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## Mapping the social study of carbon capture and storage technology as a climate strategy

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## Mapping the social study of CCS:

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**Abstract:** It is important to be aware of different approaches to social studies of science and technology. Therefore, in order to get the full picture of what the social studies of CCS is about, where progress is being made and where more research is needed this paper surveys existing approaches and suggests a way of organising and thinking about the variety of studies of 'CCS in society' that exist or perhaps ought to exist. First the various existing social scientific disciplines currently being deployed to study CCS and other related technologies from a social science point of view are mapped out. Next I discuss different criteria by which social studies of CCS can be categorised. This is designed to give a better understanding of what kind of studies exist and what might be developed and to emphasise that within each discipline, a variety of different approaches can be found.

### Introduction

The social study of CCS is many things: from stimulus-response experiments on perceptions of CO<sub>2</sub> storage sites, to anthropological studies of public engagement in new technology and infrastructure to economic surveys of incentives structures – to policy analysis of decision-making concerning CCS in the EU. And it could be even more diverse than it already is. They invariably draw on different traditions, methods and academic disciplines. The latter have their own debates about what the world is made of – or what part of it should be singled out for analysis (ontologies) – and differing views about what knowledge is – or how we can get it (epistemologies). Although there are always differences of emphasis and style concerning methods within each approach, ontologies and epistemologies, once adopted, impose some limits on what tools each perspective allows or thinks is appropriate for accessing reality, and hence involve also a choice of method and analytical strategy. It is important to be aware of different approaches in order to get the full picture of what the social studies of CCS is about, where progress is being made and where more research is needed. This paper suggests a way of organising and thinking about the variety of studies of 'CCS in society' that exist or perhaps ought to exist. First the various existing social scientific disciplines currently being deployed to study CCS and other related technologies from a social science point of view are mapped out. Next I discuss different criteria by which social studies of CCS can be categorised. This is designed to give a better understanding of what kind of studies exist and what might be developed and to emphasise that within each discipline, a variety of different approaches can be found.

### Disciplines and what they focus on

Systematic knowledge generation, or science, has been institutionalised into different disciplines, which are basically institutions, sets of actors in departments, with journals, traditions, career structures and self-understandings. This

impinges on studies of CCS too. In a rough way, each discipline has ideas about ontology (the stuff the world is made of – or what part of reality it makes sense to look at), units of analysis (how they break down reality into smaller more manageable bits), preferred methods, ideas about what makes things happen (causality), and key problems or clusters of research questions.

This may generate something like Table 1 below. However, a few disclaimers are immediately necessary:

Firstly, a particular study is of course unlikely to fit neatly into any of the categories, and a particular researcher is, over time, even less likely to feel restricted to only one tradition. New disciplines like Science and Technology Studies (STS) cuts across several (or even all) of them and compete to get institutionalised in universities or other knowledge-producing institutions as others die out. Nevertheless, understood as ideal types (i.e. selective models that capture typical traits of something that in real life is more messy), the following collection of approaches aims to draw up distinct groupings of knowledge that exist or could exist concerning CCS and other energy technologies. Disciplines provide rules and conventions that researchers can and do draw upon and identify with (or identify themselves as being against) – otherwise they are not disciplines – and so being aware of these is important for understanding controversies or orthodoxies in a field of study.

Secondly, research strategies are strategic in the sense that they involve choices – choices that could have been made differently. The following categories in table 1 are therefore to some degree arbitrary (some could have been merged with others or omitted whereas others not mentioned could have been included). A more systematic ‘sociology of CCS’ might chart in which departments, according to which method, in which country, in which journal studies are published etc. As a preliminary ‘map’ of the social studies of CCS as a novel technology, the aim is to create a framework for further debate about how the field could or should develop or proceed.

Thirdly, each discipline contains a methodological debate within it and so legitimate objections can be made about designating e.g. policy studies as to do with political *systems* of inputs, outputs and outcomes (Easton 1956). Policy studies may also be about discourses, metaphors, allegory and narrative, for example (Stone 1994). Nonetheless, as disciplines they do tend to focus on different parts of reality and they allot different weight to different types of approaches (that is arguably what makes them into disciplines). Below I have tried arranging them roughly in order of how individualist their approaches tend to be (to what extent explanations found in the nature of the units?) beginning with the most individualist and progressing to the most structuralist (where explanations are found in the social structure e.g. the market structure of oligopoly explaining the competitive behaviour of energy companies; or the structure of language use (discourse) rather than ‘individual interests’ determining what views NGOs feel they can legitimately take up). Thus, cognitive psychology examines mainly how individuals choose between rival claims depending on what information they are given and how it is presented. Variations in decisions is explained by the level of knowledge, cognitive frames held by the individual plus the external stimulus given to it (e.g. the piece of information or picture shown). At the other end of the scale, discourse studies or cultural sociology see systems or reservoirs of meaning as the primary factors that make individuals and decisions meaningful, e.g. a modernist belief in rationality and scientific practices such as experiments as the best arbiter between rival truth claims compels and actors to phrase his or her opinion in terms of ‘evidence’ Alternatively ideas about ‘individuals’ as separate entities that choose independently between different options or react to different stimuli may lead an economist to speak in terms of ‘preferences’. In a traditional society they may not understand what an experiment is, what a cognitive frame is (show me one?) or accept that idea that individuals make decisions or change their minds outside a social setting e.g. a family. Thus, opinions could be seen as primarily products of structures (of meaning in this case).

TABLE 1: DISCIPLINES AND HOW THEY PROVIDE DIFFERENT WAYS OF STUDYING CCS

Associated discipline	Social ontology (what stuff is the world primarily made	Unit of analysis (what do they end up looking	Common methods (how do they	Causal mechanisms (what	Key problem trying to solve in relation to	Examples of work
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	of?)	at?)	go about looking at them?)	makes things happen?)	CCS (what is being explained)	
<i>Cognitive Psychology</i>	Mental models, external stimuli	Mental models, decisions, preferences	Experimental	Decision making results from stimuli-response modified by rationalities	How is decision-making made in evaluations and behaviour concerning CCS	Wallquist
<i>Social psychology</i>	Preferences/perceptions and representations of self and others and world	The individual in relation to its environment	(Quasi-)experimental. Focus groups Interviews	Information distribution and perception filters	How are preferences formed/changed. Communication strategies, trust determinants	
<i>Quantitative sociology/marketing research</i>	Opinion distributions Social categories	Social groups/categories and their opinions	Survey research, cross sectional analysis, quasi-experimental design Focus groups	Distribution of information and values	What variables (demographics (age, gender, income...), information levels, proximity to CCS plants) determine opinion of ccs?	
<i>Economics</i>	Markets, producers, consumers,	Costs, benefits, equilibria, ratios	Modelling, c-b analysis	Preferences, incentives, market forces	What are the relative or marginal costs/benefits of various CCS options, and how are they distributed?	<i>Economics</i>
<i>Qualitative sociology</i>	Shared meanings, norms, knowledge	Cultural frames, value systems, narratives, group identities	Interpretivist/hermeneutics (interviews, textual analysis, narrative analysis)	Narratives and cultural tropes link together 'facts' and actors in particular ways	How are information and images about CCS communicated and interpreted according to different values and systems of meaning?	
<i>Anthropology</i>	Artefacts, relations, networks, institutions	Communities, identities, practices, rituals	Participant observation action research, interview, focus group	Practices, traditions, power relations affect behaviour	How are CCS actors formed as actors, how connected and how do they make sense of	

					reality and CCS's place in it?	
<i>Political geography</i>	Boundaries, localities, populations, territories	'Places', identities, border-drawing and – authorisation	Interviews, focus groups, symbolic analysis, textual analysis, Q-method, deliberative workshops	Modes of engagement, practices and discourses	How are conflicts constituted, located in space and time, linked to territory, history. What modes of engagement work/ further cooperation	
<i>Political/policy studies</i>	Policy positions, institutions, actors	Political system elements (inputs, procedures, outputs, outcomes)	Comparative, survey, media, institutional analysis	Actor-interaction, institutional pull, power + resources distributions	How and by whom are collective decisions taken concerning energy policy and CCS	
<i>Philosophy and ethics</i>	Rights and wrongs	Reasons, outcomes, intentions	Logic, argumentational analysis, rhetorical studies	Rationalities and premises drive forward or exclude certain arguments that validate or invalidate courses of action.	By what criteria can and should CCS options be evaluated? Procedural and outcome related questions.	
<i>Discourse Analysis</i>	Structures of meaning and language	Subject-positions (roles), constructed objects (e.g. waste), linguistic shapes	Content analysis. Critical discourse analysis	Structures of meaning fix the identities and objects that make up the field, defining the game but not calling the individual shots	How is CCS as a social practice established what are the constructed subjects and objects, strategies of legitimation	

Talk through the table including good examples of each approach. Perhaps work needing to be done...? Please fill in the right-hand column with significant studies and neglected questions of study?

## Fundamental choices in approach

Although the above table is organised (arguably) with the most individualist approach first, CCS studies can be divided up in other ways.

One way is to look at materialist versus idealist ontologies. For example, for a 'materialist', society is made up mainly of concrete observable things such as individuals, groups, resources, technologies etc. Such a person will be drawn towards a methodology that allows those to be measured and the relations between them accounted for, focussing mainly on causal effects rather than causal mechanisms (what follows what, rather than why something follows something). He or she may survey a general population noting how many young people are of opinion A or how their income or education affects their opinion of technology B. In contrast, a researcher with a more cultural or idealist ontology (not 'idealist' in terms of wishing the world were much nicer but in terms of assigning significance to the role of ideas and meaning) would work on the assumption that society is made up much more of the signs and languages that assign significance/insignificance and meaning to inanimate objects that of course cannot speak for themselves. According to such an approach a grouping of technologies, resources and know-how causes controversy mainly because it is put into a certain set of ideas and meanings (and institutions that organise those meanings) making it into 'a CCS plant' or 'CCS as a climate technology', 'clean coal' or 'a greenwash technofix' – and not just because a pile of concrete and chemical processes exist out there that can be group as 'CCS'. For someone interested in how objects are constructed, a stone is not just a stone but can be projectile, a paperweight, a weapon, a sculpture, depending on the social and discursive systems it is put into by society. 'Income' or 'geographical location' do not cause opinions on 'CCS' outside of a system of signs that organise them and allot significance to it.

Beyond idealism and materialism, approaches differ in terms of whether they focus on causal effects or causal

### Ontologies of CCS with examples of methods

	Material	Ideational
Individualist	Surveys	Interviews
Structuralist	Class analysis	Discourse analysis

mechanisms. Those focussing on causal effects look at what variables are correlated with, e.g. how income or education or profession – or proximity to a storage site – may co-vary with specific views on CCS. This looks at the causal effects of income, education etc. but does not necessarily explain why or how those variables come to have a particular positive or negative effect. Approaches more interested in causal mechanisms might look at *how* exactly higher income has an effect on views on CCS. They would often be more interested in case studies, or other methods that can track the precise causal chain, e.g. education provides for greater critical awareness of opportunity costs of choosing CCS, than surveys suitable for correlational mapping.

Another way of dividing CCS studies up according to ideas about causality would be to look at direct versus constitutive causality. A red light might directly cause a car to stop. But the whole system of roads, signs and the book 'The Highway Code' is constitutive of 'motoring' or 'driving' and hence 'causes' – in a constitutive sense – the car to stop. In terms of CCS, studies looking in terms of direct causality at who or what prevented a CCS plant from being built is of a different kind to that looking at constitutive rules a society may have for how to make an opinion or exert influence on a decision concerning CCS, e.g. democratic mechanisms, consultations, laws protecting corporate freedoms or individual property rights etc.

## Two understandings of causation?

### Direct causation

- $X \rightarrow Y$ , e.g. rules regulate behaviour
- Without X, no Y
- Variables treated as given prior to their relationship
- X temporally prior to Y plus necessary connection (not just coincidence)
- Isolate effect of X (counterfactual of  $\neg X$ )
- Aims for explanation/prediction
- narrowing down connections

### Constitutive causation

- ' $X \leftrightarrow Y$ ' e.g. rules constitute roles and game, not just behaviour: 'define the set of practices that make up any particular consciously organized social activity' (Ruggie)
- Describe conditions of possibility
- Aims for 'context-dependent generalizations about behaviour and language' (Klotz and Lynch)
- expanding connections

This direct versus constitutive causality distinction is related to the prism of individualistic versus structuralistic approaches described above.

Individualistic approaches will look for explanations in the make-up of singular elements like individuals, companies or social groups, e.g. women are more likely to think X or Y because they have certain characteristics. In contrast, structuralist approaches look for explanations in the relations between the individual units, e.g. NGOs tend to oppose CCS because are separate from and define themselves in opposition to governments, or more broadly because they exist in contradistinction to institutional elites

(the relation between the units, rather than the nature of the unit itself is given explanatory weight here). This would imply looking at how units are organised rather than examining or measuring them on a one-by-one basis. Network mapping might be useful in this case, as opposed to qualitative interviews or surveys of individuals' opinions that take each unit as essentially self-contained.

Thirdly, and probably most fundamentally, we may consider approaches in terms of whether they privilege ontology or epistemology. This is best explained by looking at how the traditional way of dividing up approaches masks a deeper schism. In methods textbooks, the usual ideal is that the question determines the method and the usual distinction is between quantitative and qualitative methods. Quantitative approaches count standardised units whereas qualitative ones explore meanings more openly<sup>1</sup>. An emphasis on the primacy of the research question is a healthy antidote to methodological tribalism whereby only certain methods are deemed permissible – except that things are not that simple. This is because the choice of method may also effectively decide the ontology of the object and hence narrow down the range of questions that can be asked. For example, if a researcher decides to interview the executive directors of companies or NGOs or government ministries to answer the question 'who is opposed to CCS?', then that method assumes an ontology in which the leader of an institution embodies or is representative of it, perhaps in a hierarchical fashion in terms of leaders embodying institutions. If another researcher does a textual database search to map the use of language about CCS to answer the question, then that method assumes a different ontology, suggesting that the politics of CCS is constituted rather by systems of language that accumulate in society and are then drawn upon by media outlets, reports, journals, legal statute books, white papers, reviews or whatever kind of material the database is composed of. In that way the database search may imply that the 'language' and authoritative knowledge available determines what the leaders are able to say or think in the first place. In that case it might make more sense to study those who generate authoritative knowledge in the field rather than what the supposed 'actors' such as managing directors think. Even if it looks as if the question has determined the methods, the opposite could therefore be the case. It is hence not 'correct' to begin from the question or from the method. However, it is preferable if conscious rather than unconscious choices are made in how methods and questions are considered.

This leads to my third way of considering different approaches that relates to what is taken for granted and what is in question. All studies have ontologies and epistemologies but what is significant is that some *start* by deciding on the former and therefore can go straight to the question of *methods*, while others choose the latter as their baseline and so need to think about *analytical strategies*. Most studies of CCS currently prioritise ontology, are happy to make their assumptions about what the world is made of, and then proceed to study the relations between the 'variables' it takes as given, e.g. 'groups' have 'interests' or 'opinions' about certain 'risks' but we want to know which groups have which opinions and perhaps when they have them. For such 'ontological approaches', *method* is a question of

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<sup>1</sup> However, the difference has often been over-emphasised, since all quantitative data rests on categories made up of meanings, and most qualitative data is gathered because it is considered somehow representative or typical of a wider number of cases or instances.

finding the right tools to make valid observations of the world, to help decide between various risks or communication strategies, that exist in a relatively straight forward way (although the relations between them may be extremely complex). This is sometimes called positivism, or designated a 'quantitative' approach, although ontological approaches might well also study ideas or values and use qualitative methods like interviews designed to ascertain what person X 'positively' thinks or feels about technology Y. The important thing for ontological approaches is that it is *not* the actual makeup or 'stuff' of the world that is in question (material or discursive). That has been fixed or 'bracketed' by the researcher making it possible to discuss options and/or arrange a scientific study of how different things affect each other.

The opposite of this kind of study is one that prioritises epistemology and begins from trying to find out how it is possible to think of the world in certain ways – *strategies of analysis*, e.g. how this or that group is construed as a group in the first place e.g. rather than asking 'what determines stakeholders views on CCS?' it could be asked 'what makes it possible for somebody to be considered a stakeholder in relation to CCS?' - or 'what does 'a view' belonging to a stakeholder entail?' – or 'what is meant by 'CCS' in the first place and does this differ between contexts. Instead of whether people understand risks accurately it could be relevant to ask how a 'risk' is constructed differently, i.e. what discourses (maths, probability, hazards, ideas about security or welfare, conceptions about nature of the future and how to handle it etc.) make it possible to think of this kind of risks in this or that way? And what does thinking in that way do, not just to what opinions they hold but to *who* 'they' are in the first place? E.g. has the rise of the idea of climate change changed the very idea of who a stakeholder is, or what a risk is in the energy debate?

## Methods or analytical strategies

(Andersen 2003, xiii)

### Rules of method

- First order observation
- Goal: to produce true knowledge about a given object
- Ontologises
- What rules and procedures are needed to produce scientific knowledge

### Strategies of analysis

- Second order observations – observation of an observation as an observation
- Goal to question received knowledge
- De-ontologises
- What analytical strategies will enable us to obtain knowledge, critically different from the existing system of meaning?

Whereas a method approach ontologizes (treats whatever the world is said to be made of as unproblematic) the epistemological approach *de-ontologizes* things: it shows how things only exist within certain frameworks and institutions that are not given by God or by nature but by being part of the institutional fabric of society – and that could change. For epistemological approaches, the goal cannot be to find fixed relations between variables like 'education level determines opinions of nuclear power when you control for the influence of age'. The answer to that kind of question may be discernible within a particular understanding of 'nuclear power' and 'education' and 'opinions', and in a situation where constructions of

nuclear power were structured in a stable way across an age group etc.. But there would be nothing perennial or necessary about it and as it is a result of society rather than nature. For epistemologists, method is about finding valid ways of examining other people's observations and the agreements over what is real/not real or legitimate/illegitimate – second order observations (observations of observations) so to speak (see Andersen 2003 for the distinction between ontological and epistemological approaches). The aim is to get new insights or perspectives on the world, to reveal the systems of meaning that rule some things in and others out, and to make sure that the vocabulary we are using, usually inherited and therefore developed for a different and by-gone world, is not being forced down uncritically onto today's world which may be different to the one which shaped our languages and understandings.

## Conclusion

The main upshot of this exercise is twofold. Firstly it shows how varied the approaches are or could be and how multidimensional the idea of studying CCS is. If the field is to contribute to the understanding of technology in society, it needs to be able to attack the problem from many angles and use many different approaches. If we are to

understand the ethics of introducing a new technology we are working at a different level compared to if we are interested in the economics of it (though the two may interact in significant ways). Secondly, and conversely, it perhaps shows some of the limitations of the field so far: how aware are we of the other disciplines' contributions or potential contributions? Has there been a preponderance of one kind of study or the study of mainly one level of reality? Have ontological approaches dominated, or if they have, is that right and proper or is there a need for more epistemological analysis of how the social reality of CCS is constructed?