BECCS – a climate friend or foe?

A discourse depiction of the negative emissions technology BECCS in the UK

Sofie Errendal

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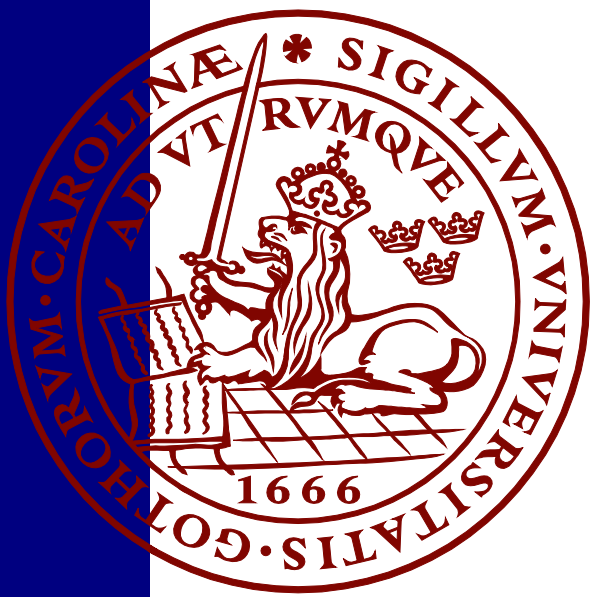

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Abstract

The UK has recently increased its 80% GHG emissions reduction target to net-zero by 2050 compared to 1990 levels. To achieve this goal, the UK emphasizes deploying the technology Bioenergy Carbon Capture and Storage (BECCS). However, despite multiple challenges, BECCS is still prevalent in the UK. This paper aims to identify why this is so by investigating how BECCS is communicated, by whom, and the social ramifications of this. This research analyzed grey UK literature describing BECCS, which revealed that BECCS is communicated, mainly by the UK Committee of Climate Change, as necessary for the UK net-zero target and beneficial for the domestic economy and environment. However, such depictions can undermine climate action and lead to British biomass imperialism. Therefore, this paper suggests that it is vital that the UK continues its climate action despite BECCS promises and that the international community establishes biomass agreements to prevent biomass imperialism.

Keywords: Bioenergy Carbon Capture and Storage, Greenhouse Gas Removal, 2050 Net-Zero Target, Climate Change, Critical Discourse Analysis, Environmental Discourse,

Word count: 11.984 words

Abbreviations:
BECCS: Bioenergy Carbon Capture and Storage
CCC: Committee of Climate Change
CCS: Carbon Capture and Storage
CDA: Critical Discourse Analysis
CO_2: Carbon Dioxide
EROI: Energy Return on Investment
ETI: Energy Technologies Institute
GGR: Greenhouse Gas Removal
GHG: Greenhouse Gas
IAMs: Integrated Assessment Models
ILUC: Indirect Land-use Change
IPCC: Intergovernmental Panel on Climate Change
LUC: Land-use change
Mha: Million Hectares
RAEng: Royal Academy of Engineering
REA: Renewable Energy Association
RQ: Research Question
WWF: World Wildlife Fund

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1 Introduction

In 2008, the UK became the first country to set a legally binding climate reduction target by passing the *Climate Change Act*, which requires the UK to reduce GHG emissions by 80% by 2050 compared to 1990 levels. However, in 2019, the reduction target was increased to net-zero by 2050 (Grantham Research Institute, 2020), requiring the UK to increase its domestic climate reduction efforts. While scientists and governments agree that the source of the climate crisis is the excess levels of anthropogenic Greenhouse Gas (GHG) emissions, particularly carbon dioxide (CO_2) (EC, 2020; IPCC, 2014), there are differences when it comes to the solutions of the climate crisis. These differences can also be considered discourses that entail different ways of understanding and responding to the world, and in this case, the climate crisis.

Discourses influence all aspects of society, and certain discourses can advance particular interests while suppressing others (Dryzek, 2013a). Such examples are seen in the global climate debate, where many actors push for technological climate change solutions. Especially prevalent amongst technologies are the Greenhouse Gas Removal (GGR) technology Bioenergy Carbon Capture and Storage (BECCS), which entails combining two known methods: bioenergy and carbon capture and storage (CCS). BECCS entails creating carbon-neutral energy by incinerating biomass and capturing the generated emissions to be stored in geological reservoirs deep in the underground (Canadell & Schulze, 2014). Due to putting two known methods together and its CO_2 removing abilities, it is a prominent method that often features in climate scenarios of the Intergovernmental Panel on Climate Change (IPCC) and many others where global warming is limited to 1.5°C (IPCC, 2018).

Furthermore, its carbon removal and energy-generating abilities promise a decoupled and continuously growing economy while mitigating climate change. BECCS is, therefore, inherently subscribing to an ecological modernization discourse, where economic development and environmental protection not only co-exists but also enhance each other (Dryzek, 2013a). Thus, although BECCS originates from one discourse, the surrounding debate can draw on multiple discourses.

While there are opportunities to BECCS, challenges also exist, such as its commercial unavailability (Shue, 2017), its technological uncertainty (Bui et al., 2018), and environmental (Fajardy & Mac Dowell, 2017) and social risks (Buck, 2016). Despite the positive and negative aspects, BECCS still appears as a dominantly prevalent climate mitigation tool within the UK climate debate. As a certain depiction of BECCS can influence its future deployment, which can then impact other climate actions,

it remains relevant and important to critically question the communication of BECCS in the UK; however, no such research yet exists. **Therefore, this paper aims to identify how BECCS is communicated in the UK, by whom, and the social ramifications of this,** thus addressing the research gap**.** The research questions (RQs) guiding this paper are,

1. *How is BECCS discussed in the UK, and by whom?*
2. *What is the hegemonic discourse on BECCS in the UK?*
3. *What are the possible social ramifications of this depiction of BECCS?*

2 Sustainability science

The topic of this paper is situated within the field of sustainability science since a) it engages with one of humanity's responses to climate change and b) it utilizes elements from different disciplines. Sustainability science aims to understand the complex interactions between human and natural systems, such as climate change, to safeguard the earth's life support systems (Clark, 2007). It applies an inter- and transdisciplinary approach (Spangenberg, 2011), meaning it draws on multiple disciplines as it argues that global sustainability challenges cannot be solved by one discipline alone (Jerneck et al., 2011). By incorporating the issue of climate change, the solution of BECCS as a carbon-neutral energy system, the politics surrounding it, and the social effects of it, this research draws on knowledge and theories from both the natural and the social sciences.

Sustainability science is a field that follows two cross-cutting theory approaches: problem-solving theories and critical theories (Jerneck et al., 2011). While the former seeks to solve the problems as they are found within a structure, the latter seeks to understand how that structure came about. To acquire benefits beyond what is possible by these individual approaches alone, the two methods "must cooperate in a dialectic and reflexive mode" (Jerneck et al., 2011, p. 80). This research first applied the problem-solving approach to define the issue by reducing it to variables that could then be studied (Cox, 1981): the depiction of BECCS. Secondly, the critical theory approach was applied to investigate the structures and powers embedded within these depictions and how they are used in particular contexts by certain actors to arrive at specific arguments of BECCS (Cox, 1981). The two theoretical approaches are, thus, found to be complementary as they investigate both the problem, its reinforcing structures, and the result of this.

3 Background

The following section describes BECCS, its origins, its environmental, social, and technological challenges as identified in a literature review, alongside its GGR abilities and the UK's interest in BECCS. Such information is crucial, as all climate change technologies have benefits and challenges.

3.1 Conceptualizing BECCS

BECCS is known as a GGR method and is the aggregation of bioenergy and CCS. Bioenergy is energy derived from biomass (e.g., trees or crops), which captures atmospheric CO_2 and uses it to grow. The biomass is then cut down and taken to a processing plant, where it either undergoes incineration, fermentation, anaerobic digestion, or gasification processes to produce energy. CCS is then applied to capture and compress the CO_2 released during these processes. It is hereafter transported to geological storage sites, e.g., depleted oil fields or aquifers, to be stored indefinitely (Bioenergy Europe, 2019) (Figure 1).

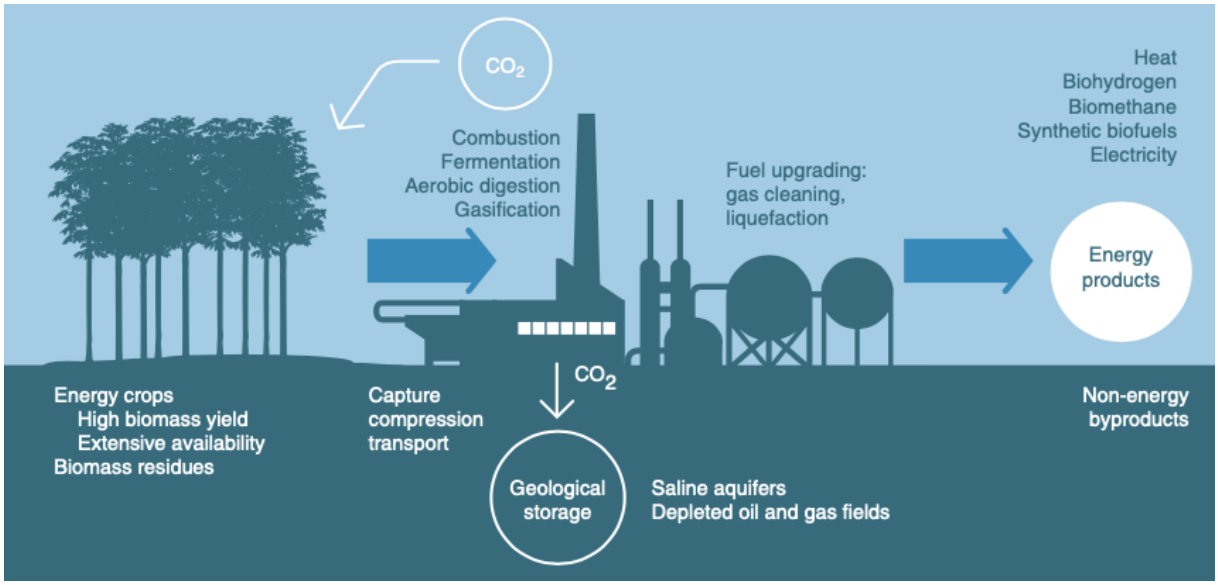

Figure 1: The components of BECCS. BECCS components consist of biomass or energy crops that capture CO_2. The biomass is then burned creating energy and CO_2, of which the latter is captured, compressed, and transported to geological storage. Source (Canadell & Schulze, 2014).

3.2 BECCS's increasing popularity

BECCS has become an increasingly popular technology over the years, and it has been a critical element in scenarios limiting climate change to 1.5-2°C. BECCS was first brought up in 1998 (Carbon Brief, 2016); however, it was not until the IPCC introduced BECCS in their Fourth (Fisher et al., 2007) and Fifth (IPCC, 2014) Assessment Reports that it gained traction. The latter report acknowledged

that 2°C could not be reached if key mitigation technologies, such as BECCS, were delayed or of limited availability (IPCC, 2014). In 2015, BECCS was re-introduced as the primary climate mitigation tool as 197 nations committed to the Paris Agreement's 1.5°C promise (Minx et al., 2018; UNFCCC, 2015). Its popularity was further reinforced in 2018 by the IPCC's 1.5°C emissions scenarios. Three of four scenarios included BECCS, while the last entailed a rapid, yet rather unrealistic, phase-out of fossil fuels (IPCC, 2018), positioning BECCS a necessity. BECCS is also especially popular because climate scenarios estimate that BECCS has one of the highest emissions removal potentials, at 2[1]- 10[2] $GtCO_2$/year in 2050 and 6[1]- 16[2] $GtCO_2$/year in 2100 (Rogelj et al., 2018). However, such high amounts will require significant quantities of biomass which can compromise biodiversity, land and water availability, and livelihoods.

3.3 Biodiversity

Despite its popularity, scientific evidence reveals that BECCS negatively affects biodiversity due to its significant use of biomass; yet some biomass crops are more biodiversity-friendly than others. As natural habitats are converted to bioenergy plantations or crops, ecosystems are changed, and habitats are lost, which causes negative impacts on biodiversity (Babin, Vaneeckhaute, & Iliuta, 2021). A review indicates that most studies find a negative correlation between biodiversity and first-generation bioenergy crops, mainly corn, oil palm and soy crops. In the US, corn and soy has rapidly increased since the 2000s (US EPA, 2018) to decrease the reliance on fossil fuels, yet at the expense of grassland conversion (Lark, Meghan Salmon, & Gibbs, 2015). Due to the monocultural nature embedded in the expansion of these crops, ecosystems have become less resilient, which has led to increased risks of destructive plant pests and invasive species (Gonzalez-hernandez et al., 2011). Therefore, these low-resilient crops require the application of pesticides for a successful harvest to be possible, which unfortunately results in soil degradation (Kline et al., 2015) and, thereby, biodiversity loss (Robertson et al., 2017).

However, the literature suggests that second-generation bioenergy crops, which are non-food crops (e.g., switchgrass and miscanthus), have less of a negative impact. In some cases, they are even positively correlated with biodiversity compared to first-generation bioenergy crops (Immerzeel, Verweij, van der Hilst, & Faaij, 2014). This is because native perennial vegetation in and between first-generation crops supports biodiversity, pollination, and pest protection (Werling et al., 2014)

[1] 1.5°C Scenario with low temperature overshoot (Rogelj et al., 2018).

[2] 1.5°C Scenario with high temperature overshoot (Rogelj et al., 2018).

and decreases fertilizer use (Ruan, Bhardwaj, Hamilton, & Robertson, 2016). Perennials, however, have lower yields than first-generation crops, meaning greater quantities are needed (Robertson et al., 2017; Werling et al., 2014). However, such positive effects only exist when second-generation bioenergy crops replace first-generation crops, not natural grasslands, or forests.

3.4 Water and land use

Growing biomass requires significant amounts of water and land, increasing the global competitiveness of these resources for either food or energy. To obtain a yearly BECCS removal of 3.3 $GtCO_2$ globally, consistent with 2°C scenarios in 2100, water-wise crops, such as switchgrass or Miscanthus still requires 3.6-15.7 tons m^3 of water per year – of which the upper-limit is equivalent to twice the world's annual water use for agriculture (Fajardy & Mac Dowell, 2017). While the land needed for the same crop and CO_2 removed is between 363-2392 Million hectares (Mha), which is high considering the current area used for the global cereal production is 721 Mha (Fajardy & Mac Dowell, 2017). This land increase would be accompanied by an increase in fertilizers. For nitrogen, 21-210 Mt yr^{-1} would be required, whereas, for phosphate, this number is 0-161 Mt yr^{-1}, of which the upper limits collectively correspond to 20 times the current annual fertilizer use in the US (Fajardy & Mac Dowell, 2017). The increased usage of fertilizer has not only financial costs but also climate impacts, as N_2O, a potent GHG with higher global warming potential than CO_2 is a by-product of the nitrogen applied in agriculture (Crutzen, Mosier, Smith, & Winiwarter, 2008). Biomass' need for fertilizer is, therefore, contributing to climate change rather than mitigating it.

Water has a dual purpose as it is also used for the CCS process, which increases water use in power plants by 20-60% (Magneschi, Zhang, & Munson, 2017) and require 106 m^3 of water/tCO_2 captured (Abu-Zahra, Schneiders, Niederer, Feron, & Versteeg, 2007). In a 2°C scenario by 2100, BECCS is estimated to require 720 km^3 of water per year, from which 450 m^3 can be attributed to the CCS process (Smith et al., 2016). Thus, the overall water, land, and fertilizer requirements of BECCS results in decreased availability of the same resources elsewhere (Ottmar Edenhofer, Seyboth, Creutzig, & Schlömer, 2013), which could be detrimental to a growing global population (UN, 2019) and its needs.

3.5 Social impacts

Biomass production could displace and reduce the area available for food production, leading to negative social impacts (e.g., food insecurity). Nevertheless, not all scientists agree that it has only negative outcomes.

Amongst other nations, Brazil experienced a decrease in food security in 2004-09 as the production of biomass increased (Finco & Doppler, 2010). Furthermore, the higher land demand for biomass crops can displace small landholders (Buck, 2016) or be the source of land-rights-based conflicts (A. Wright, 2014). The shift can also cause an increase in food demand, as fewer fields are available for food crops, resulting in higher food prices, leading to either a skewed food distribution or an actual food shortage (Shue, 2017). In 2000-07, the global average grain price, for instance, increased by 30% due to an increase in biomass production for biofuel (Rosegrant, 2008), while US corn production for bioenergy in 2010, caused a 20% increase in staple crop prices (Roberts & Schlenker, 2013).

Moreover, as discussed above, the high water requirement is likely to reduce clean water access for people and the ecosystems they depend on (Buck, 2016). For developing countries where populations spend a high share of their income on food (World Economic Forum, 2016), a slight increase in food prices or the modification of other dependent ecosystem services can be detrimental to food security, economic security, and human health. Thus, developing countries are likely to be negatively affected by a global demand for biomass to generate bioenergy.

Nevertheless, not all scientists agree with this negative impact of biomass and instead claim that it can result in positive economic and social effects. For example, some argue that bioenergy production does not result in food insecurity (Kline et al., 2017; Shrestha, Staab, & Duffield, 2019) but enables food security and employment (Kline et al., 2017). For instance, small landholders have claimed to be better off with biomass production than without (A. Wright, 2014). In addition, several studies show an increase in GDP, economic benefits, and employment opportunities with biomass production (Brinkman et al., 2018; de la Rúa & Lechón, 2016; Nepal & Tran, 2019). This, therefore, leaves the overall social impact of bioenergy as rather context-dependent.

3.6 Technological challenges

Despite BECCS's perception as a viable GGR method, it faces multiple technological challenges that have contributed to its lack of deployment. As aforementioned, BECCS consists of bioenergy and CCS, of which the former is an established energy source; while the latter technology for biomass has been discussed and researched for a while, yet it has still not developed at scale (Bui et al., 2018).

As of 2015, there were five operating BECCS projects globally, each capturing between 0.1-0.3 $MtCO_2$/year (Kemper, 2015), except for the corn-based Illinois Basin Decatur project in the US, which captures 1 $MtCO_2$/year (US Department of Energy, 2017). Newer and still developing projects, such as the Australian Gorgon gas processing project, is four times bigger than the Illinois Decatur project

and aim to sequester 3.4-4 $MtCO_2$/year (Gough et al., 2018). Such a large number may sound great; however, it is still much less than the IPCC expected CO_2 removal of 2-10 $GtCO_2$/year by BECCS in 2050 for a 1.5°C scenario (Rogelj et al., 2018). Moreover, if this number is to be reached, 500-2000 Gorgon projects and connecting infrastructure must be built (Gough et al., 2018); thus, there is still far to go.

Transporting the captured CO_2 from the biomass plant to geological storage is another challenge (Babin et al., 2021). Pipelines are deemed the most viable option for large-scale carbon transport, and although existing pipelines can partly be used, many new ones will be required (Noothout et al., 2014). These endure high costs, potential public opposition, and in the case of offshore pipelines, the need for new infrastructure, capital investments, and ships (Brownsort, Scott, & Haszeldine, 2016; Noothout et al., 2014).

A third technical challenge of BECCS is the energy return on investment (EROI), a ratio between the energy used to obtain the energy resource versus the energy produced by that resource (Fajardy & Mac Dowell, 2018). According to Hall, Balogh, and Murphy (2009), energy resources must have an EROI of at least 3 to be a viable option. BECCS, depending on the biomass input, have an EROI between 0.5-5.7 (Fajardy & Mac Dowell, 2018). An EROI below 3 could require fossil fuel energy contribution (Hall et al., 2009), which will likely decrease the amount of carbon removed (Fajardy & Mac Dowell, 2018). Furthermore, a trade-off exists between the amount of CO_2 BECCS can remove and the power it can produce; thus, the more CO_2 removed, the less power generated (Bui et al., 2018; Fajardy & Mac Dowell, 2017, 2018).

BECCS, thus, face several technical challenges, and its inclusion in climate mitigation scenarios, also called Integrated Assessment Models (IAMs), can therefore be questioned. However, the inclusion of BECCS in these models does not translate to its technical feasibility in reality. Feasibility in IAMs is equivalent to what is computationally possible to reach a specific temperature target, whether via a likely or unlikely scenario (Carton, 2019; Low & Schäfer, 2020), with or without a temperature overshoot (Beck & Mahony, 2018). It is perhaps due to these reasons that although BECCS is publicly perceived and discussed as a feasible GGR method, it has not yet manifested in reality. However, the IPCC is also a powerful organization, and their inclusion of BECCS in future scenarios displays their performative power, which can transform “purely speculative visions in to politically powerful visions of actionable futures” (Beck & Mahony, 2018, p. 2).

3.7 Carbon negative or positive?

The degree to which BECCS can deliver negative emission are questioned, yet this depends on what is included in the emissions calculation. Some deem BECCS to be carbon-neutral or even carbon-positive; however, such claims depend on the definition of system boundaries in emissions accounting. System boundaries are conceptually drawn barriers that separate a system from everything around it (Gough et al., 2018; Meadows, 2008). BECCS assessments often draw a "gate-to-gate" system boundary (Figure 2), meaning that they only include emissions from within the power plant (Tanzer & Ramírez, 2019). A further expansion is the "cradle-to-gate" system boundary which includes upstream emissions (e.g., direct land-use change (LUC) and transportation) but excludes downstream emissions (e.g., products use and waste treatment) (Tanzer & Ramírez, 2019). The "cradle-to-grave" system includes both, along with indirect land-use change (ILUC) (Tanzer & Ramírez, 2019). ILUC occurs when the planting of bioenergy crops causes the unintended conversion of land to crop or pasture elsewhere (Creutzig et al., 2015). Both LUC and ILUC are important in emissions accounting, as they can increase GHG emissions significantly (Fajardy & Mac Dowell, 2017). Fajardy & Mac Dowell (2017) found that the inclusion of LUC and ILUC accounted for over 50% of biomass' carbon footprint. When incorporating LUC and ILUC in the emissions calculations, BECCS could only sequester 45.6% of total emissions, meaning more CO_2 was emitted than sequestered (Fajardy & Mac Dowell, 2017).

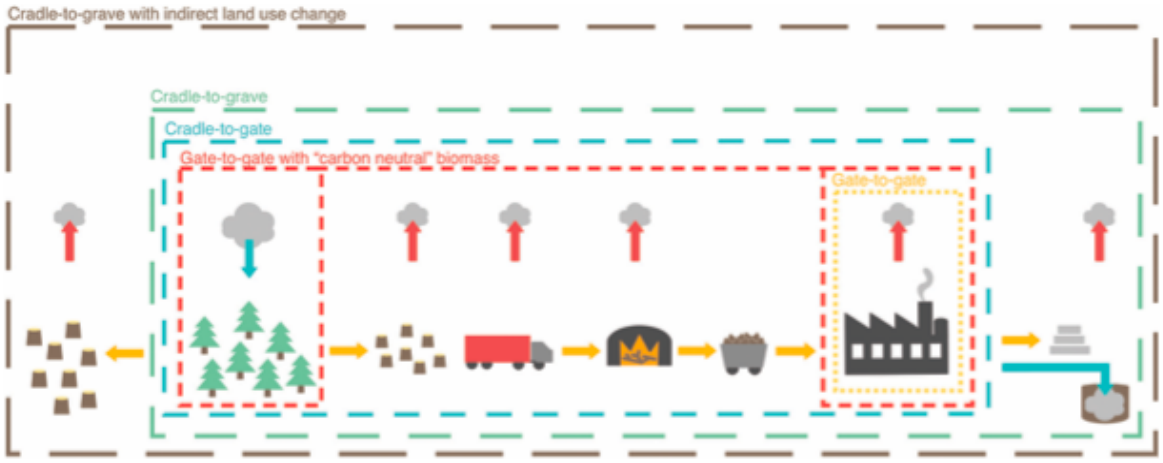

Figure 2: Various system boundaries definitions and inclusions when conducting emissions accounting for BECCS. Source (Fajardy & Mac Dowell, 2017).

3.8 UK Interest in BECCS

By examining the societal and political infrastructure in the UK more closely, the UK interest in BECCS can be traced to two main elements which act as pre-requisites: the UK bioenergy infrastructure; and the *Climate Change Act*.

Since biomass' classification as carbon neutral by the UNFCCC (EC, 2014; UNFCCC, 2008) and the EU's Renewable Energy Directive (EU, 2009), many countries, and especially the UK, have substituted coal for biomass (Norton et al., 2019). In 2017, more than 10% of the UK's energy was renewable, of which bioenergy represented almost 40% (Office for National Statistics, 2019). Wood pellets represent most of this percentage, and the amount grew from 0.6 Mt in 2010 to 7.8 Mt in 2018 (Office for National Statistics, 2019). Furthermore, coal power stations have been transformed into biomass power stations, and biomass policies, such as subsidies, have been established (ONS, 2019). For instance, the UK biomass power station Drax which runs a BECCS pilot project has received biomass subsidies of £789.5 million during 2019 (Drax Group, 2019), equivalent to £2.1 million per day (Biofuelwatch, 2020a). An infrastructural bioenergy system is thus evidently in place, setting the frame for the bioenergy component of BECCS.

Secondly, from 2008, the UK has had a *Climate Change Act* that requires them to cut GHG emissions by 80% compared to 1990 levels by 2050 (UK Government, 2008). To help the government fulfill this goal, the CCC was established to set five-year carbon budgets and reduction measures (UK Government, 2008). In 2019, following the Paris Agreement (2015), the IPCC's special report on 1.5°C (2018), and the CCC's advice (CCC, 2019), the 80% reduction target was increased to 100% (UK Government, 2019a). To reach this net-zero goal, carbon avoidance and removals, such as engineered and nature-based GGRs, are needed. Nature-based removals (e.g. afforestation and reforestation) are expected to remove 39 $MtCO_2e$/year by 2050, whereas engineered removals are expected to remove 58 $MtCO_2e$/year in 2050 of which BECCS is responsible for 53 $MtCO_2e$/year (CCC, 2020b, p. 197). BECCS is, therefore, assigned an important prospective role in the UK.

4 Theoretical framework

This research is rooted in the critical realist paradigm and utilizes Fairclough's Critical Discourse Analysis (CDA), Gramsci's Ideological hegemony, and Dryzek's environmental discourses as its theoretical framework. Collectively, these laid the analytical foundation that helped answer the RQs.

4.1 Research paradigm of critical realism

This paper aligns itself with a research philosophy of critical realism. The ontological claim of critical realism argues that a natural world exists independently, whereas the social world is human-dependent and constructed (Fairclough, 2013a). The real world is, thus, external, "but not directly accessible through our observation and knowledge of it" (M. Saunders, Lewis, & Thornhill, 2009b, p. 139). Therefore, the ontology of critical realism is stratified into three different levels: the *real*, the *actual* and the *empirical* (Figure 3) (Bhaskar, 2008). The *real* relates to objects, their structures, and powers; the *actual* corresponds to the potential events of those powers; and the *empirical* to the experience of the observable events (Sayer, 2000). This thesis, and critical realists in general, attempts to examine the underlying structures and powers (the real) and their generated observable events (the actual) to explain the experienced events (the empirical) (M. Saunders et al., 2009b). The research, thus, follows a retroductive approach, which involves going beyond observed events to discover which conditions (structures and power) produce them (Blaikie, 2011).

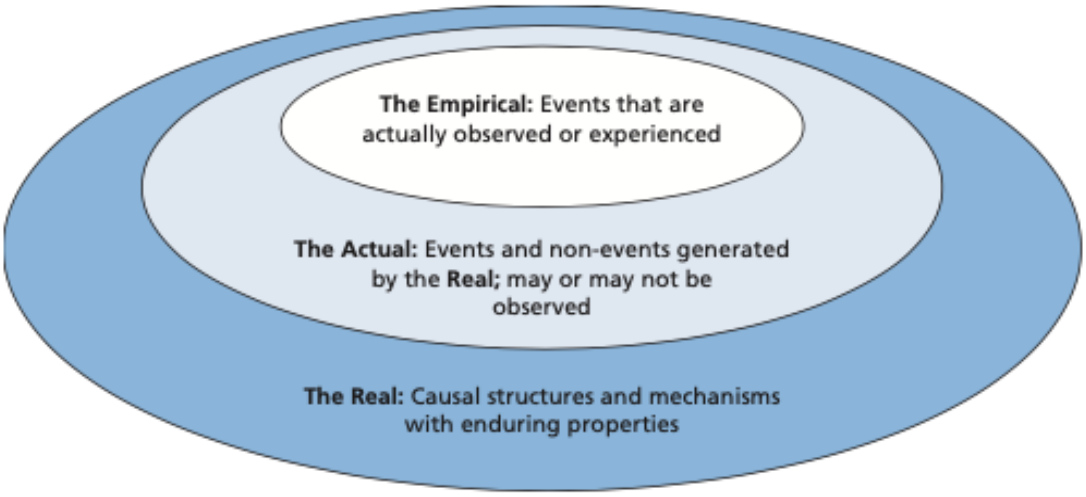

Figure 3: Critical realism's ontology presented in the real, the actual, and the empirical levels developed from Bhaskar. Source (M. Saunders et al., 2009b, p. 139).

The epistemology of critical realism leans against relativism, which identifies knowledge as historically, culturally, and socially shaped (M. Saunders et al., 2009b). Knowledge is, therefore, context-specific and subjective as it is told from various perspectives of various agents (Archer, Decoteau, & Gorski, 2016). For instance, this research takes place in the UK, where context knowledge is used to determine the appropriate UK pathways to fulfill the net-zero target, which are selected and based on the perspectives of the CCC. The outcome would have differed if the same situation took place in a different country, had different UK actors proposing pathways, or had a different author conducting the same research. Thus, it underlines the importance of acknowledging

the critical realist researchers' axiology, as it is biased by the researcher's worldview, culture, and experiences (M. Saunders, Lewis, & Thornhill, 2009a). Therefore, the researcher must acknowledge their positionality (section 5.4 Positionality) (M. Saunders et al., 2009b).

4.2 Critical discourse analysis

Fairclough's Critical Discourse Analysis (CDA) is the applied theory that helps reveal the connections between language and power. CDA is a social science research approach that draws on many different fields such as linguistics and anthropology to critically analyze "the relation between language and society" (Wodak, 2013, p. xix) through ideology and power (Wodak, 2007). Ideology is defined as beliefs (Dictionary, 2021); however, in reality, ideologies are abstract and difficult to identify (van Dijk, 2006). Ideologies are, nevertheless, expressed, reproduced, and acquired through discourses (van Dijk, 2013) which can be identified to understand how certain ideologies exercise power.

Discourses are rooted in written and spoken language, as how we choose to speak or write about something – being the use of language – shapes our perception of the world and the experiences within it (Willig, 2014). Discourses relate to how "knowledge, subjects, behavior, and events are depicted and defined in statements, assumptions, concepts, themes, and shared ideas" (Braham, 2014, p. 58). Language use, therefore, often becomes sites of struggle that displays different discourses and their underlying ideologies competing for power (Wodak, 2007).

Power through language use is central in CDA. Although language does not directly equal power, language is a power vehicle that can challenge, change, or alter power distributions (Wodak, 2007). Language use is not viewed as objective but rather subjective and influential in its ability to change people's perceptions and actions. Language use is a social practice implying it has an action mode, which operates in relativism's social and historical context, meaning that language is both shaping society, but is also being shaped by society (Fairclough, 2013b).

To uncover the interconnectedness of power and discourses, Fairclough proposes a three-dimensional model (Figure 4), which draws on both linguistic, social, and political theory. According to Fairclough (2001), the model can be both a theory and a method, as is the case here.

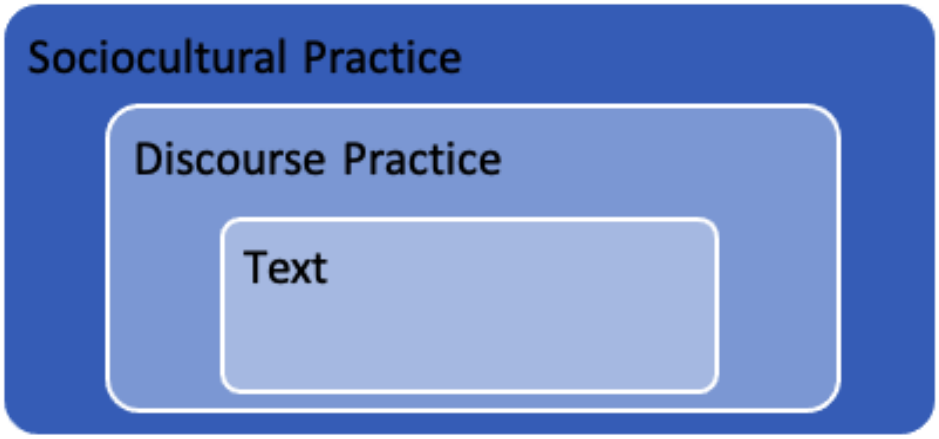

Figure 4: Fairclough's three-dimensional model. Author, 2021, based on Fairclough (1992a, p. 73).

The CDA's linguistic element (text) refers to how texts are communicated and understood. The middle dimension (discourse practice) is about how texts are produced, which discourses they draw upon, and combine in text to either reinforce, change, or challenge the hegemonic societal discourse. The last dimension (sociocultural practice) is occupied with how these lower layers relate to and influence the wider society (Fairclough, 1992c). Hegemony, a political concept elaborated below, is another term for power that focuses on creating alliances and integrating counter-hegemonic (less dominant) discourses to stay in control (Fairclough, 1992a). CDA's main objective as a critical theory is, therefore, to reveal dominant power relations by focusing on "what is wrong with society, and how 'wrongs' might be 'righted' or mitigated" (Fairclough, 2013d, p. 7). In this case, this would be how BECCS is communicated in the UK, the ramifications this has for the wider society and proposals as to how these ramifications can be mitigated.

4.3 Ideological hegemony

Ideological hegemony (from here on hegemony) stems from Marxist philosophy and was developed by Antonio Gramsci. Hegemony involves "the successful attempt of the dominant class to use its political, moral, and intellectual leadership to establish its view of the world as all-inclusive and universal and to shape the interests and needs of subordinate groups" (Berberoglu, 2017, p. 100). This political power has historically emerged from higher societal classes that occupied state bodies and political institutions, and hegemony, thereby, often belonged to the state (Berberoglu, 2017). Hegemonic processes combine force and consent to obtain dominance, although the former will appear grounded in the latter. Therefore, the hegemonic class dominates those who oppose it and leads those who agree (Gramsci, 2009). Hegemony is, thus, focused on how dominant power develops through discourses and how power is reproduced or challenged and changed by counter-

hegemonic discourses. Therefore, discourses are both an instrument of dominance aiming for reinforcement but also a site of struggle aiming for change (Donoghue, 2018). According to Fairclough, hegemony is suitable with CDA as it allows the investigation of how certain discourses become hegemonic through language use (Fairclough, 1992a).

4.4 Environmental Discourses

Environmental discourses are different ways of understanding environmental issues and have been chosen to support the forthcoming analysis. Discourses represent shared ways of understanding the world and enable people who support the same discourses to define knowledge and solve problems based on this (Dryzek, 2013a). However, a mix of discourses can be utilized when depicting a specific topic as outlined in the discourse practice above (Fairclough, 1992c). According to Dryzek, four main environmental discourses and their sub-discourses exist, which all have distinct definitions of and solutions to environmental problems. However, this paper only includes the following three discourses relevant to the scope (Figure 5) (for further elaboration see Appendix 11.5 Elaborated Discourse Table). It does not consider other existing environmental discourses, which could offer different interpretations of BECCS than those displayed here.

	GLOBAL LIMITS AND SURVIVAL	ECONOMIC RATIONALISM	ECOLOGICAL MODERNIZATION
BELIEF	Ecological limits exist, and if exceeded, it will result in negative consequences such as ecosystem and population crashes.	Nature exists only to supply resources to human needs and desires, and these resources are distributed in a competitive fashion.	Economic development and environmental protection can reinforce one another; thus, no hard choices must be made.
ADVOCATES	Monitoring of limits and regulation of human populations to avoid the exceeding of these limits.	Market-oriented policy such as tradeable emission quotas, but also emissions offsetting and green taxes.	Green growth and decoupling made possible by the help of technological advances.
AGENTS	Experts within modeling or earth system science and governments are central actors.	Mainly self-interested homo economicus with a minor role for governments to define and enforce environmental taxation or property rights.	Partnerships between governments, businesses, moderate environmentalists, and scientists are believed essential for change.

Figure 5: The three relevant environmental discourses and their descriptions. An elaboration of these can be found in appendix 11.5 Elaborated Discourse Table. Author, 2021, based on (Dryzek, 2013e).

5 Methodology

This section displays the data collection and analysis process and shows how the CDA can also function as a method, which helped structure the data analysis. Other items that impacted the research process, such as positionality, are also addressed in the following section.

5.1 CDA as a method

As aforementioned, Fairclough's CDA is both the chosen theory and model applied in this paper (Fairclough, 2001). Its three-dimensional discourse approach consists of text, processing, and social analyses (Figure 6). The **text analysis** investigated how BECCS is described in various texts by different UK actors and focused on the emerging themes and actors in the BECCS debate. The **processing analysis** identified the connection between the discourse practice and the text by identifying the environmental discourses (Dryzek, 2013e) the BECCS themes drew upon and investigating "how it works them into particular articulations" (Fairclough, 2001, p. 124). Finally, the **social analysis** focused on explaining the relation between the discourse practice and the sociocultural practice (Fairclough, 2001) by identifying the impact of the "discourse practice upon the social practice" (Fairclough, 1992b, p. 237). Therefore, the UK's hegemonic BECCS discourse was explored regarding its impacts on the broader society.

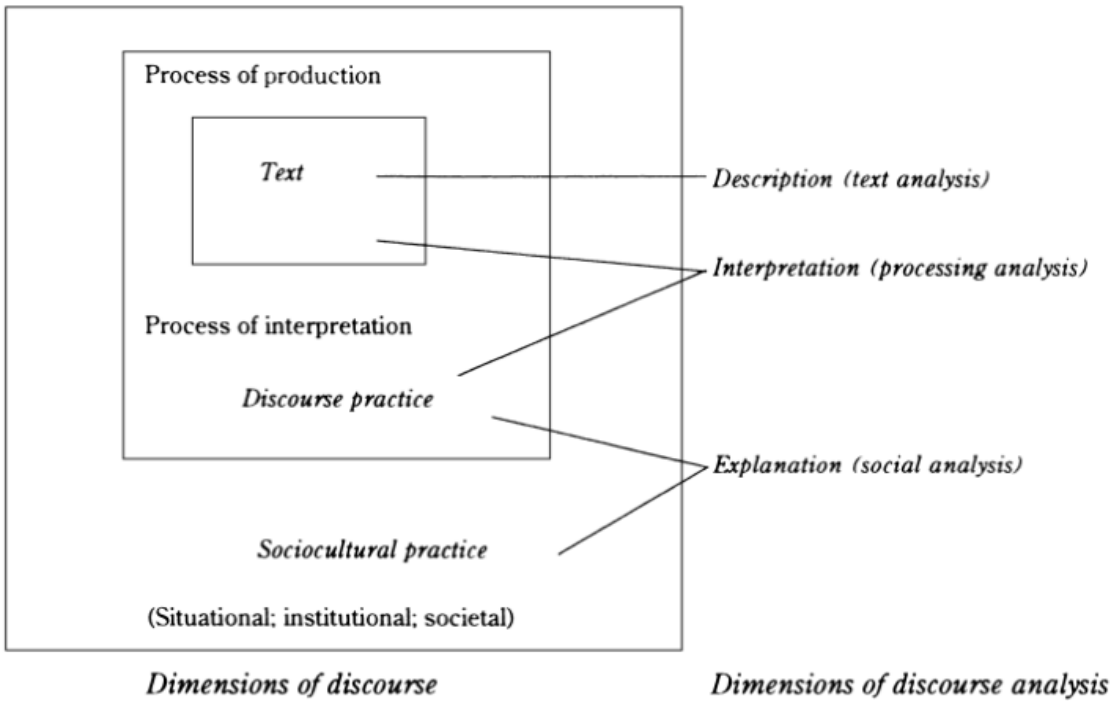

Figure 6: Fairclough's three-dimensional discourses and their analysis. Source: (Fairclough, 2013c, p. 133)

5.2 Data collection and justification

This research was occupied with identifying the depiction of BECCS in the UK; thus, data was gathered from multiple societal actors. As such depictions and societal conditions are not explicitly present within the scientific literature, grey literature such as policy recommendations, articles, and reports were included to reflect societal structures and opinions. Google and the UK government's web page were used as search engines along with the search terms, inclusion and exclusion criteria outlined in Table 1 (elaborated in appendix 11.1 Data collection and criteria). The search occurred between the 19th of January – 17th of April 2021, and generally, a text could not be older than 5 years (2016-2021) to reflect current depictions; and it had to originate from institutions, companies, etc. to reflect a wider societal representation of BECCS rather than that of a private individual. Although an individual from an organization can be responsible for a text, that text still embodies the organization's values. Furthermore, BECCS in a UK context had to feature in the text, and the text had to be a finished product. The initial literature search resulted in data advocating *for* BECCS, with few opposing texts; thus, the search terms were adjusted to uncover data more critically oriented towards BECCS.

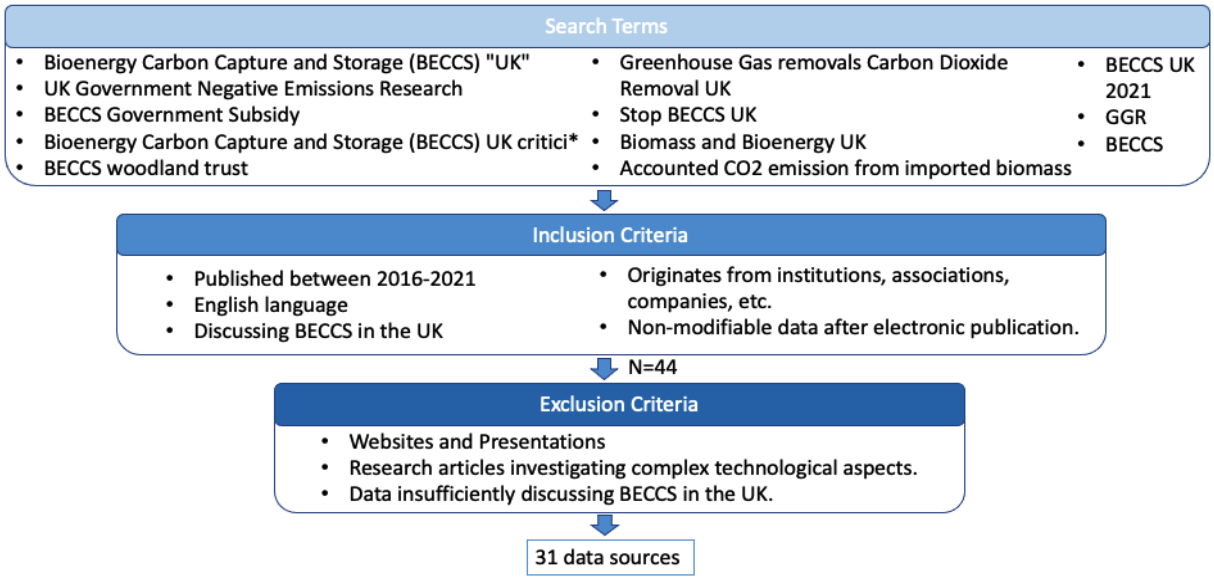

Table 1: Search terms, inclusion, and exclusion criteria.

Using the inclusion and exclusions criteria generated 31 data sources (Table 2) which were represented by 22 actors, as some actors were responsible for multiple sources. These 22 actors were then categorized according to genres, either self-proclaimed or according to genre criteria (11.2 Genre classification), with online news articles being the largest category (n=6).

Category	Actor	Source	Year	Title
News Media	BBC	BBC	2020	Humber carbon capture scheme 'may create 49,000 jobs'
	Bdaily News	Bdaily News	2020	Environmental groups respond to carbon capture funding pledge in UK Budget
	Current News	Current News	2020	Bioenergy with carbon capture and storage pilot to launch at Drax Power Station
	T&D World	T&D World	2021	Bioenergy with carbon capture - decarbonize UK
	Market Screener		2021	Drax kickstarts application process to build vital negative emissions technology
	Bioenergy Insight		2021	Developing BECCS at Drax 'could save UK billions', says report
NGOs	Biofuelwatch and Friends of the Earth		2020	BioEnergy with Carbon Capture and Storage (BECCS): A Dangerous Distraction from Meaningful Climate Action
	NRDC		2018	Don't Throw Good Climate Money After Bad with BECCS
	FoE, NRDC, Fern, etc.[1]	ELCI	2021	Joint NGO Statement on BECCS 19 environmental NGOs warn the UK government about the risks associated with BECCS
	WWF	Vivid Eco.	2018	Keeping it cool: how the UK can end its contribution to climate change
	Intergenerational Foundation		2021	How promising is Drax's proposal to build negative emission technology? - Intergenerational Foundation
Research and Policy Institute	Grantham Research Institute & CCCEP		2019	How to price carbon to reach net zero emissions in the UK
	Supergen Bioenergy Hub		2021	Research and innovation need for biomass to energy with carbon capture and storage (BECCS)
	Renewable Energy Association		2019	Position Paper Going Negative Policy Proposals for UK BECCS.
	Royal Society & RAEng[2]		2018	Greenhouse Gas removal
	UKERC		2019	BECCS and DACC: Examining the evidence on deployment potential and costs in the UK
Advisor	CCC[3]		2016	UK climate action following the Paris Agreement
			2018	Biomass in a low-carbon economy
			2019	Net Zero: The UK's contribution to stopping global warming
			2020	The sixth carbon budget - the UK's path to net zero
			2020	Policies for the Sixth Carbon Budget and Net Zero
PPP	Energy Technologies Institute		2016	The Evidence for Deploying Bioenergy with CCS in the UK
UK Government	BEIS[4]	Ricardo Energy & Env.	2018	Analyzing the potential of bioenergy with carbon capture in the UK to 2050: Summary for policymakers
	BEIS[4]		2019	The UK government's view on GGR technologies and Solar Radiation
			2019	UK's largest carbon capture project to prevent equivalent of 22,000 cars' emissions from polluting the atmosphere from 2021
	BEIS[4]	Vivid Economics	2019	Greenhouse Gas removal (GGR) - policy options
	BEIS[4]		2020	The Energy White Paper: Powering our net zero future
	HM Government		2020	Greenhouse Gas Removals - call for evidence
	UK Parliament Post		2020	Bioenergy with Carbon Capture & Storage
Energy Company	Drax	Medium	2020	Why the UK needs biomass energy capture, use and storage to reach net zero
		Baringa	2021	Value of Biomass with Carbon Capture and Storage (BECCS) in Power

Table 2: The 31 data sources included in the Critical Discourse Analysis. [1]Greenpeace, ActionAid, Biofuelwatch, Campaign against Climate Change, Dogwood Alliance, EcoNexus, Economy, Land and Climate Insight, Environmental Justice Foundation (UK), ETC Group, Feedback Global, Friends of the Earth (FoE) England, Wales and Northern Ireland, FoE Scotland, WWF, Green Christian, Southern Environmental Law Center, Sustain, Whale and Dolphin Conservation; [2] Royal Society & Royal Academy of Engineering; [3] Committee of Climate Change; [4] The Department of Business, Energy, and Industrial Strategy, (Author, 2021). PPP: Public-Private Partnership.

5.3 Data coding and analysis

The CDA's three-step approach, the hegemony, and the environmental discourses sat the frame for the analysis, which helped answer the RQs (Figure 7). The **text analysis** entailed the coding software NVivo and the creation of codes "to establish a framework of thematic ideas" (Gibbs, 2007, p. 38). First, the data underwent a preliminary reading, in which sections for the analysis and general themes were identified. The general themes were then used to define the coding categories

(Appendix 11.4 Coding categories), resulting in concept-driven codes. However, some codes changed during the analysis to account for new ideas (Gibbs, 2007); thus, the coding process moved between concept and data-driven codes. The data then underwent analysis where themes and influential actors were identified, addressing RQ1. The **processing analysis** was guided by the chosen environmental discourses (Dryzek, 2013e) and Gramsci's theory of hegemony (Berberoglu, 2017; Gramsci, 2009). Together with the identified themes and actors, this analysis clarified the main discourses in the various themes and contributed to identifying the hegemonic discourse, answering RQ2. Finally, the **social analysis** explored the implications of the hegemonic discourse on society, tackling RQ3.

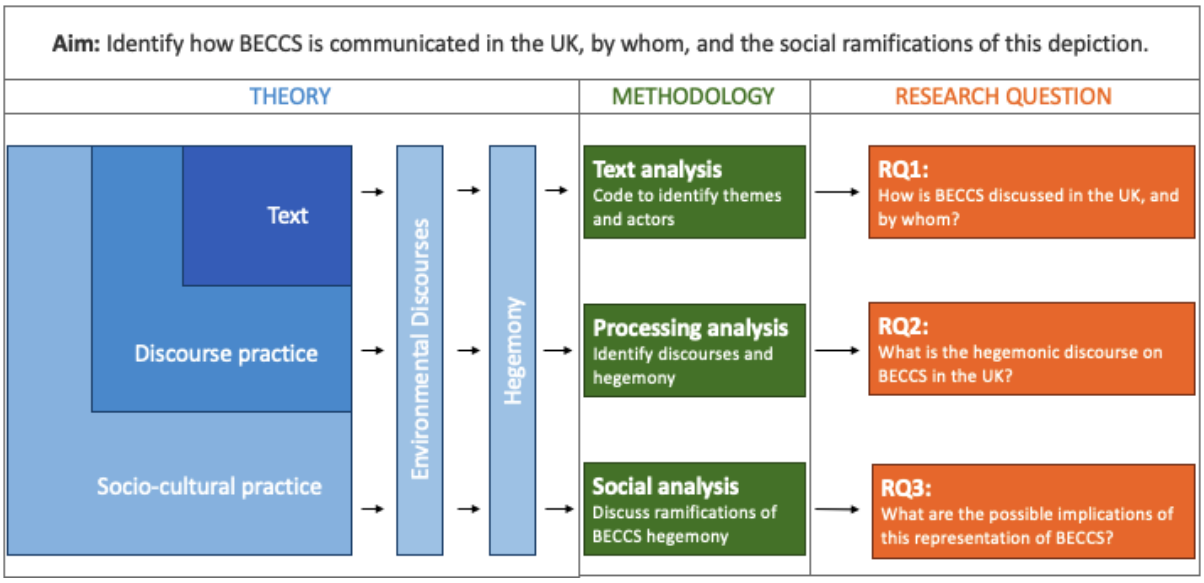

Figure 7: Connecting theory, methodology, and research questions to aim (Author, 2021).

5.4 Positionality

Critical realist researchers must acknowledge their values and positionality, as these cannot be separated from the research (M. Saunders et al., 2009a). First, this research is based within a UK context; however, I am not a UK citizen, nor have I ever lived there. Therefore, I am not familiar with the general opinion of BECCS – giving me an outsider perspective. This outside perspective may have impacted the inclusion of sources and the representation of data in this paper. However, it may also have provided a more neutral and unbiased approach to the research (Holmes, 2020). Secondly, as a citizen of Denmark, a country highly dependent on bioenergy for reducing its domestic GHG emissions, I understand the pride associated with being a pioneering green country, and how it can be difficult to understand the negative impacts of bioenergy when it is not one's own forests that suffers. Exploring how climate mitigation technologies such as BECCS is perceived and represented

within countries where the public only sees glimpses of the process, is part of the reason for why I chose to research BECCS.

6 Analysis and findings

By combining the text and processing analysis, applying Dryzek's environmental discourses and Gramsci's hegemony to the 31 data sources, this section presents the overall dominant actor, the CCC, and three emerging themes: the BECCS-net-zero lock-in, the focus on sustainable biomass, and BECCS's economic and environmental benefits (RQ1). It also identifies the environmental discourses these themes draw upon (RQ2).

6.1 The UK BECCS actors

Out of the 22 actors present in the debate, a majority (n=17) supports BECCS while a minority opposes it (n=5); thus, already displaying the general UK attitude towards BECCS. Regarding power, the CCC, the government, and the research and policy institutions are powerful due to their authority and credibility. Drax is powerful as it is the UK bioenergy power plant with a BECCS project that can prove or disprove the technology. The Energy Technologies Institute (ETI), a public-private partnership, has power as it combines BECCS development and finance from the private sector while engaging with the government. Less powerful are the news media and the NGOs. The former is due to BECCS not being a highly publicly discussed topic and because many of the news media included are smaller, topic-specific media, except for the BBC. For the latter, these are comparatively few; their opposing arguments are not picked up by included news media, except for by Bdaily News; and they do not have a direct link, e.g., a consultation, with the government or the research and policy institutions (Figure 8).

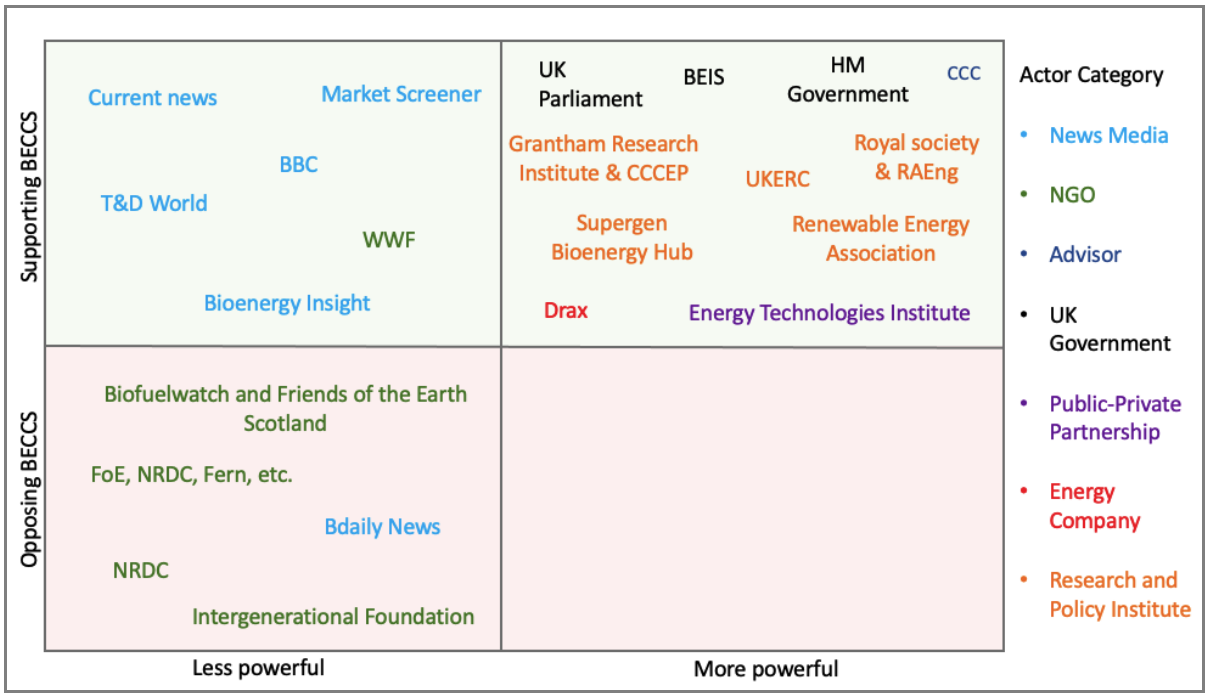

Figure 8: Actor distribution regarding support and power (Author, 2021).

Although the news media (n=6) and the NGOs (n=5) are numerous in the debate, as are the research and policy institutions (n=5), it is the CCC's name and ideas which appear most frequently. Compared to other commonly mentioned actors, the CCC is mentioned 1109 times in all sources, while other popular actors such as BEIS and Drax are mentioned 389 and 290 times, respectively. The CCC, therefore, appears to be a highly influential actor in the UK.

6.1.1 BECCS and the Committee of Climate Change

The Committee of Climate Change (CCC), which advises the UK government on climate action and carbon budgets, has been the leading actor in fostering BECCS as 'the' climate solution for the UK and its government throughout their reports from 2016-21. In 2016, BECCS, afforestation, and biomass were displayed as three GGR options with biomass. Although BECCS did not, and do not exist as the two other GGR options, it still had the superior estimated mitigation potential (47 $MtCO_2$/year against 16 $MtCO_2$/year for afforestation and 4 $MtCO_2$/year for wood in construction). As the CCC at the time highlighted that there were limits to biomass, it positioned BECCS as the better choice by stating that "its [biomass] role must be targeted at options where it has the largest impact on emissions" (CCC, 2016, p. 36). In 2018, the CCC further developed the notion that BECCS has benefits for the UK and, therefore, encouraged the idea that the UK should be a "global hub for carbon removal" (CCC, 2018, p. 106) due to its experience with bioenergy and its capacity for CO_2 storage. Not only would it help the UK reduce its emissions, but it would also advance business

opportunities for UK actors. It is, therefore, not surprising that the CCC went on to directly encourage the government to proceed with its preparations for BECCS:

> *The Government should examine how BECCS can be incentivised with changes to existing policy mechanisms and/or new mechanisms.*
>
> (CCC, 2018, p. 126)

In their 2019 report on net-zero in the UK, it became clear that the UK net-zero strategy relies heavily on BECCS, as it is the primary method for emissions removal (Figure 9) (CCC, 2019).

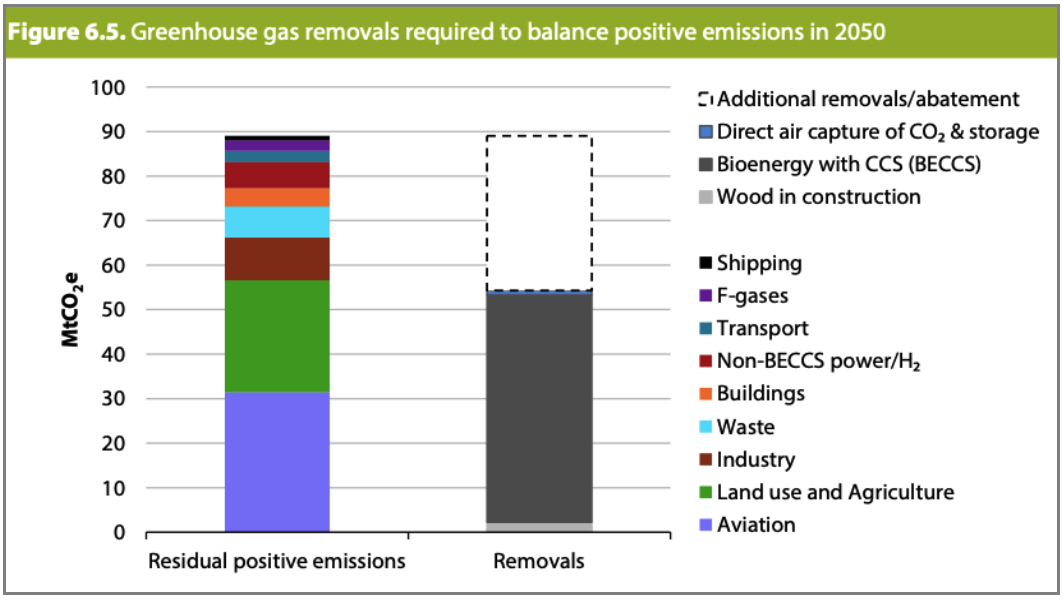

Figure 9: Greenhouse Gas Removals required to reach net-zero in 2050 in the UK. Source: (CCC, 2019, p. 208).

In their latest report from 2020, the *Sixth Carbon Budget,* the first budget to incorporate the net-zero target, the CCC outlines different pathways for reaching net-zero by 2050 with BECCS present in all of them. In the main scenario, BECCS removes 58 $MtCO_2$/year by 2050, whereas in the four alternative scenarios, BECCS deployment ranges from 36-96 $MtCO_2$/year by 2050 (CCC, 2020b, p. 200). The CCC, furthermore, recommends the government to initiate support schemes for BECCS and other biomass uses, initiate CCS operations, and create governance and sustainability frameworks for biomass before the UK government publishes its biomass strategy in 2022 (CCC, 2020a). Not only does such advice suggest that BECCS is likely to be part of the forthcoming biomass strategy, but it also indicates the power of the CCC in its ability to influence the direction of the UK's climate actions.

Overall, the CCC displays BECCS as highly necessary for the UK climate targets and, thereby, reveal their faith in BECCS despite its lack of technological and infrastructural development as identified in section 3 Background). By doing so, the CCC takes a prosaic departure from industrialism, meaning

that the current society that developed out of industrialism - the established industrial society - is believed to be able to solve the climate crisis. This stands in opposition to imaginative departures where solutions are found within new societies (Dryzek, 2013a).

6.1.2 The Influential Committee of Climate Change

As the CCC is the UK's climate expert and government advisor it has high credibility, as seen by the numerous references to their reports. However, more interestingly, their advice infiltrates the UK government, as indicated by the dashed sphere in Figure 10: The CCC's spheres of influence. In six out of seven governmental publications included in this study, the CCC is directly referenced regarding their call for BECCS to reach net-zero by 2050. For instance, this is seen in a report by Vivid Economics for The Department of Business, Energy, and Industrial Strategy (BEIS):

> *The recent CCC net zero advice explicitly includes extensive deployment of bioenergy with carbon capture and storage (BECCS) and relies on various more speculative GGRs to close the 'gap' between remaining emissions and achieving net zero.*
>
> (Vivid Economics, 2019, p. 7)

The CCC's credibility also emerges in the remaining 19 non-governmental or non-CCC sources where its influence spreads like rings in the water. Direct references to the CCC appears in 11 of the 19 sources (58%) as seen by the third sphere of influence (Figure 10: The CCC's spheres of influence), of which eight incorporate the CCC's 'need for BECCS' argument in a positive light. This is exemplified in a summary report of a workshop with policymakers, industrialists, and academics, who identified future initiatives and research areas to support the development of BECCS.

> *BECCS is an essential technology for the UK to meet its climate targets. The UK pathway to net zero by 2050 described in the Climate Change Committee (CCC) 6th Carbon Budget requires an engineered emissions removals of 58 Mt pa by 2050. BECCS has the largest potential with different types of BECCS together contributing 52 Mt pa removal by 2050.*
>
> (Supergen Bioenergy Hub, 2021, p. 3)

In seven of these 19 sources where the CCC is not included directly, they feature indirectly through other sources engaged with the CCC as indicated by the last sphere of influence (Figure 10: The CCC's spheres of influence). For instance, the Royal Society and Royal Academy of Engineering (RAEng) were asked by the UK government to explore the scientific and engineering aspects of GGRs and "how they may be deployed together to meet climate targets, both in the UK and globally" (The

Royal Society & Royal Academy of Engineering, 2018, p. 2). Although this comes from the UK government, the original request stems from the CCC, who advised the government to initiate preparations for BECCS to reach their climate targets. Thus, the CCC operates through the UK government.

Another example is seen in the short article from Bioenergy Insight (2021), which refers to several arguments from a report made by Baringa (2021) for Drax – who engages with the CCC. One example is the elevated costs of reaching net-zero by 2050 without BECCS (Bioenergy Insight, 2021), which is similar to the CCC argument, stating that it is improbable that net-zero can be reached "cost-effectively without also a significant contribution from 'engineered' removals of CO_2 (e.g., use of bioenergy with carbon capture and storage (BECCS))" (CCC, 2020b, p. 423). The BBC is the only source that does not have an explicit indirect link to the CCC, and it has, thus, been put outside the spheres of influence (Figure 10: The CCC's spheres of influence).

Additionally, few actors (n=5), spread throughout the two last spheres (Figure 10: The CCC's spheres of influence), oppose the deployment of BECCS, as also marked in red. These are thus creating a counter-hegemony, challenging the BECCS-deployment hegemony. Their arguments entail that BECCS is "a dangerous distraction from meaningful climate action" (Biofuelwatch & Friends of the Earth Scotland, 2020, p. 3) and that "it actually digs the climate hole deeper" (NRDC, 2018, p. 5). In these cases, the references to the CCC or the government is not of a supportive character but rather a critiquing one. As hegemony is "about constructing alliances and integrating, rather than simply dominating subordinate classes" (Fairclough, 1992a, p. 92), one could expect the CCC to incorporate some of the counter-hegemonic actors' critique to preserve the hegemony.

However, except for the NRDC, these opposing actors have published their material in the same year as the CCC's last report (2020) or later, thus, there is currently no evidence of these being incorporated. Investigating the NRDC's critique of BECCS, an example of incorporation, nevertheless, emerges. The NRDC state that forest biomass "imperils forests around the world" (NRDC, 2018, p. 2) and that "BECCS would threaten the environment in a range of ways" (NRDC, 2018, p. 4), basically claiming that BECCS's demand for biomass is environmentally unsustainable. The CCC incorporates these biomass concerns by emphasizing that "Biomass sourced from high-carbon content land [forests] or with detrimental impacts on other aspects of sustainability should be ruled out by sustainability criteria"(CCC, 2020a, p. 206). Although the NRDC might not be the only actor who voiced this concern, it still displays how hegemony maintains power by consuming slight resistance.

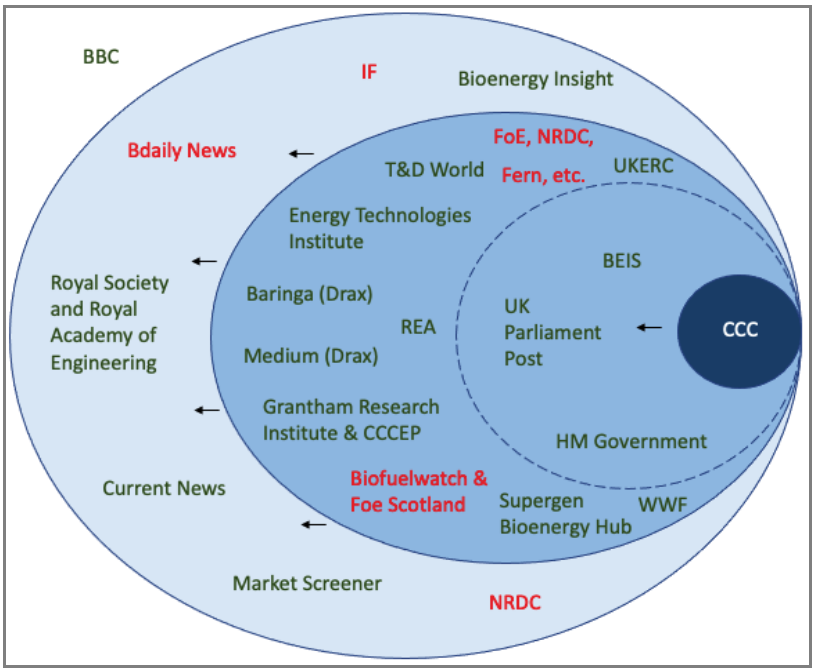

Figure 10: The CCC's spheres of influence mowing from the right towards the left as displayed by arrows, and actors' position to BECCS (green/red: supportive/opposing), (author, 2021).

The CCC's overall favoritism of BECCS, an inherently ecological modernization technology as elaborated in the 1 Introduction, infiltrates and dominates the general opinion on BECCS in the UK. According to Gramsci, hegemony occurs when the capitalist class distributes its ideology via control of the state and dominates society by establishing "its view of the world as all-inclusive and universal" (Berberoglu, 2017, p. 100). As the UK government already takes advice from the CCC and reproduces this advice as its policy, the CCC controls the state. Furthermore, by having other organizations within society also referring to the CCC's ideas or the CCC themselves, their voice is extremely relevant in the debate as opposed to other actors, such as NGOs and news media who are, nevertheless, superior in numbers. Furthermore, by incorporating critique – the CCC's control is extended, and their predominant worldview appears "all inclusive", and the CCC is, therefore, the hegemonic actor.

6.2 The emerging themes

Three main themes, which all put BECCS in a positive light, were found during the coding of the 31 data sources.

6.2.1 Theme 1: The BECCS-net-zero lock-in

BECCS is an essential technology for the UK to meet its climate targets.

(Supergen Bioenergy Hub, 2021, p. 3)

The argument of BECCS being necessary for fulfilling the UK climate targets and its net-zero target that was legislated in 2019 is a prominent theme frequently occurring from 2016-21. It features especially often in the reports published by the CCC, from which it trickles down as displayed above.

In 2016, the CCC emphasized that reaching net-zero would require "significant CO_2 removals in the long run" (CCC, 2016, p. 26), given the difficulty in removing all emissions. Displaying it as a necessity for removing GHG emissions, the CCC acknowledges an upper limit on CO_2 levels and, thus, recognizes ecological limits. However, the CCC also emphasizes in the same paragraph that the deployment of these would allow a "delay in reaching [net] zero at the expense of a temporary [CO_2] overshoot" (CCC, 2016, p. 26). Therefore, the concept of ecological limits and overshoot, as known from the *Global Limits and Survival* discourse, becomes blurry. The tendencies of the CCC, therefore, seems to agree with the *Ecological Modernization* discourse, where ecological limits are more fluid due to being largely ignored, and where nature's "balance should not be overburdened" (Dryzek, 2013e, p. 173); however, no strict limits exist. One may also believe that the CCC is downplaying the urgency of the climate crisis by expressing that BECCS can later reverse the elevated CO_2 levels, yet such thinking also falls under the *Ecological Modernization's* vague definition of limits.

Counting the CCC, 15 out of 22 actors (68%) also argues directly or indirectly that BECCS is necessary for net-zero. These include the government (BEIS, 2020; Ricardo Energy & Environment, 2018; Vivid Economics, 2019), four news media (BDaily, 2020; Bioenergy Insight, 2021; Current News, 2020; T&D World, 2021), five research and policy institutes (Grantham Research Institute & CCCEP, 2019; Renewable Energy Association, 2019; Supergen Bioenergy Hub, 2021; The Royal Society & Royal Academy of Engineering, 2018; UKERC, 2021), the WWF (NGO) (Vivid Economics, 2018), Drax (Baringa, 2021; Medium, 2020) and ETI (2016) (Figure 11).

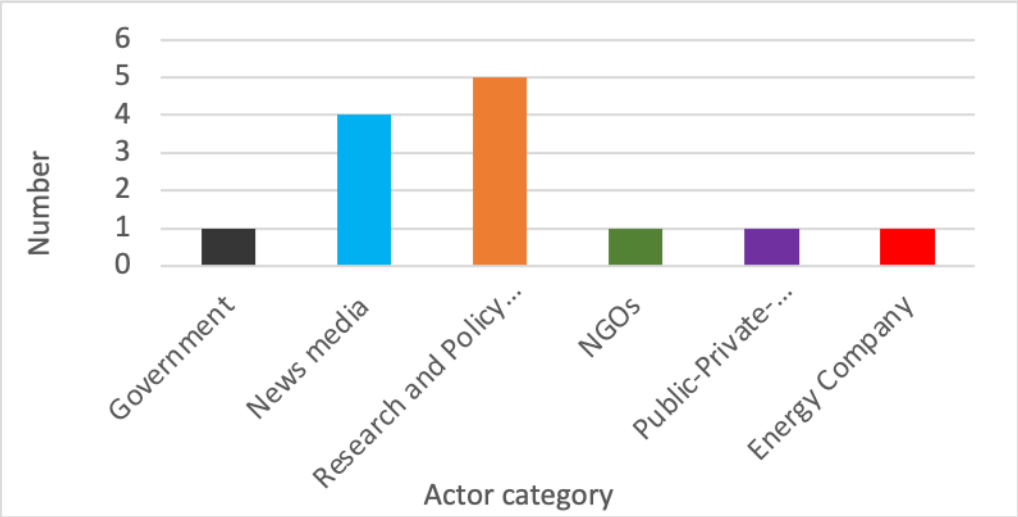

Figure 11: Distribution of actors supporting BECCS being necessary for the UK net-zero target (Author, 2021).

Out of these 15, nine actors are identified as powerful (Figure 8) and their view of BECCS as necessary for the net-zero target is, therefore, dominant. This is indirectly exemplified by the government (BEIS via Ricardo) as they acknowledge that without BECCS, it is unlikely that the UK can fulfill its Paris Agreement obligations, upon which the UK climate targets are based.

> *In the UK (and internationally) the impetus for BECCS comes from a recognition that it will be difficult and costly to achieve the Paris Agreement global climate change ambitions without using this technology.*
>
> (Ricardo Energy & Environment, 2018, p. 2)

The research and policy institutes display support for BECCS as necessary for net-zero by, for instance, the Renewable Energy Association (REA) stating that "achieving net zero is not possible without a portfolio of GGR strategies, most likely including BECCS" (Renewable Energy Association, 2019, p. 5). The ETI also echoes this by stating upfront in their 2016 report that BECCS is "critical to deploy in order for the UK to meet its 2050 GHG emission reduction targets" (Energy Technologies Institute, 2016, p. 4).

Another actor of importance is the NGO, the WWF. Although the WWF do not have much power in the debate, they are relevant because they display an excellent case of the workings of hegemony. The WWF advocates for preserving nature and its wildlife, yet BECCS - due to its use of biomass - would negatively impact these. However, the WWF still acknowledges that BECCS is vital if the UK is to reach net-zero by 2050 without the use of international offsets (Vivid Economics, 2018). Therefore, this is an excellent case of how the CCC, with the help of the state and other actors,

shapes “the ideas, hence consciousness, of the masses” (Berberoglu, 2017, p. 100). Nevertheless, as none of the actors mentioned above, except the CCC, argues for a temperature overshoot, belonging to the *Ecological Modernization* discourse, the concept of adhering to strict ecological limits from the *Global Limits and Survival* discourse is re-introduced; thus, both discourses are at play.

As revealed by the data analysis, the UK 2050 net-zero target has created a BECCS lock-in, which most actors support. A lock-in, in general, means that the commitment to one technology entail establishing several dependencies (e.g., societal, institutional, and technological), which makes it costly and difficult to change to a different technology (Unruh, 2000). In this case, BECCS is displayed as the only way to reach net-zero emissions, and as this is ‘necessary’ for the UK to mitigate climate change, the UK ‘must’ commit to a BECCS lock-in.

By positioning BECCS in this way, there are hegemonic elements of force and consent (Gramsci, 2009). Consent of BECCS as the most appropriate climate mitigation tool for the UK is shown through the multiple references to BECCS being necessary for fulfilling the climate targets. Force is applied by positioning BECCS as the only valid option for net-zero, thus forcing actors to accept the technology as no other alternative seems to have a similar mitigation potential. As the BECCS discussion has moved *“*from something that might happen to something that is expected to happen” (Supergen Bioenergy Hub, 2021, p. 5), it has created a BECCS-net-zero lock-in.

6.2.2 Theme 2: Sustainable biomass is the answer to all criticism

> *Without sustainable biomass, BECCS could cause more climate and environmental problems than it solves.*
>
> (Vivid Economics, 2018, p. 34)

If sustainable biomass is used with BECCS, it is depicted in the UK debate as making up for all the negative environmental and social effects and even be beneficial in some instances. However, BECCS is often criticized for its high use of biomass which often originates from established forests, monoculture plantations, or newly planted energy crops where food crops or nature used to reside. These sources significantly impact biodiversity, the ecosystem, and living beings dependent on them (Babin et al., 2021). Furthermore, the ILUC that occurs from these processes may result in increased, and not negative, emissions (Fajardy & Mac Dowell, 2017; Tanzer & Ramírez, 2019).

Based on this analysis, nine UK actors, nevertheless, claim that if biomass is sustainable, BECCS will be successful, meaning that environmental and social factors are not significantly impacted while

negative emissions are generated (The Royal Society & Royal Academy of Engineering, 2018). These nine actors include six powerful actors: the CCC (2016, 2018, 2020a), the government (Vivid Economics, 2019), and four research and policy institutions (Renewable Energy Association, 2019; Supergen Bioenergy Hub, 2021; The Royal Society & Royal Academy of Engineering, 2018; UKERC, 2021). Although their representation may be small out of the 22 actors, their credibility and authority are high, thus, their voices are very relevant.

To fulfill the mitigation role assigned for BECCS in the UK, several actors, including the hegemonic CCC, encourages an increased sustainable domestic production, for instance, by "meeting and exceeding current tree-planting targets" (CCC, 2020a, p. 201). Despite this, the CCC and others still acknowledge that sustainable biomass is limited, which poses questions of its future origins. However, the UK government does acknowledge that the current large deployment of bioenergy has only been achieved by "importing large quantities of biomass, predominantly from North America, East Europe and Russia" (Ricardo Energy & Environment, 2018, p. 7). Thus, foreign biomass is likely to be needed. Overall, the recognition of the need for sustainable biomass and its limited amount indicates an acknowledgment of resource scarcity, thereby, ecological limits, which belong to the *Global Limits and Survival* discourse.

There are also calls for the "close monitoring of biomass sourcing" to occur (Vivid Economics, 2018, p. 34). Although it is not indicated who should oversee such a task, monitoring, according to Dryzek (2013d), falls under the *Global Limits and Survival* discourse, whose agents are the government and experts. However, for sustainable biomass to become a reality, sustainability criteria are necessary. Fortunately, the UK already have these in place, which according to the REA, gives them a particular privilege in handling the expansion of BECCS.

> *The UK currently has the most stringent biomass sustainability criteria in the world and is therefore well placed to manage the development of BECCS.*
>
> (Renewable Energy Association, 2019, p. 6)

Due to this 'favorable' position, the CCC recommends the UK to continuously lead efforts on "further developing and improving UK and international biomass governance and sustainability criteria" (CCC, 2020a, p. 201). The UK is, thus, incentivized to take on the role of teaching other countries how to manage biomass resources, as expanding such knowledge can "stimulate sustainable forestry and economic development" (Renewable Energy Association, 2019, p. 7) in other countries. Although the UK portrays this as benefitting others, UK advantages also come with setting sustainability criteria, teaching others about them, and forestry practices. Overall, this contributes to establishing the UK as

the leading BECCS country. Furthermore, these potential actions relate to hegemony as they can be seen as an extension of power in which the UK is trying to dominate not only the domains of its own society, but also the domains of global biomass.

6.2.3 Theme 3: BECCS – A Boost to the UK economy … and the environment?

> *Drax is ready to invest in this essential technology which will help the UK decarbonise faster and kick-start a whole new industry here [UK].*
>
> (Bioenergy Insight, 2021, p. 1)

Another theme emerging that supports the implementation of BECCS is the economic benefits it can bring while simultaneously contributing to a healthy environment by reducing CO_2 levels and using sustainable biomass. BECCS, therefore, has an economic-environment duality that entertains the belief of being able to "have it all". However, despite this economy-environment duality, most sources are mainly focused on the economic aspects of BECCS, as can be seen in Table 3.

Increases business opportunities	Domestic biomass can "significantly increase the current bioenergy market" (Renewable Energy Association, 2019, p. 6).
Maintains and creates jobs	It can "protect 55,000 jobs" (Current News, 2020, p. 2) and it "may create up to 49,000 jobs" (BBC, 2020, p. 1).
Generates public and governmental funds	It can "save the UK energy system and consumers billions of pounds over the next decade" (Bioenergy Insight, 2021, p. 1).

Table 3: Economic benefits of BECCS in the UK

This focus indicates an alignment with the *Economic Rationalism* discourse, where economic indicators, markets, and prices are the main elements. However, reasons for why there is such a heightened focus on economic aspects could be because they are easier selling points in a country shaped by neoliberalism; because economic aspects are more concrete than the environmental aspects; or because the UK department in charge of BECCS is BEIS – the Department for Business, Energy, and Industrial Strategy. BEIS does not encompass environmental representation of any kind, so BECCS is naturally viewed with economic and industrial lenses rather than environmental and ecosystem lenses. As BEIS is part of the state and, thereby, the BECCS hegemony, this enhanced focus on the economic benefits of BECCS - as seen throughout the majority of sources - is another exercise of hegemony. The state's economic view of BECCS has been disseminated and reproduced

by several actors as seen above; thus, society and the state have therefore won "the active consent of those over whom it rules" (Gramsci, 2009, p. 91).

Several sources also elaborate on how to incentivize the development of BECCS. The CCC, being the leading hegemonic actor, suggested already back in 2018 that the UK government go ahead and "support the demonstration and deployment of BECCS" (CCC, 2018, p. 16), and again in 2019 (CCC, 2019) and 2020 (CCC, 2020b). This government encouragement aligns with the *Economic Rationalism* discourse, which advocates a minor role for the government in steering "the system in the public interest" (Dryzek, 2013e, p. 134). However, once done, BECCS is likely to be left to market forces. As specified by the ETI (2016), BEIS (Vivid Economics, 2018) and, hereafter, integrated by the CCC in its report: *Policies for the Sixth Carbon Budget and Net Zero* (2020a), the government needs to establish supportive policy frameworks, infrastructure, and investments to kickstart BECCS. Once this is finalized, market mechanisms will take over to further incentivize the uptake and running of BECCS. However, CO_2 is difficult to privatize; thus, property rights cannot be made. Yet other market mechanisms exist, such as financially rewarding negative emissions (Grantham Research Institute & CCCEP, 2019) or incorporating negative emissions into loose government-managed emission trading schemes (Renewable Energy Association, 2019) – alluding to the polluter-pays-principle (Dryzek, 2013c). Although, actors' primary focus is economic, some actors also explicitly link BECCS to environmental improvements, such as the CEO of Drax (UK BECCS project).

> *This [*BECCS*] could kickstart a whole new industry in the UK, enabling us to show the world what can be achieved for the environment and the economy when governments, businesses and communities work together.*
>
> (BBC, 2020, p. 1)

Or REA, which, amongst others, use the argument of sustainable biomass:

> *The scale-up of both domestic and international sustainable biomass can facilitate this shift with potential economic and environmental benefits across the agricultural and forestry sectors.*
>
> (Renewable Energy Association, 2019, p. 3)

With the use of sustainable biomass – an element from the *Global Limits and Survival* Discourse - BECCS can bring both environmental and economic benefits. The two elements, thus, go "hand-in-hand and reinforce one another" (Dryzek, 2013e, p. 173), bringing both the *Ecological Modernization* discourse and the *Global Limits and Survival* discourse into play.

6.3 Summary: BECCS is not only necessary but also beneficial for the UK

This paper's analysis found the following three themes in the UK BECCS debate: 1) BECCS is necessary for the UK net-zero target; 2) Sustainable biomass is needed for BECCS to be net-negative and environmentally and socially sustainable, and 3) BECCS provides economic but also environmental opportunities for the UK. These collectively portray BECCS as necessary for mitigating climate change and as beneficial for the UK. Thus, BECCS in the UK is discussed in a serious but opportunistic way, which leads to an overall positive and performative communication of BECCS (RQ1). This way of discussing BECCS is mainly led by the hegemonic actor, the CCC, but also by the UK government and the research and policy institutes, whose authority and scientific credibility make their voices very relevant, compared to the NGOs and the news media (RQ1).

As identified in the above standing analysis, the communication of BECCS in each of the emerging themes draws on various discourses, as also displayed in Table 4: The environmental discourses and their arguments used in the various themes in the UK BECCS debate (Author, 2021), although BECCS belongs to an *Ecological Modernization* discourse, as mentioned in the1 Introduction.

In the first theme, BECCS is displayed as essential for removing CO_2 emissions; thus, an ecological limit originating from the *Global Limits and Survival* discourse, on CO_2 levels is acknowledged. However, as the CCC discusses the allowance of a temporary CO_2 overshoot, the concept of limits becomes blurry; thus, the *Ecological Modernization* discourse is introduced. Although no other actors mention this overshoot, the *Ecological Modernization* discourse is kept as one of two main discourses, as the CCC is the hegemonic actor who influences the other actors.

The second theme identifies sustainable biomass as needed for BECCS to succeed, but limited amounts exist. This acknowledgment indicates a belief in resource scarcity, thereby, ecological limits – a central element in the *Global Limits and Survival* discourse – the second theme's discourse.

In theme three, there is a focus on the economic benefits, such as the jobs and business opportunities that BECCS can bring and the market structures that can be used to incentivize and govern BECCS. Such a focus aligns theme three with the *Economic Rationalism* discourse. However, there is also a minor focus on the environmental benefits of BECCS when using sustainable biomass, which, therefore, brings both the discourse of *Ecological Modernization* and *Global Limits and Survival* into play. All three discourses are, therefore, utilized in the third theme.

As evident, there is not one hegemonic discourse on BECCS in the UK, but rather one which combines ecological limits, capitalism, and green growth into one (RQ2).

	Main Argument	Environmental Discourse
Theme 1: The BECCS-net-zero-lock-in	Essential for removing CO_2 to prevent the exceeding of ecological limits, although an overshoot is allowed.	Global Limits and Survival Ecological Modernization
Theme 2: Sustainable biomass is the answer to all criticism	Sustainable biomass is needed for BECCS to be successful, but there are limited amounts of it.	Global Limits and Survival
Theme 3: BECCS – a boost to the UK economy … and the environment?	BECCS brings economic but also environmental benefits if sustainable biomass is used	Global Limits and Survival Ecological Modernization Economic Rationalism

Table 4: The environmental discourses and their arguments used in the various themes in the UK BECCS debate (Author, 2021).

7 The social ramifications of the BECCS hegemony

The hegemonic representation of BECCS, as shown in section 6 (Analysis and findings), by key actors, such as the CCC and the UK government, who have high authority, impacts how the public perceives BECCS, its opportunities, and its challenges. This representation can therefore lead to the following modified social practices (RQ3).

7.1 Climate action – what's the rush?

One reason for BECCS' popularity is that it represents a "silver bullet" solution to climate change. This expression means that nations and their citizens are not required to abandon their high-emissions societies but rather continue business as usual, a notion also identified by Carton, Asiyanbi, Beck, Buck, and Lund (2020). In fact, BECCS, with its carbon removal abilities, entertains the idea of climate reversibility where the technology "buys the world more time" (Harvey, 2016, p. 1) regarding GHG reduction. Believing that the damage done today can, in theory, be reversed tomorrow is appealing and could draw countries in, and as a result, slow down their actions on climate change. Research has shown that countries that are strong proponents of carbon sinks in the form of forestry or CCS are often countries with low climate policy ambitions (Jung, 2004) or have economies dependent on fossil fuels (Røttereng, 2018). BECCS is, therefore, likely to serve business interests while neglecting

environmental interests. Thus, it is not unlikely that climate policy in the UK will be less stringent if BECCS is deployed.

Yet, as the above standing debate on BECCS displays, it is not a question of *if* it will be deployed but rather a question of *when* (Supergen Bioenergy Hub, 2021). However, this is a reason of concern, as the support for climate action falls, when people are informed about BECCS, as the threat of climate change is perceived as reduced (Campbell-Arvai, Hart, Raimi, & Wolske, 2017). The promise of BECCS being deployed soon is, therefore, assumed to reduce or delay climate actions, causing what is known as mitigation deterrence (Markusson, McLaren, & Tyfield, 2018), thus, undermining the climate crisis.

Furthermore, reduced climate action could lead to accumulated CO_2 levels, which will trigger several climate tipping points. Once triggered, these cannot be reversed, resulting in a more uninhabitable earth for future generations (Cai, Lenton, & Lontzek, 2016; Dietz, Rising, Stoerk, & Wagner, 2021). However, there is also the question of what happens if BECCS is less successful than anticipated or even unsuccessful. The accumulated CO_2 resulting from mitigation deterrence (Markusson et al., 2018) can then not be removed as planned, causing the climate mitigation trajectory to be even steeper.

Irrespective of whether BECCS is successful or not, there is a high chance that its vague promise will undermine climate action. By doing so, it causes what Shue (2017) calls “risk transfer”; risks associated with excess CO_2 levels are transferred from the current to the future generation (Shue, 2017). Although Shue applies this to the failure of BECCS, it can be argued to also apply to its success, as both results in accumulated CO_2 levels. Thus BECCS, no matter the outcome, will cause intergenerational injustice (Sovacool & Dworkin, 2015). It, thus, remains vital that the UK government continues its domestic climate efforts. According to the NGO actors in the BECCS discussion, the UK should “instead of wasting money on BECCS” (BDaily, 2020, p. 2), invest in proven energy technologies such as wind and solar as well as ecosystems, peat- and wetlands for CO_2 sequestration (BDaily, 2020; Biofuelwatch & Friends of the Earth Scotland, 2020; NRDC, 2018). However, these ideas do not gain traction from the other more powerful actors and, thus, remain in the margins.

7.2 Biomass imperialism

If BECCS is deployed, domestic and international biomass will most likely be needed. Considering the business opportunities viewed by the UK in the biomass market, UK biomass imperialism, which

means to extend the rule over other countries' biomass resources, may become a reality. Although some UK sources claim sufficient domestic biomass, it is not unlikely that foreign biomass will be needed for BECCS in the UK, as current bioenergy use relies on imports from "North America, East Europe and Russia" (Ricardo Energy & Environment, 2018, p. 7). However, only one actor in the UK debate, the Supergen Bioenergy Hub, raises concerns regarding biomass imperialism.

Drax, the UK power plant with BECCS, operates as a bioenergy power station daily. For this, it uses large amounts of biomass, mainly sourced from forests in the US, Canada, Europe, and Brazil (Drax, 2020). Moreover, it has recently acquired a Canadian pellet factory which will double its production, decrease its cost, and according to Drax, position them as a world leader within sustainable bioenergy (Drax, 2021). However, Drax has been accused of causing deforestation and several other biomass-related problems due to its imports (Biofuelwatch, 2020b), issues that commonly arise with biomass imports (Dogwood Alliance, 2020; Fern, 2015; Scott, Rosenow, & Thomas, 2021). With Drax's acquisition of the Canadian pellet factory and the problematic imports, UK biomass imperialism seems to be already taking place. As BECCS is deployed, the demand for biomass will increase, and with the UK's focus on becoming a global BECCS leader and exporting its sustainability criteria, biomass imperialism could manifest.

This is, nevertheless, not the only problem with sourcing biomass in foreign countries to solve domestic GHG issues. Problem displacement is also an issue in which rich countries, like the UK, transfer their problems to poorer yet forest-rich countries (Dryzek, 2013b). Problem displacement does not only legitimize the continuation of the UK's, and in general the global north's, lifestyle (Brockington & Ponte, 2015). It also deprives poorer countries of domestic carbon removal options, increasing their trajectory to reduce domestic GHG emissions (Carton, Lund, & Dooley, 2021).

Furthermore, such problem displacement is supported by the current method of accounting for national GHG emissions, as CO_2 emissions from biomass are only counted where they are used, and not grown (EC, 2014). It is, therefore, estimated that this method would incentivize the conversion of global forests to bioenergy (Searchinger et al., 2009). Thus, to avoid a further acceleration of biomass imperialism, there is a need for an international agreement on not only the sustainability of biomass but also on the governance, trading, and accounting of biomass which takes justice and social aspects into account.

8 Conclusion, future research, and sustainability science

8.1 Conclusion

This study aimed at identifying how BECCS is communicated in the UK, by whom (RQ1), what the hegemonic discourse of BECCS was (RQ2), and the social ramifications of this depiction (RQ3). To undertake this task, grey literature focusing upon BECCS in a UK context was collected from multiple societal UK actors to reflect societal opinions. These were then analyzed using Fairclough's CDA, Dryzek's relevant environmental discourses, and Gramsci's hegemony.

The CDA's first dimension, the text analysis, helped answer RQ1 by uncovering the powerful actors and the emerging themes in the discussion of BECCS in the UK. The leading actor was the CCC, which influenced and dominated not only the opinion of the government but also that of the other actors present in the debate. However, the UK government and the research and policy institutes were also seen as powerful voices in the debate due to often being referenced, their credibility, and authority. Regarding the themes, the following three emerged:

1) BECCS is necessary for reaching the UK's 2050 net-zero target;

2) As long as sustainable biomass is used, BECCS is environmentally sustainable; and

3) BECCS provides economic but also environmental opportunities.

Collectively, these contributed to an overall positive yet performative communication of BECCS, which is likely to influence its future deployment.

The second CDA dimension, the processing analysis, contributed to answering RQ2 by revealing the environmental discourses used in the emerging themes, thereby helping to identify the hegemonic discourse on BECCS in the UK. The identified environmental discourses were: *Global Limits and Survival; Economic Rationalism*; and *Ecological Modernization*, which were drawn on collectively and separately in the themes mentioned above. The hegemonic discourse on BECCS is, therefore, not one of these, but a combination which emphasizes ecological limits, capitalism, and green growth (RQ2).

The social analysis, the last CDA dimension, assessed the social ramifications the hegemonic BECCS discourse might have in the UK to answer RQ3. This displayed that the aforementioned depiction of BECCS can, firstly, lead to the undermining of climate action, as BECCS promises to reverse excess CO_2 levels and, therefore, promotes reduced climate action. Secondly, when BECCS is deployed,

foreign biomass will be needed, and with the UK's focus on becoming a global BECCS frontrunner and exporting its sustainability standards, biomass imperialism is likely to occur.

Connecting these findings back to the overall aim, the hegemonic communication of BECCS is positive, performative and targets support building for the deployment of BECCS and its surrounding structures (e.g., infrastructure and policy frameworks). BECCS is, therefore, positioned as a climate friend rather than a foe which can help the UK fulfill its climate targets and boost the economy at the same time. However, the social ramifications of such a depiction can accelerate the climate crisis and biomass imperialism, thus, caution must be taken in the deployment of BECCS in the UK.

8.2 Limitations and future research

This study investigated the societal representation of BECCS in the UK but did not include the perspectives of individual citizens; thus, it only partially represents the UK society. However, such perspectives would be interesting to investigate to see how BECCS is perceived and if the emerging themes of this paper are present in the perspectives of UK citizens. Furthermore, this study neither went into depth with how BECCS has affected UK climate policies and action since its introduction, which could also be a future research topic. Additionally, this research assessed a specific time range (2016-21) and specific texts. Expanding this time range and investigating more elements such as the impact of oil prices on biomass demand, drawing on different environmental discourses, or approaching BECCS in a techno-optimistic mode could offer different interpretations of BECCS.

8.3 Sustainability science contribution

By having combined the problem-solving and the critical theoretical approaches (Jerneck et al., 2011), this paper has first illuminated the hegemonic depictions of BECCS in the UK and then critically reflected on the impact of these by identifying the possible societal ramifications. This paper has shown that specific depictions of BECCS can advance particular agendas, being the support for and the deployment of BECCS in the UK. Therefore, the communication of BECCS in the UK has overlooked the importance of communicating several complex human-nature interactions (Spangenberg, 2011), which are necessary to ensure a thorough public understanding of the implications of BECCS deployment. If such an understanding fails, it may lead to the deployment of ineffective climate change solutions, which causes more destruction than repair. To ensure that the UK chose the most stable and effective pathway to net-zero, it is important that BECCS's benefits, implications, and challenges are communicated equally. This, for instance, means giving equal room

to perspectives from various disciplines, as climate change cannot be solved by one discipline or technology alone (Jerneck et al., 2011).

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11 Appendices

11.1 Data collection and criteria

Date	Search engine	Search terms	Author	Title	Year	note
19/01/ 2021	Google	Bioenergy Carbon Capture and Storage (BECCS) "UK"	Ricardo Energy & Environment for UK's Department for Business, Energy, and Industrial Strategy (BEIS)	Analysing the potential of bioenergy with carbon capture in the UK to 2050	2020	
			UK Parliament POST	Bioenergy with Carbon Capture & Storage	2020	
			UK Energy Research Center	Bioenergy with carbon capture and storage, and direct air carbon capture and storage	2019	
			Energy technologies institute	The evidence for deploying bioenergy with CCS (BECCS) in the UK	2016	
			Climate Change Committee (CCC)	UK climate action following the Paris Agreement	2016	snowballed from Energy Technology Institute
			Dr. Clair Gough for Tyndall Centre	GGR Policy Options Roundtable	2020	EXCLUDED - not specific

						to BECCS UK
			Current News	Bioenergy with carbon capture and storage pilot to launch at Drax Power Station	2020	
			Drax for Medium	Why the UK needs biomass energy capture, use and storage to reach net zero	2020	
			Renewable Energy Association (REA)	going negative: Policy Proposals for UK Bioenergy with Carbon Capture and Storage (BECCS)	2019	
			UK's Department for Business, Energy and Industrial Strategy (BEIS)	powering our net zero future	2020	
			Imperial College London, Grantham Institute	BECCS deployment: a reality check	2019	EXCLUDED - not enough on BECCS UK
			The economist (sponsored by Climeworks)	Bioenergy with Carbon Capture and Storage: Opportunities and trade-offs	n.d.	EXCLUDED - not discussiong BECCS UK enough

			biofuelwatch and friends of the earth scotland	BioEnergy with Carbon Capture and Storage (BECCS): A Dangerous Distraction from Meaningful Climate Action	2020	
11/04/ 2021	Google	Bioenergy Carbon Capture and Storage (BECCS) "UK"	ELCI, Friends of the Earth, NRDC, action aid, Fern, WWF, Greenpeace	UK: Joint NGO Statement on BECCS - 19 environmental NGOs warn the UK government about the risks associated with Bioenergy with CCS (BECCS)	2021	
			Supergen Bioenergy Hub	Research and innovation needs for biomass to energy with carbon capture and storage (BECCS). Supergen Bioenergy	2021	
			T&D World	Bioenergy with Carbon Capture and Storage Can Help Decarbonize UK	2021	
			Market Screener	Drax kickstarts application process to build vital negative emissions technology	2021	

			Intergenerational Foundation (IF)	How promising is Drax's proposal to build negative emission technology?	2021	
19/01/ 2021	Google	BECCS woodland trust	Royal Society for the Protection of Birdlife (RSPB)	Land use is key to responding to the nature and climate emergencies	2020	EXCLUDED - BECCS mentioned once
19/01/ 2021	Google	Bioenergy Carbon Capture and Storage (BECCS) UK critici*	BBC	Humber carbon capture scheme 'may create 49,000 jobs'	2020	
19/01/ 2021	Google	UK Government Negative Emissions Research	Centre for climate change economics and policy (CCEP); The Grantham Research Institute on Climate change and the environment	How to price carbon to reach net-zero emission in the UK	2019	
			Vivid economics for BEIS (UK gov)	Greenhouse Gas Removal (GGR) policy options – Final Report	2019	
			BEIS and HM treasury, UK gov.	Greenhouse Gas Removal: call for evidence	2020	

			Carbon Brief	UK launches ‘world first’ research programme into negative emissions	2017	EXCLUDED - not enough on BECCS UK
19/01/ 2021	Google	BECCS Government Subsidy	UK gov	UK’s largest carbon capture project to prevent equivalent of 22,000 cars’ emissions from polluting the atmosphere from 2021	2019	
			Bdaily News (by Friends of the Earth UK, Dogwood Alliance, Southern Environmental Law Center, Biofuelwatch, Fern and Natural Resources Defense Council.)	Environmental groups respond to carbon capture funding pledge in UK Budget	2020	
			NRDC (Natural Resources Defense Council)	Don't Throw Good Climate Money After Bad with BECCS	2018	
19/01/ 2021	UK Govern-ment webpage (search field)	BECCS	Royal Society and Royal Academy of Engineering	Greenhouse Gas Removal	2018	

			BEIS, UK Government	The UK Government's View on Greenhouse Gas Removal Technologies and Solar Radiation Management	2020	
			BEIS, UK Government	UK becomes first major economy to pass net zero emissions law	2019	EXCLUDED - not addressing BECCS
20/01/ 2021	UK Govern-ment (search field)	GGR	BEIS, UK Government	The role of GGRs in Net Zero: UK Government view	2020	EXCLUDED - too visual, not enough text
			Climate Change Committee (CCC)	Biomass in a low-carbon economy	2018	snowballed from one of the CCC, 2019, Net zero - the uk's contribution to ending global warmin
21/01/ 2021	google	Greenhouse Gas Removals Carbon Dioxide Removal UK	World wildlife Fond (WWF) (by Vivid Economics for WWF)	Keeping it cool: how the UK can end its contribution to climate change	2018	

21/01/ 2021	google	Stop BECCS UK	Climate assembly UK	The path to net zero	2020	EXCLUDED – citizen view
21/01/ 2021	google	Biomass and Bioenergy UK	The Guardian (Hazel Sheffield)	Carbon-neutrality is a fairy tale': how the race for renewables is burning Europe's forests	2021	EXCLUDED - not addressing BECCS
			Cut carbon not forests	webpage with several anti-biomass material		EXCLUDED - webpage not document
			Cut carbon not forests	Update: Burnout EU Clean Energy Policies Lead to Forest Destruction	2020	EXCLUDED - webpage not document and not addressing BECCS
			Chatham House	Net Zero and Beyond What Role for Bioenergy with Carbon Capture and Storage?	2020	snowballed from Cut carbon Not Forests webpage - EXCLUDED not specific to BECCS UK
26/01/ 2021	google	Accounted CO2 emission from imported biomass	Chatham House	Woody biomass for power and heat	2017	EXCLUDED - not specific to BECCS UK

17/04/ 2021	Google	BECCS UK 2021	Bioenergy Insights	Developing BECCS at Drax 'could save UK billions', says report	2021	
			Baringa (drax)	Value of Biomass with Carbon Capture and Storage (BECCS) in Power	2021	snowballed from bionenergy insights 2021, developing BECCS at drax could save millions
			Climate Change Committee (CCC)	The Sixth Carbon Budget	2020	snowballed from baringa, 2021
			Climate Change Committee (CCC)	Policies for the Sixth Carbon Budget and net-zero	2020	snowballed from the sixth carbon budget, 2020

11.2 Genre classification

Genre	Description	Intended Audience
Online news article	Discusses topics of current or recent happenings in a language most often easily understandable to the public, and of interest to a certain target audience. (Toppr, n.d.).	Topic-interested audience and wider public.
Report	Presents information on a certain topic of which data has been collected, analyzed, and discussed (Wollongong University, 2000).	Topic-interested audience.
Policy report	Outlines current knowledge, facts, and various evidence on a particular issue to help readers understand it, and formulates policy responses can be neutral or subjective (Wollongong University, 2021).	Government ministers and decision makers, private sector leaders and non-government organizations (NGOs) (Wollongong University, 2021).
Briefing note/paper	Informs political actors of what is necessary to know of a certain topic to make a decision or a response regarding the topic, or engage in a meeting on the topic (Graham, n.d.).	Political actors and topic-interested audience.
Summary report	Provides a summary of an event or research process.	Topic-interested audience.
Position paper	Presents the author(s) opinion or position regarding a certain topic.	Topic-interested audience.
Technology and policy assessment	Delivers a scientific assessment of the technology in question, potential issues and policy options (UKERC, 2021).	Policymakers.
White paper	Typically advocates a certain position or solution for a particular issue (Purdue University, 2021).	Audience outside of the organization and topic-interested audience (Purdue University, 2021).

Call for evidence	An process of information gathering to gain perspectives on a certain topic (UK Government, 2019b).	Stakeholders.
Press release	A quick display of important information (Colorado State University, 2021).	Topic-interested audience.
Expert blog	Presents fact-based statements while conveying the author(s) position.	Topic-interested audience.

11.3 Data analysis sections

#	Author + year	title	section to be analyzed
1	BBC, 2020,	Humber carbon capture scheme 'may create 49,000 jobs' - BBC News	all
2	Bdaily News, 2020	Environmental groups respond to carbon capture funding pledge in UK Budget	all
3	Biofuelwatch and Friends of the Earth Scotland, 2020,	BECCS A Dangerous Distraction from Meaningful Climate Action	all
4	CCC, 2016	UK climate action following the Paris Agreement	p 10, 16, 27, 42-46
5	Current news, 2020,	Bioenergy with carbon capture and storage pilot to launch at Drax Power Station	all
6	Medium (Drax), 2020,	Why the UK needs biomass energy capture, use and storage to reach net zero	all
7	NRDC, 2018	Don't Throw Good Climate Money After Bad with BECCS	all
8	Grantham Research Institute &	How to price carbon to reach net zero emissions in the UK	Negative emissions technology p18-21

	CCCEP, 2019		
9	ELCI, 2021	UK: Joint NGO Statement on BECCS – 19 environmental NGOs warn the UK government about the risks associated with Bioenergy with CCS (BECCS)	all
10	Supergen Bioenergy Hub	Research and innovation needs for biomass to energy with carbon capture and storage (BECCS)	all
11	T&D World, 2021	Bioenergy with carbon capture - decarbonize UK	all
12	Market Screener, 2021	Drax kickstarts application process to build vital negative emissions technology	all
13	Intergenerational Foundation, 2021	How promising is Drax's proposal to build negative emission technology? - Intergenerational Foundation	all
14	REA, 2019	Position Paper Going Negative Policy Proposals for UK BECCS.	all

15	Royal society, 2020	Greenhouse Gas removal	Executive summary p8 BECCS p39-42 Cross-cutting issues - Resources p71-73 - Storage p74-76 - Environment p77-78 - Economics p83 - Legislation p84-85 - Social Aspects p86-87 UK scenario - Annual GGR of 130 MtCO2 in 2050 p91-93, 98-99, 101, 106, 114-115,
16	UKERC, 2019	BECCS and DACC: Examining the evidence on deployment potential and costs in the UK	Executive summary Introduction p1 Quality of the BECCS lit. 7-9 BECCS 24-44
17	WWF, 2018	Keeping it cool: how the UK can end its contribution to climate change	Feasible Deployment of greenhouse gas removal options p23-29 The UK pathway to Net zero 2050 vs 2045 p31-34
18	Energy Technologies Institute	The Evidence for Deploying Bioenergy with CCS in the UK	all
19	BEIS, 2019	The UK government's view on GGR technologies and SRM	all
20	BEIS, 2020	The Energy White Paper: Powering our net zero future	The strategic context p42 Bioenergy innovation p53 Our Key commitments p59 Glossary p148

21	Vivid Economics, 2019	Greenhouse Gas removal (GGR) - policy options	Executive Summary P4-7 Scale and cost of future GGR p9-10 Overview table p13-15, The need for a policy portfolio to support GGRs p17, 19 Review of current GGR policies p22-24, 26-28, 30, 33-34, Enabling and integrating policies p41-43, 45-47, 49, FAQ: p51, 56-58 Obligations: general desing notes: p61, 63-64 Increasing carbon tax on FF in electricity to support BECCS: p67-69 Inclusion of GGR in ETS: p73 Provision of co-investment equity: p80 Government CfD instrument for BECCS and DACCS: p82-83
22	HM Government 2021	Greenhouse Gas Removals - call for evidence	Executive summary p3 Introduction p11-12 Details of the call for evidence p12-14 chapter 2, incentivising investment in GGRs p21, 23-28, chapter 3: supporting and enabling policies for GGRs p30-31, 34
23	Ricardo Energy and Environment (for BEIS), 2018	Analysing the potential of bioenergy with carbon capture in the UK to 2050 Summary for policymakers	All

24	UK gov.	UK's largest carbon capture project to prevent equivalent of 22,000 cars' emissions from polluting the atmosphere from 2021	Call for CCUS innovation p3
25	UK Parliament	Bioenergy with carbon capture and storage	all
26	CCC, 2018	Biomass in a low-carbon economy	Executive summary p8, 12-14 Recommendations p16-17, 19 Why is biomass important 25-28 UK BECCS hub scenario p107-109 Sustainable low-carbon biomass is a flexible and finite ressource 115-117 Best-use of sustainable biomass to 2050 p120 The imporatnce of BECCS p126-129 The air quality implications of BECCS application p130 Biofuels in aviation p131 Bioenergy in industry p134 industry p148
27	CCC, 2020	the sixth carbon budget - the UK's path to net zero	introduction & key messages: p50 ch. 3: sector pathways to net-zero p135, (157-158) ch. 11: GGRs p197-202, 213-214, 226, Capital investment and operational savings p246 A contribution to the Paris Agreement p337, 341, the shaoe of the emissions to net zero p407, 423, 434, 437,

28	CCC, 2020	Policies for the Sixth Carbon Budget and Net-Zero	introduction & key messages: p29 Ch. 5 electricity generation p118 ch. 11 GGR p198 Key policy actions required p201,203-204
29	CCC, 2020	Net Zero The UK's contribution to stopping global warming	Ch. 2 Climate science and international circumstances p67, 71, ch. 3: an appropriate UK contribution to the global effort p90, 94 Ch. 5 reaching net-zero emissions in the UK p143, 145, 148-149, 155-159, 163,168, 170-171, Ch. 6 delivering a net-zero emissions target for UK 178, 199, 207-208, Ch. 7 Costs and benefits of a net-zero target for the UK p222, 225-226, 265
30	Baringa for Drax, 2021,	value of BECCS in power	all
31	Bioenergy insight	Developing BECCS at Drax ‘could save UK billions’, says report	all

11.4 Coding categories

Name	Description	Files	References
Alternatives	Referring to the alternatives suggested instead of BECCS.	8	28
BECCS - a techno-optimistic CC solution vs behavior change	Referring to BECCS in relation to reaching the UK climate targets or the UK net-zero target in 2050.	32	265
Biomass Sourcing	Referring to where biomass is or will be sourced from.	17	45
CCC and BECCS		10	24
Economic development and environmental protection	Economic development and environmental protection co-exists, and can actually benefit each other.	17	59
Economic impacts	Referring to the economic impact of BECCS.	0	0
Cost	Referring to the economic cost of BECCS and everything that surrounds it, excluding cost/tCO2.	22	56
Economic opportunity	Referring to the economic opportunities BECCS can provide.	8	20
Employment	Referring to the job BECCS can create or the protection it can offer to current jobs.	7	24
Feedstock	Referring to the feedstock (e.g. wood, energy crops and agricultural residues) of BECCS.	13	67
Government and BECCS (no ccc)	Referring to the government and government action when talking about BECCS	6	19
net-zero target and BECCS	Claiming BECCS necessary for reaching the UK net-zero target.	25	69

Policy support	Referring to text which discusses the policies needed for BECCS.	27	160
Sustainability of Biomass	Referring to the need for and possibility of sustainable biomass for BECCS.	24	104

11.5 Elaborated Discourse Table

	Global Limits and Survival	Economic Rationalism (ER)	Ecological modernization
Key items	**Resource limits to economic and population growth, survivalism, and elites** Population, resource stocks, global pollution levels, and crucially, monitoring and control of these aggregates (Dryzek, 2013e, p. 41) And international cooperation No time for system complexity (Dryzek, 2013e, p. 173)	**Homo economicus, markets, prices, property, and governments** (Dryzek, 2013e, p. 138) "Homo economicus can appear as a consumer or producer" (Dryzek, 2013e, p. 134) "Markets, prices, and property have real existences" (Dryzek, 2013e, p. 134)	**Systems approach, green growth and decoupling, economic actors, and technological advances** Env. Problems best left to be handled by partnerships which can initiate green growth "economic development and environmental protection can proceed hand-in-hand and reinforce one another" (Dryzek, 2013e, p. 173). "Systems approach that takes seriously the complex pathways by which consumption, production, resource depletion, and pollution are interrelated. "(Dryzek, 2013e, p. 173). "revolves around the business opportunities associated with low-emission technologies, and how "green growth" can be sought in all kinds of countries" (Dryzek, 2013e, p. 172).

Nature, natural resources, and limits	**Nature, natural resources, and limits all exist.** If we don't stay within the limits, there will be negative consequences and potentially ecosystem collapse. " human actions are depleting Earth's natural capital, putting such strain on the environment that the ability of the planet's ecosystem to sustain future generations can no longer be taken for granted". (Dryzek, 2013e, p. 34)	**Nature is a social construct; natural resources aren't but limits might be** Natural resources exist, but only for the sole purpose of providing for humanity. There is therefore no need to be concerned about planetary boundaries. As long as people have the property rights to a certain area, they can do as they please to whatever exists within it. Sometimes the system might have a bump (e.g., env. Issues) and re-organizing the system will cause it to run smoothly again. Nature is a human social construction (Dryzek, 2013e, p. 135) Natural resources exist and "it is crucial to establish the right kinds of property rights to these" (Dryzek, 2013e, p. 135)	**Nature and natural resources are acknowledged, while limits are ignored** Nature and natural resources are needed for growth and prosperity to occur. Ecological limits do not need to be considered as such, as most economies will decouple economic growth and environmental resource usage. "Nature is treated as a source of resources and a recycler of pollutants – a giant waste treatment plant, whose capacities and balance should not be overburdened." (Dryzek, 2013e, p. 173). "EM pushes limits to growth into the background… limits are not so much explicitly denied as ignored" (Dryzek, 2013e, pp. 173–174).

		"ER would not necessarily dismiss the existence of limits to human activity imposed by finite resources" (Dryzek, 2013e, p. 135)	
anthropocentric	**Yes – does care for earth but from a human benefit perspective** "the earth systems is not just a set of constraints on human activity as implied by the limits and boundaries; the content of the system itself is affected in fundamental ways by what humans do" (Dryzek, 2013e, p. 37)	**Yes, indeed** "ER is thoroughly anthropocentric: nature exist only to provide inputs to the socioeconomic machine, to satisfy human wants and needs." (Dryzek, 2013e, p. 135)	**Yes**, Denied are any notion that nature might spring surprises on us, defy human management, have its own intrinsic value, and its own open-ended developmental pathways" (Dryzek, 2013e, p. 173). "The natural world is subordinate to human desires and calculations" (Dryzek, 2013e, p. 174).
Agents	**Elites (experts) and governments** "Elites – especially those associated with governments, and especially those with pertinent expertise, be it in systems modelling, ecology, atmospheric science or population biology – play a central role." (Dryzek, 2013e, p.	**Economic and selfish actors and few governmental positions** "The main agents for ER are Homo economicus ones, motivated by self-interest, and pursuing it rationally. … exemption is granted for a few agents in governmental positions who are allowed to be motivated by concern for	**Partnerships between governments, businesses, reform-oriented environmentalists, and scientists.** "Their motivations have to do with the common good or the public interest, defined in broad terms to encompass economic efficiency and environmental conservation". (Dryzek, 2013e, p. 174).

	40) “populations” be they national, global, or class-specific, have no agency; they are only acted upon as aggregates to be monitored through statistics and controlled by government policy.” (Dryzek, 2013e, p. 42)	the public interests, albeit defined in economic rationalist terms.” (Dryzek, 2013e, p. 136)	
Key metaphors and rhetorical devices	**Overshoot and collapse** ”The notion of overshoot and collapse, drawn from models of simple ecosystems where one species breeds excess and then experiences a crash” (Dryzek, 2013e, p. 42)	**Mechanistic** ”The social world is treated as a machine whose products meets human needs and wants” and “environmental resources are treated as inputs to the social machine” (Dryzek, 2013e, p. 136)	**Ecological and economic progress** “The word “modernization” like the word “development”, connotes progress, and so ecological modernization is linked with the ever-popular notion of social progress” (Dryzek, 2013e, p. 175). “No though choices need to be made between economic growth and environmental protection, or between the present and the long-term future” (Dryzek, 2013e, p. 175).