First, we qualitatively analysed about 20 national planning documents, such as the national low carbon strategies, public expert reports (from ADEME¹, INERIS², BRGM³, and IPFEN⁴), and documentation on R&D projects. These documents helped us to identify the evolution of narratives and the targeted issues and opportunities at stake. We also studied the press coverage to identify the main actors promoting and implementing CCUS.

Second, we interviewed 24 actors involved in CCUS development (Table 1). We differentiate three main types of actor: public research agencies, corporations, and public planners. The objectives of the interviews were to know their type of involvement, their role (actions, investments), and what types of narrative they used. Each interview was unique with its own dedicated questions but they all followed a similar frame, targeting the chronology of CCUS development in France, the various justifications for innovation, the scope of the actors' involvement in different periods, the identified brakes and breakthroughs, etc. Interviewees were put into the position of witnesses and asked to remember particular moments of decision or conflict, or particular meetings. Here, we do not use the words of interviewees as an objective testimony or analysis; rather, we multiply the witnesses of a situation to cross the various points of view and interpretations.

Table 1 - List of interviewees

CCS project manager, IPFEN

¹ State agency in charge of energy management.

² National institute for industrial environment and risks.

³ National geological survey.

⁴ French school of petroleum and new energies.

CCS Project manager, ADEME	x2
Deputy Director, General Directorate for Research and Innovation, Ministry of Higher Education and Research	
CCS Coordinator, Total	
Senior Research Officer, BRGM	
Institutional Relations Coordinator, Total	
Senior Project Manager, IFPEN	
Former Project Manager, Schlumberger, and Consultant	x2
Business Developer, Le Havre Developpement	
Project Manager, General Directorate for Climate and Energy, Ministry of Ecological Transition	
Project Manager, BRGM	
Project Manager, CFG	
Communication Manager, BRGM	
Project Manager, CFG	
Research Engineer, Engie	
Legal Expert, Université de Nancy	
Project Manager for Climate Planning, Paris	
Project Manager, ADEME	

CCS Project Manager, ADEME
Strategy Manager, Terega
Engineer, Solexpert
Project Manager, EDF

Finally, we used participative observation. We were involved in different meetings with CCUS promoters, and more generally with experts and operators of the French underground. We participated to colloquia dedicated to those questions and to partnership research programmes aimed at improving the governance of the French subsurface.

Most specialists describe the development of CCUS at a global level as a three-period history: a rise, a decline, and a ‘renewal’ (Minx et al., 2018; Hansson et al., 2022). Nonetheless, they differ about the exact timing of the sequences, depending on the technology used as a starting point. The 2016 IEA report describes a peak of political support in 2009 and a lowest point in 2014 (IEA, 2016, p. 18). Hansson et al. (2022) analyse public debate about carbon geological storage and describe a peak of attention between 2007 and 2013. Pigeon (2016), studying the French case, sets the upper tipping point in 2012, following the release of the results of the European programme funding CCS demonstrators. Overlapping these political, social, and economic considerations, different technologies targeted various industrial sources of carbon: CCUS initially targeted clean-coal development until the late 2000s and diversified at the beginning of the 2000s towards heavy industries; it then developed after 2015 towards valorisation but also bioenergy and waste- and gas-fired power plants.

We sequenced the development of CCUS following the recurrent milestones our interviewees used, namely the post-2008 economic crisis and COP21. The first stage (*circa* 1993-2009) is the demonstration period. The aim was to prove that the technology was viable and realistic on an industrial scale through public-private industrial pilots and demonstrators (O'Neill & Nadaï, 2012). It starts with the first European research project and ends with the European Directive on CCUS and the European Demonstrators Funding Scheme in 2008-2009. The period of decline starts in 2009 with the financial crisis, but also commercial, regulatory, technical, and acceptability issues put a stop to further advances in CCUS. Most projects halted in Europe and the European Funding Scheme failed in 2012 (Markusson et al., 2012; Scott et al., 2012). The 'renewal' period starts in 2015 with COP21. If CCUS is widely recognised nowadays as having a role to play in limiting climate change, the technology remains controversial and the number of CCUS projects is still low in Europe (and even in the USA and China) (IEA, 2021).

4. The changing Strategies and Narratives of the three Types of Promoter of CCUS in France: Inconsistencies and Synergies

In this section, we analyse the main actions and narratives of the three categories of actor during the three-stage history of CCUS in France (Figure 1).

	Public experts			Industrialists		Public planners	
	BRGM	IFPEN	Total	Power producers (EDF)	Steel factories (ArcelorMittal)	ADEME	Ministries (MoE)
Demonstration period (1993-2009)	<i>Developing and exporting French subsoil expertise Greening previous activities</i>			<i>Developing technologies Being prepared for new regulations Responding to public pressure Greening previous activities</i>		<i>Supporting innovation Avoiding 'carbon leakage'</i>	
Lacq demonstrator + post-2008 crisis							
Decline (2009-2015)	BRGM maintains but reduces its CCS program	IFPEN loses interest	Total loses interest	EDF and Mittal give up	ADEME and MoE show limited interest in CCS		
	<i>Developing subsoil expertise Technical certainty</i>		<i>Being ready just in case...</i>		<i>Avoiding 'carbon leakage'</i>		
IPCC 2014 + COP 21							
Renewal (2015-2022)	BRGM still maintains CCUS in small structures	BRGM, IFPEN with Mittal and Total investigate carbon reuse	Total finally includes CCS significantly in its agenda		CCUS included in French strategy		
	<i>Developing subsoil expertise Smaller storage CO₂ use promoted</i>		<i>Offshore CCS mainly (with a "waste management" model with decoupled activities)</i>		<i>Carbon neutrality Promoting CO₂ use and BECCS</i>		

Figure 1 - Synthesis of the main actions and narratives of the members of the CCUS coalition

Public-sector Experts on the Subsurface: the central Role of BRGM and IFPEN

During the first period (1993-2009), subsurface experts presented their work as an endogenous R&D effort designed to demonstrate the value, safety, and competitiveness of the technology, and to convince policymakers to include CCUS in the energy transition portfolio. *‘It was all about studying the feasibility of this concept, because some people were beginning to suspect human activity to have an impact on the climate. And even if we were not sure, the Commission pushed for a research project to study the possibilities to act.’* (Senior Research Officer, BRGM) In France, subsurface scientists and experts working for the public sector are at the heart of CCUS research and promotion, which they see as a continuation of their traditional technical activities. University research centres, such as the *École des Mines de Paris* and the University of Lorraine, got involved in several research programmes. More importantly, BRGM and IFPEN (formerly IFP), the two French organisations originally responsible for training in mining and for hydrocarbon exploration

and extraction, went through a crisis in the 1980s, with the decline of hydrocarbon and mines exploitation and the relocation of production outside Europe (Chailleux, Merlin & Gunzburger, 2018). In the 1990s, CCUS looked like a new opportunity to reform their activity, and also to green it. *'At IFP, we are fortunate in being able to intervene in the entire chain, from capture to final storage. So IFP came to this subject quite naturally, because we were starting to work on the energy transition, a little ahead of schedule, before the politicians got hold of it.'* (Senior Project Manager, BRGM) CCUS could potentially benefit from policy incentives because it was portrayed as a way to produce a national expertise to be exported worldwide, and could fit neatly into the EU industrial innovation strategy (O'Neill & Nadai, 2012; BRGM & IFPEN interviews).

During the years of decline (2009-2014), the main French oil and gas company, Total, implemented a first pilot in Lacq, but the economic crisis and the rise of renewables obscured the future of CCUS. Total aimed to demonstrate that the company had mastered the whole carbon chain from capture from a nearby chemical site to storage in a depleted gas reservoir (51ktCO₂). When the Lacq project (2009-2013) was contested (mostly about the risk of carbon leaking and induced seismicity), public experts were called upon as honest brokers. They claimed that the only significant experiment made was relatively 'small' and technically 'simple', and they reiterated public narratives about know-how and technical mastering. The contestation remained limited but made an impression on the public experts who framed social acceptability as a main limiting factor for future projects. They also mobilised the failure of the Barendrecht project (Netherlands) because of social unrest, an example of the lack of social acceptability of CCUS. However, CCUS has never been in the spotlight in France. A 'technocratic' way was chosen by experts, who could thus decide whether CCUS would fit into public decarbonisation strategies; besides, no other actors (e.g. environmental NGOs) publicised the issue. The French subsurface experts overcame the issue

of technical credibility in Lacq, and almost stopped considering such an issue as plausible in the late 2000s, at least in their discourse (in parallel, our interviews and our press analysis show the decline of the argument about technical uncertainty in the French press at that time). However, they also stressed the limitations of CCS implementation in France with the release of their own geological survey, the 'France-Nord' study (2008-2012), which showed that no important geological reservoir existed in northern France.

Another role for BRGM and IFPEN during this period was to keep CCUS on financial life-support through the continuation of research programmes, if not through demonstrations and industrial pilots (as in the COCATE project in the harbour of Le Havre (2010-2013); aiming at developing a prototype carbon capture technology, this involved the rail industry manufacturer, Alstom, and was funded by ADEME and the EU through a three-year 4.5M€ research programme). Pigeon (2016) also describes many R&D activities until 2012, e.g. the industrial programme led by MinesParisTech. The narratives targeting policymakers were about the need for more demonstrations and assessments. Not all experts maintained the same level of enthusiasm over the years, however: while BRGM continued to produce numerous research articles and engaged in new research projects (BRGM interview), IFPEN researchers lowered their expectations and their interest in CCUS (IFPEN interview).

In addition, while subsurface scientists asserted that CCUS no longer had major 'technical credibility' problems and that no major social resistance had arisen (in France), they pointed their efforts at designing a discourse and a business model that would make CCUS a solution to both limiting CO₂ emissions and keeping industries on French soil (IFPEN interview). BRGM and IFPEN had actually put forward the argument of CCUS as a way of keeping carbon-intensive

industrial activities in France from the outset, but with the economic crisis, this became a more powerful argument and all three types of actor made greater use of it.

Finally, during the ongoing period from 2015, French CCUS has accentuated its efforts in offshore CO₂ storage abroad, while diversifying its domestic activities. For CCUS promoters, diversification sounds like a means of escaping from the economic valley of death in which the traditional CO₂ capture, transport, and storage model for big facilities was stuck, and of restoring the value of their expertise. In recent years, the emphasis has often been put on the potential for CO₂ re-utilisation (with CCS giving way to CCUS, standing for Carbon Capture, *Use*, and Storage, in discourses), BECCS has gained traction (Hansson et al., 2022), and smaller projects have been initiated (IEA, 2016: 26). French experts have also targeted smaller projects in order to maintain the possibility of onshore storage (BRGM interview).

Industrial Actors: the Oil and Gas Company, Total, is the only Manufacturer with significant and enduring Involvement in CCUS

Public funding was central to the development of CCUS R&D (INERIS, 2017), but most projects were ‘public-private funded’, and some private companies invested several million euros during the 2000s. Total was at the forefront of CCUS promotion through its Lacq pilot and the development of its own combustion technology. Other industrialists with high-emission facilities also participated. The main electricity producer, EDF, developed CO₂ capture in the harbour of Le Havre in 2010, Arcelor-Mittal joined forces with ADEME to develop a technology for CO₂ capture from blast furnaces as early as 2004, and Alstom and Air Liquide worked with MinesParisTech to develop another capturing technology. Initial interest among industrialists was geared to

technological innovation to prepare for the forthcoming limitations of CO₂ emissions, particularly those linked to the implementation of the EU's ETS.

However, the industrial emissions abatement was not the only reason for investment. First, big industrialists presented CCUS as a 'greentech' and thus used it to 'green' their investments. Total felt pressure from civil society but also from the French State: along with other oil companies, it was targeted as being among those highly responsible for climate change. A member of Total R&D staff explained: *'We wanted to show our good will. At that time, we were constantly under the threat of windfall taxes, and the French government was saying "You have to do something or we'll tax you." So we prepared some 'ammunition' for Thierry Desmarest⁵, such as the pilot project at Lacq, and we said we could "improve the science, do the R&D". It cost us 100 M€ but it was an order of magnitude that Total could bear'* (Total interview). With the Lacq pilot, Total did not only intend to prove that it was possible to capture and store a significant amount of CO₂ on a French industrial site, it also 'wanted to show the national authorities that it was getting ready' (Géodénergies & CNRS interviews).

Second, industrialists argued that CCUS was a way of preventing the relocation of employment. Arcelor-Mittal, for instance, used this argument to justify its CCUS projects in Florange and Dunkirk, all the more so as the French government was investing in those projects with the same justification.

Third, an external incentive appeared interesting to oil and gas companies: they had little interest in capturing CO₂ in their refineries, but power producers, and especially coal-power producers,

5 CEO and then honorary chairman of Total

'did not have the competences to store CO₂' and hence needed their expertise on CO₂ storage (Total interview). This opened up a promising new field where oil and gas companies would become service providers for CCUS consortiums. But, in the end, all the industrialists that we interviewed have mixed feelings about CCUS. Even for Total, which appears to be the only company to have been significantly and enduringly involved, CCUS is only a marginal part of its present strategy of diversification to sustain its growth, to become more resilient to economic and political shocks, and to change its public image.

CCUS not only had to prove that it was technically and socially feasible, but also that it was able to work within a viable, more autonomous (free-market) economic model that could become less reliant on public funding in the medium term. The post-2008 economic downturn acted as a test: not only did it have a dramatic economic impact on the sector, but it proved the confidence of industrialists in CCUS to be very fragile. In France, most of these withdrew from CCUS during the 2009-2014 period: Alstom withdrew entirely; Schlumberger reduced its interest; and, more importantly, most power producers left the Zero Emission Platform, which had been the main CCUS lobby in the EU (O'Neill & Nadaï 2012). Besides, with the drop in ETS carbon prices, the grants for CCUS in the NER300 programme were reinvested in renewables. These both proved the flaws of the ETS mechanism and put the emphasis on another vivid event, the boom in renewables, which may have made CCUS less credible for decarbonising power production. In any case, only two European industrial demonstrators were built in the late 2000s and early 2010s (Lacq/Total in France and Ketzin/GFZ in Germany); and even though Total labelled its project in Lacq a success, it launched no other initiative on a significant scale in the 2010s.

With the late-2000s shock having questioned their strategies, the industrialists decided to test new pathways. Total set aside its CCUS agenda after the end of the Lacq project in 2013, but reinstated

it “*just before COP21 [in Paris in late 2015, when] the future director of Total, P Pouyanné, announced that the company would invest 10% of its R&D budget in CCUS*”. This announcement was perhaps ‘*a game-changer*’, as a public subsurface researcher argued. In any case, several French industrialists decided to get involved in new projects. The first direction explored was that of CO₂ reuse. After giving up the Florange CCS project due to technical difficulties and – even more so – for economic and political reasons (Géodénergies and ADEME interviews), Arcelor-Mittal explored different technologies which they renamed ‘smart carbon technologies’. Air Liquide Cryocap project also exemplifies such an orientation. Developed between 2012-2015, this 40M€ project has the capacity to capture 100ktCO₂/year from Air Liquide hydrogen production facilities in Le Havre and to sell it back to local industrial carbon users.

The second pathway was offshore storage abroad. This has clearly become the main priority of Total since the early 2010s. Contrary to the public researchers at BRGM, oil and gas companies continued to defend a model of large facilities with CO₂ storage after 2009, but the framing was altered. The Northern Lights project, a joint venture in the North Sea between Total, Shell, and the Norwegian company, Equinor, illustrates this shift which relied, first of all, on facilitating social acceptance for new projects, mostly for offshore storage which is less controversial. The third transformation was the emergence of a new business model that divided the CCUS chain between storage and capture, with harbours being the new strategic loci (in France, these were Le Havre and Dunkirk). This new model has been promoted as more effective, both economically (still mainly based on the carbon market⁶), and practically, since its narratives adapt to the constraints

⁶ In the case of Northern Lights, the Norwegian carbon tax applies and has proved to be more effective than the carbon market in supporting CCUS development. Nonetheless, 2/3 of the costs are publicly funded for this project, with the final cost for industrialists reaching 70 euros per tonne.

of public fora by simplifying the solution and by comparing it to waste management, thus making it more understandable and acceptable to non-specialists (Total interview).

Public Planners: the French Ministry of Ecology and its agency (ADEME)

The third type of actor involved significantly in CCUS development in France is the public planner for energy transition: the Ministry of Ecology (MoE) and the ADEME agency which works under its supervision. In the first phase, the emphasis was put on R&D, and MoE gave ADEME the job of choosing relevant projects for funding and connecting the relevant technical actors (researchers and industrialists). Clearly, the technology has never been a priority for MoE and ADEME, partly because the national planning documents put the emphasis on reducing energy consumption and developing renewables, and partly because CCUS is broadly seen as a controversial technology in the energy transition community. Nevertheless, ADEME played a discreet but necessary role. From the early stages, it insisted on the virtues of CCUS as a way of preventing industries from offshoring for ecological dumping purposes, and tried to gather industries around projects (ADEME interview). *“We entered this technology via energy efficiency for capture technology. (...) One thing leading to another, we understood even if we solved the issue of capture, the problem of transportation and storage would remain. So we supported the whole industry.”* (ADEME interview) In 2002, ADEME created and supported the activity of ‘Club CO₂’ which includes most actors involved in CCUS. ADEME played an important role in legitimising CCUS in France through its reports and its provision of funding. It also produced several roadmaps and guidelines on CCUS.

During the subsequent period of decline, and along with the subsurface experts, ADEME actively helped to keep CCUS alive through its project funding and its reports for policymakers and industrialists. While continuing to stress that CCUS was a good way of preventing offshoring, it

also started to change its policy framing: it gave more room for public management; it marginalised oil and gas companies; like most public subsurface experts, it favoured *CCU* (re-utilisation rather than storage), non-energy industries, and smaller facilities; and it decoupled CCUS activities.

Three events in the national and international climate governance gave a new boost to CCUS in the mid-2010s and reframed its goal in French climate policy. The first was the unexpected importance that the IPCC Working Group III 2014 report, and the subsequent COP21, gave to BECCS (IPCC, 2014; Minx et al., 2018). Nevertheless, and although France hosted COP21 in 2015, the French government and MoE clearly avoided the topic, to the disappointment of the policy officer in charge of it who regretted the absence of public debate on the matter (MoE interview). The second event was the renewed support given to CCUS by the 2019 EU Climate and Energy Policy Framework, which integrated CCUS into the portfolio for reaching the EU's long-term objectives. An EU Innovation Fund came into force in 2021, in part to make up for the failure of NER300 (ECA, 2018; DG R&I & IEA interviews).

The third major event was the change in the national energy transition objectives. Between 2007 and 2015, national planners at MoE had promoted a -75% emission reduction goal for 2050. Within this framework, ADEME documents promoting CCUS presented it only as another way to “*help fulfil the CO₂ reduction objective*” (ADEME, 2013), and MoE documents did not mention it at all. MoE took an initial step to promote CCUS in its 2015 *National Low-Carbon Strategy*, but only as an optional solution. It really became part of the State strategy with the revised version released in 2020 (MoE, 2020, pp. 163-165), in which CCUS (including BECCS) was described as one of the solutions necessary to reach the new, highly ambitious, and symbolic national objective of carbon neutrality.

However, the CCUS objectives of the 2020 *National Strategy* are rather low compared with other European countries. Besides, the topic has not been scaled up at ADEME: between 2002 and 2021, the agency dedicated one engineer to work almost full-time on the development of CCUS, but her successor since 2021 has had more diversified missions (ADEME interviews). Interviews at MoE and ADEME confirm that the French State has only a remote interest in the solution: *'It is not on the agenda. It is not a political priority. We are left with our research priorities, we included [CCUS] in the [National Low-Carbon Strategy]. We know that it is planned, so we are preparing ourselves. But it's a long-term agenda'* (MoE interview). In theory, CCUS fills a gap in the search for carbon neutrality, but the horizon for its development is not before 2030, most experts acknowledge, and it thus remains a technological promise at this point.

4. Discussion: unsteady Framings, unstable Coalitions

As with many EM technologies, the trajectory of French CCUS can be better understood if analysed in terms of the articulation between the strategies and narratives of public planners and R&D actors, and those of private actors. We have shown the instability of the commitments of the main actors and the various strategies they developed, and argued that this illustrates the intrinsic weaknesses of Ecological modernisation. Even if it is not quite unusual to see disagreements causing the failure of networks of actors promoting innovation (Latour, 1992), our case study addresses the issue of an endogenous renewal from incumbent actors – as Turnheim and Sovacool (2022) invite us to do. In this last section, we explain why CCUS benefited from discrete policy support despite a low inherent interest and important external constraints, and why unstable framings limited the ability of its promoters to convince a larger audience; we then insist on the links between the narratives and the actors supporting them and conclude with the difficulties in CCUS being a solution affiliated to the oil and gas industry.

First, the apparent French paradox can be explained by the public-private features of the coalition promoting CCUS. CCUS perpetuates the existing, dominant carbon-based regime, but this endogenous renewal did not succeed despite the support of industrial incumbents, official experts, and a friendly regulatory frame. In France, the coalition was clearly not able to accommodate room for CCUS, neither in the carbon-based regime, nor in the emerging “post-carbon” regime based on renewables and nuclear power. The assets of CCUS to the national economy, its costs and market acceptability, the types of facilities (big or small), to cite only a few, remained unresolved after 20 years of studies.

But despite external failure, the CCUS case shows how the intricate relationships between public and private actors enabled them to gain political traction for their proposal. Promoters mostly developed CCUS in discrete spaces, where their narratives were rarely challenged. While technical aspects and economic schemes supporting the proposal were complex and uncertain, making it difficult to publicise, this case shows that CCUS did not need publicisation for most of its development. The solution was maintained outside public fora, both because supporting it publicly was too big a responsibility for policymakers (MoE never put CCS at the front of its agenda), and because it was channelled through confining procedures (limited consultation during the Lacq demonstrator implementation). The proposal did not need a high-profile policy decision, it only needed to fit within funding programmes that the experts mastered. CCUS displayed a co-construction process between the Administration and the CCUS promoters. Overall, the case of French CCUS exemplifies the limitations of EM coalitions in implementing the European and national promises of public participation, especially regarding the environment. Solutions only circulate within confined spaces and reflect a specific definition of problems.

Second, the failure to develop CCUS can be explained partly by external factors (social acceptability of the projects, economic model, and technical problems), but we argue that internal debates within the CCUS coalition, and the related instability of framings, are also needed to understand it. While the ambiguity of CCUS made it possible to coalesce firms, experts, and public planners, it became a liability when the solution was put under stress by external events. The objectives of the coalition were rather convergent, but the strategy and the framing of their cooperation followed different pathways. This sheds light on why their endeavour has failed up to now. Throughout the years, the industrial strategy has always been vague enough to encompass different pathways and coalitions. No significant CCUS pilot has been implemented since the Lacq experience; if there is any interest at all in CCUS in France, it has not been translated into a single strategy and a single clear discourse capable of justifying carbon storage. Beyond the discourse on the necessity of storing carbon to fulfil a net-zero emissions strategy, the actors involved have simply pursued different self-serving goals, lasting until today, with BRGM defending the capture of small quantities of CO₂ near emission sites, the oil industry building large facilities to store huge amounts of CO₂ in depleted, mainly offshore, oil reservoirs, and French public policymakers hesitating between the two (if not simply procrastinating).

The coalition had difficulty in meeting these different and unstable goals through economic and political means. CO₂ storage is at once a way of pursuing existing activities and expertise, mitigating climate change, greening previous activities, responding to political and public pressures, and developing a new carbon industry. But since none of these frames is considered dominant or certain, the CCUS industry cannot rely on a single strong policy that would ensure economic support for a highly risky and still controversial activity. This unstable framing has failed to convince policymakers to mobilise for CCUS. There is no political leadership on CCUS in

France: neither national nor local elected representatives endorse this solution as their own so as to defend it against criticism⁷. CCUS has a flexible meaning: this can be a strength when facing criticism, enabling its promoters to adapt their narratives to changing situations; but it is also very difficult to understand, and to trust its promoters' goals as these have varied along the way and have not gained traction within a particular policy framework.

Third, framing has to do with the building of identities. On the one hand, the promoters' identity shapes their narratives. Promoters are not entirely free in the choice of narratives, as they develop them within a 'regime of truth' that they share with the other members of the coalition (Foucault, 2009). This regime of truth, or feasibility, shapes the way in which they think about a problem and its solutions (Zittoun & Chailleux, 2022). Here, CCUS reflects the way that the three types of promoter think about climate change policies mainly as a new – somehow 'ecological' – modernisation process, mainly undertaken through market-based technological solutions. But the situation is more complex. As shown, the initial proposal made by geoscientists was translated by the oil and gas companies, which redefined CCUS as a part of their environmental strategy. The excessive cost of CCUS was only acceptable for those with extraordinary financial resources and a strong network of allies and international organisations backing them up. More generally, CCUS is not a proposal that can be promoted by any actor, but one led by experts and industrialists. In turn, the solution, as defined, participated in shaping new identities: for subsurface experts, CCUS renewed professional opportunities and political salience; for industrialists, CCUS showed their will to possess a climate agenda. However, this co-ownership of CCUS was revealed to be confrontational and led to divergent redefinitions of the solution given the identity of the owners:

7 The exception of Le Havre has to be mentioned: local elected representatives did show interest (Pigeon, 2016).

in the latest period, the experts tried to maintain their position and their implication in French policies while most industrialists looked for new markets.

On the other hand, the framing process – as a means of convincing – also reflects the identity of the promoters. The message cannot be separated from the messengers, at least not entirely. When CCUS met local publics, or when the media addressed the topic, both CCUS and its coalition were under scrutiny: CCUS is the solution promoted by subsurface experts in general, and by the oil and gas industry in particular. This made it harder for policymakers, and for MoE and ADEME, to defend it. They found themselves publicly having to support companies that are held responsible for climate change, and which regularly reap huge profits from their polluting activities.

Conclusion

In this article, we have described the heterogeneous strategies of the three types of French CCUS promoters for adapting to fluctuating trends. We showed that interactions, and even synergies, exist between them, but that there are also inconsistencies between their strategies and narratives. We looked at the existing literature about CCUS to show how not only external, but also internal, struggles within the coalition played a role in its failure to scale up in France. No clear overall frame emerged. If CCUS is persisting today, this is because the French public-private subsurface community is well embedded at the national – if not the European – level, and because CCUS fulfilled – and still fulfils – goals other than CO₂ storage only. These goals change over time and between actors. Although a coalition exists, alignment does not, since the coalition is embedded in a regional (here, European) and a global landscape, as well as deeply dependent on national (and, more marginally here, local) identities, which can all evolve rapidly.

This article urges more micro-observations of EM coalitions, in order to gain a better understanding of their internal conflicts and their heterogeneity, and to document the general, now dominant

discourse of Ecological modernisation in the field of environmental policies. We suggest that such investigation highlights the politics of transition from the inside of coalitions that are dominating the policy agenda of transition, and reveals the complexity and instability of EM coalitions. More works are needed that look into the struggles within EM debates and coalitions in order to refine how the current ecological crisis is being reframed through EM solutions such as CCUS. These studies could open the black box of the formation and maintenance of coalitions, and pay equal attention to the public and to discrete spaces of debate. They could also address the struggles to define CCUS and other negative-emission technologies in specific arenas. While we tried to depict these struggles over two decades, refining the analysis to a smaller grain would help us to gain a better understanding of why actors support these solutions, and under what frames.

The authors declare no conflict of interest.

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