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The Application of the Environment Act 2021 Principles to Carbon Capture and Storage

Angelica Rutherford

School of Law, Liverpool Hope University, Liverpool L16 9JD, UK; ruthera1@hope.ac.uk

Abstract: Carbon Capture and Storage (CCS) is a new technology considered to have the potential to decarbonise economies. However, nationally and internationally the use of CCS has also been raising concerns about its potential global risks and adverse impacts on the environment. CCS was part of the discussions at the fourth United Nations Environment Assembly (UNEA) in March 2019 and in side-events in the 26th UN Climate Change Conference that took place in Glasgow in November 2021. The UK Government aims to deploy CCS at scale during the 2030s, subject to cost reduction. At the same time, the UK Government has recently enacted the Environment Act 2021, which provides a set of five environmental principles: the integration principle, the principle of preventative action, the precautionary principle, the rectification at source principle and the polluter pays principle. This work seeks to analyse the application of the UK environmental law principles to carbon capture and storage policies in the United Kingdom and its balance with other considerations. Given the concerns surrounding the use of CCS, the debate about its legality may arise in the United Kingdom and in other countries. To this end, this paper initially carries out a systematic review of CCS policy documents to discover the policy considerations that support the development of CCS. It then examines the application of the UK environmental law principles to CCS initiatives and its balance with other considerations, such as reduction of carbon emissions, security of energy supply, economic growth and technological leadership. In doing so, this paper aims at contributing to the debate surrounding recent technological developments that have been utilised to help address climate change and some of the legal challenges emerging through the use of CCS under UK environmental law.

Keywords: environmental law principles; carbon capture and storage; energy; climate change

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1. Introduction

The increase in concentration of greenhouse gases (GHGs), particularly carbon dioxide (CO2), has been associated with climate change and global warming. As a result of the negative impacts of carbon-intense economies, low-carbon technologies have been developed to reduce the CO2 concentration both in the atmosphere and in flue gas emissions. Carbon capture, utilisation and storage (CCUS) applied to biomass, hydrogen and fossil fuels is part of a portfolio of mitigation options that countries have been relying on to achieve ambitious climate goals set under the Paris Agreement in 2015. It was part of the discussions at the fourth United Nations Environment Assembly (UNEA) in March 2019 (Tollefson 2019) and in side-events in the 26th UN Climate Change Conference that took place in Glasgow in November 2021 (IEAGHG 2021).

Carbon capture and storage (CCS) consists essentially in capturing the carbon dioxide produced through the combustion of fossil fuels in power stations and in a variety of industrial processes and storing it permanently in artificial reservoirs such as saline aquifers or depleted oilfields where it cannot enter the atmosphere (IPCC 2005). CCS is typically considered as three independent yet inter-connected steps: (i) the separation and purification of CO2 from fuels, feedstocks and industrial processes; (ii) the compression and transport of CO2 by pipeline or tanker to its storage destination and (iii) injection of

CO2 through an oilfield-style borehole into microscopic pore space of geological reservoirs of the deep subsurface, where the CO2 will remain in perpetuity (Haszeldine et al. 2018). As of 2020, there were almost 40 commercial-scale CCS facilities in operation worldwide (Global CCS Institute 2020).

Carbon capture and utilisation (CCU) aims to convert the captured carbon dioxide into more valuable substances or products. Another emerging technology that could be utilised to manage carbon emissions is Direct Air Capture (DAC), which captures carbon dioxide out of the atmosphere rather than at the point of emissions, being as such independent of the source and timing of emissions (IPCC 2018). Nineteen DAC plants are currently operational in Europe, the United States and Canada. Most of these plants are small and sell the captured CO2 for use—for carbonating drinks, for example (Budinis 2021). This work, however, focuses on carbon capture and storage (CCS) due to controversies surrounding the environmental benefits of this technology and the more advanced stage of development of commercial-scale facilities in operation when compared with DAC.

Previous scientific literature has identified the need to deploy CCS if society is to transition to a low-carbon economy (Kemper 2015; Haszeldine et al. 2018) and this has been confirmed in legal scholarship (Heffron et al. 2018). The latest Intergovernmental Panel on Climate Change (IPCC) Special Report on global warming also includes CCS technologies in all pathways that bring the global temperature below 2 °C (IPCC 2018). In the United Kingdom, the independent Committee on Climate Change described CCS as 'a necessity, not an option' (Committee on Climate Change 2019), although this position has been criticised and subject to public opposition (Thomas 2021; Holland 2021).

Internationally, carbon dioxide removal technologies, such as CCS, have been raising concerns about their potential global risks and adverse impacts on the environment and sustainable development, and due to the lack of multilateral control and oversight. At UNEA 4, a resolution that would have mandated the United Nations Environment Programme (UNEP) to make an assessment of potential risks and governance needs of geoengineering, including CCS, did not pass (Switzerland 2019; Xaver Perrez 2020). However, this question may come up again at the Fifth Session of the United Nations Environment Assembly (UNEA-5) in February/March 2022 (UNEA 2022).

The need to reduce emissions of CO2 and other greenhouse gases is recognised by the UK Government in the Climate Change Act of 2008, as amended by the Climate Change Act 2008 (2050 Target Amendment) Order 2019 (S.I. 2019/1056), which sets legally binding targets for the United Kingdom to reduce emissions of CO2 and other greenhouse gases by 100% from 1990 levels, by 2050.

In its Clean Growth Strategy, the United Kingdom has reaffirmed its commitment to deploying CCUS in the United Kingdom's major manufacturing and refining areas subject to cost reduction as part of a green industrial revolution and to reach net zero carbon emissions by 2050 (BEIS 2017). With the aim of becoming a global technology leader for CCUS, the UK Government committed 1 billion GBP of public funds for a new CCUS Infrastructure Fund to help develop CCUS schemes in Britain (BEIS 2020b; HM Treasury 2020). Five eligible CCUS clusters have been announced: DelpHYnus, East Coast Cluster, Hynet, Scottish Cluster and V Net Zero. The ambition is to capture 10Mt of carbon dioxide a year by 2030, the equivalent of four million cars' worth of annual emissions (HM Government 2020). In addition to CCUS, the United Kingdom has also recently started to fund projects on Direct Air Capture (DAC). However, there are currently no operational DAC plants in the United Kingdom (BEIS 2022).

At the same time, the UK Government has introduced the Environment Act 2021, which provides a set of five environmental principles that will guide future policymaking to protect the environment: the integration principle, the principle of preventative action, the precautionary principle, the rectification at source principle and the polluter pays principle. With the enactment of the Environment Act 2021, the United Kingdom has a definite catalogue of environment principles set in one document. The aim of this work is to analyse the application of these principles to carbon capture and storage (CCS) policies

in the United Kingdom and its balance with other considerations, such as socioeconomic benefits, security of energy supply and diversity of technologies and fuels. In doing so, this paper aims at contributing to the debate surrounding recent technological developments that have been utilised to help address climate change and some of the legal challenges emerging through the use of CCS under UK environmental law.

CCS is largely absent from the Nationally Determined Contributions submitted by Member States to the United Nations Framework Convention on Climate Change (UNFCCC) in the run-up to COP26 as a type of technology that countries intend to use for implementing adaptation and mitigation actions (UNFCC 2021). It is also lowly ranked in investment priorities around the world (Fridahl 2017), particularly for ramping up large CCS infrastructure (Bhave et al. 2017). However, due to international concerns surrounding the use of CCS, the debate about its legality may arise in other countries. Therefore, it is important to learn about CCS policies in the United Kingdom and the applicability of principles of environmental law under the Environment Act 2021 as a case study because this may serve as an example to other countries discussing such matters. The importance of this paper also lies in the fact that the area of International Environmental Law lacks publications that focus on the Environmental Constitutional Principles and the environmental principles contained in the national legislation or constitutional charters of each country are of fundamental importance to the advancement of Comparative Law.

This paper is structured as follows. First, in Section 2, policy considerations justifying the adoption of CCS in the United Kingdom are explored. Next, the application of principles of UK environmental law to CCS is analysed. Finally, this paper concludes and also highlights areas for future research.

2. Policy Considerations Justifying the Adoption of CCS in the United Kingdom

This section involves a systematic review of CCS policy documents. The guidelines in Rousseau et al. (2008) and in Denyer and Tranfield (2009) surrounding question formulation, location, selection, evaluation, analysis and synthesis of study are observed. Following studies conducting systematic reviews in other subject areas, such as Danese et al. (2017) and Nolan and Garavan (2016), a five-stage structured process is adopted. In Stage 1, the scope and objectives of the analysis are identified. The primary objective is to investigate the policy considerations used to justify the adoption of CCS. In Stage 2, the inclusion criteria are set. The focus is on official policy documents published from January 2009 to October 2021 by the UK Government and its departments. In Stage 3, the exclusion criteria are applied. The aim of the research is to analyse CCS policy considerations contained in official government documents. Therefore, firstly, independent and non-UK Government reports are excluded. Secondly, policy documents that do not examine CCS are excluded. In Stage 5, the final data are classified into themes based on the focus of the paper.

In total, 14 documents were selected and analysed as per Table 1. Four themes were identified as policy considerations used to support CCS development: reduction of carbon emissions, security of energy supply, economic growth and technological leadership.

Table 1. Summary of CCS policy considerations.

Document Title	Department	Year	Policy Considerations
Carbon Capture Readiness (CCR): A guidance note for Section 36 Electricity Act 1989 consent applications	DECC	2009	Reduction of carbon emissions
Overarching National Policy Statement for Energy (EN-1)	DECC	2011	Reduction of carbon emissions, security of energy supply

Table 1. *Cont.*

Document Title	Department	Year	Policy Considerations
National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)	DECC	2011	Reduction of carbon emissions
The Clean Growth Strategy: Leading the way to a low carbon future	HM Government	2017	Low carbon growth, energy efficiency and emissions reduction
Implementing the end of unabated coal by 2025: Government response to unabated coal closure consultation	BEIS	2018	Ruled out mandating CCS to be deployed on existing coal power stations due to high costs, length of time beyond 2025 and inefficiency
The UK carbon capture, usage and storage (CCUS) deployment pathway: an action plan	HM Government	2018	Decarbonisation of economy, contribution to industrial competitiveness and generation of new economic opportunities
Carbon capture usage and storage: third time lucky?	Business, Energy and Industrial Strategy Committee	2019	Decarbonisation of economy, economic growth, job creation, technological leadership
Carbon capture usage and storage: third time lucky? Government Response to the Committee's Twentieth Report	HM Government	2019	Decarbonisation of economy, economic growth, job creation, technological leadership
Carbon capture, usage and storage: A Government Response on potential business models for Carbon Capture, Usage and Storage	BEIS	2020	Climate change (net zero transition), economic growth, job creation, technological leadership
Carbon Capture, Usage and Storage: An update on business models for Carbon Capture, Usage and Storage	BEIS	2020	Climate change (net zero transition), economic growth, job creation, technological leadership
The ten-point plan for a green industrial revolution	HM Government	2020	Enhancement of UK industry competitiveness, job creation, climate change (net zero transition)
National Infrastructure Strategy	HM Treasury	2020	Advancement of newer technologies, job creation, climate change (net zero transition)
Energy white paper: Powering our net zero future	BEIS	2020	Advancement of newer technologies, job creation, climate change (net zero transition)
Cluster Sequencing for Carbon Capture Usage and Storage Deployment: Phase-1	BEIS	2021	Decarbonisation of economy, leadership in CCUS technologies

Exploring and developing carbon capture storage technology is presented in official policy documents as being able to bring substantial benefits and help meet the United

Kingdom's objectives for secure energy supplies, economic growth, lower carbon emissions and leadership in CCUS technologies. In all documents, deploying CCS is presented as supporting the United Kingdom to successfully transition in the longer term to a low-carbon economy.

Fossil fuel generating stations are said to contribute to the diversity of energy supply needed to balance supply and demand and ensure that UK energy grids can cope with increasing amounts of intermittency. In this context, CCS appears as the main technology that can turn high-carbon fuels into genuinely low-carbon electricity (DECC 2012). The UK government also had originally planned to deploy CCS technology on existing coal power stations. However, due to the high costs, length of time beyond 2025 and inefficiency to be adapted to reduce emissions and meet CO2 abatement requirements, the UK government ruled out mandating Carbon Capture and Storage (CCS) technology to be deployed on existing coal power stations (BEIS 2016, 2017). There is also an emphasis on the role of CCS in developing new nationally significant energy infrastructure projects.

UK world leadership in CCS technology also appears strongly in official documents as an important policy consideration. At the same time, CCS is presented as driving growth across the United Kingdom and providing high skill and well-paying jobs for all sections of society, particularly in the context of creating jobs to support the recovery from COVID-19 (BEIS 2020a). In terms of supporting economic growth, CCS is seen as providing a decarbonisation service to other countries and benefiting from growing international demand for low-carbon products and services (Business, Energy and Industrial Strategy Committee 2019). These policy considerations will be taken into account when applying the environmental law principles.

3. The Application of Principles of UK Environmental Law to CCS

In November 2021, the government enacted the Environment Act 2021, which includes clauses on environmental principles and governance after Brexit. Drawing on the current international and EU environmental principles, the UK government set five environmental principles in one place: (i) the principle that environmental protection must be integrated into the making of policy (integration principle); (ii) the principle of preventative action to avert environmental damage; (iii) the precautionary principle, which states that when there are threats of serious or irreversible environmental damage, a lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation; (iv) the principle that environmental damage should as a priority be rectified at source and (v) the 'polluter pays' principle, in which those who cause pollution or damage to the environment should be responsible for mitigation or compensation.

UK environmental principles should be integrated into the making of public policies and their application and interpretation may permeate a great deal of case law. The 'Environmental Principles Duty' created by the Act requires that Ministers must have 'due regard' to the Environmental Principles Policy Statement when making new or updating existing policy. However, a final version of the Environmental Principles Policy Statement has not been published yet. Therefore, it is unknown whether environmental principles will serve exclusively as policy drivers behind environmental initiatives, such as CCS, and will play no role in informing the reasoning of a court or if UK environmental principles will inform legal cases and influence decision-making. By the language used in the latest Draft Environmental Principles Policy Statement (Department for Environment, Food & Rural Affairs 2021) in which principles 'cannot dictate policy decisions by Ministers' and the requirement is of only 'due regard', it seems that the direction is leaning towards the former approach. However, the exact obligations entailed by the application of these principles remain unclear.

The Environmental Principles Policy Statement is meant to explain in more detail how these are to be interpreted and provide information as to how they should be applied as per article 17 of the Environment Act 2021. However, the Explanatory Notes related to the

Environment Act 2021 make clear that the principles should be proportionately interpreted and applied.

Proportionate application implies ensuring that action taken on the basis of the principles balances the potential for environmental benefit against other benefits and costs associated with the action. This means that a policy where there is the potential for high environmental damage would require more stringent action than a policy where the potential environmental damage is low. In light of that, in order to apply these principles to carbon capture and storage policies in the UK, these policies must be balanced with other considerations, which in the case of CCS are reduction of carbon emissions, security of energy supply, economic growth and technological leadership.

Ministers should also consider the environmental impact of a policy, the value of any mitigating actions, the associated costs and benefits to society of the policy's primary objectives as well as the financial and economic costs and benefits. However, although due regard to the policy statement on environmental principles should be observed, there is no obligation for a policy to be carried out if doing it would have no significant environmental benefit, or would be in any other way disproportionate to the environmental benefit, as per article 19 of the Environment Act 2021. In this sense, for example, the policy statement does not need to be used to change the direction of a CCS policy if the environmental impact would be negligible.

Article 19(3) of the Environment Act 2021 also covers certain policies that are excluded from the duty to have due regard to the environmental principles, i.e., the armed forces, defence or national security as well as taxation, spending or the allocation of resources within government. An interesting way to disregard the applicability of environmental principles to CCS policies would be the association of the use of CCS with national security.

Energy security is one of the policy considerations used by the UK government to justify the implementation of CCS. A rich literature associates energy security with national security on the basis that energy products and services are absolutely essential for society to function (Cornell 2009; Luft et al. 2010; Peoples and Vaughan-Williams 2015; Kivimaa and Sivonenac 2021). In this vein, if the use of CCS is considered paramount to ensure energy security, then there may be a possibility that the environmental principles may not apply to CCS policies if these policies are framed in the context of national security, and therefore justify actions outside the normal bounds of political procedure (Buzan et al. 1998).

Concerning the applicability of environmental principles under the Act to CCS policies in the United Kingdom, the integration principle simply means that environmental protection must be embedded into the making of CCS policies, except in the circumstances stated under article 19 of the Act as explained above. When considering the case of CCS, the remaining four principles may be cause for some discussion and controversy, particularly if the argument to be raised is against the compatibility of CCS with these principles: the principle of preventative action, the rectification at source principle, the precautionary principle and the polluter pays principle.

3.1. The Principle of Preventative Action and CCS

Based on the 1992 Rio Declaration, the principle of preventative action requires the adoption of measures intended to prevent damage from arising as an alternative to remedying harm already caused. As per the 2005 arbitral award in the *Iron Rhine Arbitration (Belgium v Netherlands)* case, the preventative principle requires that 'where development may cause significant harm to the environment there is a duty to prevent, or at least mitigate, such harm'. Based on this concept, minimisation of quantifiable risks could still be seen as preventative.

In international law, the principle's prescriptions range from mere due diligence obligations to obligations to limit emissions or set exposure standards (de Sadeleer 2002). However, the level of risk or damage required to trigger the principle remains unclear. One example of the application of the preventative principle to guide legal reasoning is the joint European case *ARCO Chemie Nederland Ltd. v Minister van Volkshuisvesting* [2000]

ECR I-4475 where the court relied on the precautionary and the preventative principles to determine that the concept of waste could not be interpreted restrictively (Scotford 2017). So far, UK policy documents do not fully explore how the preventative principle operates in the context of protecting the environment. Given that Ministers only need to have due regard to environmental principles, the preventive principle on its own will most probably not provide a broad obligation to prevent environmental harm within English jurisdiction.

Many of the debates about CCS centre on the relationship between risk and the perception of that risk. One may argue that by deploying carbon capture and storage (CCS) and storing carbon dioxide permanently in artificial reservoirs, preventive action is being taken to avert immediate environmental damage with the removal of carbon dioxide from the atmosphere. However, it would be in the public interest if policies aimed at observing the preventative principle focused on the source of pollution by encouraging the development of technologies that prevent the emissions in the first place. Considering that CCS does not avoid the production of harmful emissions but instead buries them, there may be a substantial risk to the environment and burden on future generations. The question is whether there is evidence that CCS can cause substantial harm. Some research suggests that carbon capture and storage risks can be minimised (Bruckner et al. 2014). If actions can be taken to at least mitigate such harm, then CCS development may be deemed compatible with the principle of preventative action.

One of the issues between CCS and the principle of preventative action lies in the fact that CCS is a new technology. Certainties rest on cumulative experience concerning the degree of risk posed by an activity. Preventive measures are thus intended to avert risks for which the cause-and-effect relationship is already known (Trouwborst 2009). As there are uncertainties in CCS deployment due to a lack of scientific research and actual experience, precaution rather than prevention may take priority.

However, UK environmental law principles should be proportionally interpreted and applied. Factors such as the environmental impact of a policy, the value of any mitigating actions and the associated costs and benefits to society of the policy's primary objectives must be included in the equation along with the policy considerations given for CCS, i.e., reduction of carbon emissions, security of energy supply, economic growth and technological leadership. The question then is whether support for CCS can be considered proportional when there are other technologies available that can tackle climate change without having to leave a burden for future generations.

3.2. The Rectification at Source Principle and CCS

The rectification at source principle means that environmental harm should be prevented at its source rather than rectifying the resulting damage by repairing and restoring the affected environment and compensating for the adverse impact. This principle has not been a central concept employed by English courts in structuring its decisions nor has it been widely applied in international and European case law. There is, therefore, a lack of authoritative doctrine around the rectification at source principle.

Considering that CCS does not avoid the production of harmful emissions but instead buries them, there is a threat of possible major damage to the environment and burden on future generations. By burying harmful emissions, a substantial amount of funds is being used to support policies that do not tackle environmental damage at its origin, being, therefore, incompatible with the rectification at source principle. In this sense, CCS policy pays lip-service to the principle of rectifying damage at source since the aim is to tackle the root cause of the problem rather than simply tackling its consequences. In any case, principles are intended to encourage public policies, to allow courts to weigh and reconcile highly divergent interests. In the case in analysis, the balance is between protection of the environment and human health on one side and the policy considerations given to CCS in official policy documents, i.e., reduction of carbon emissions, security of energy supply, economic growth and technological leadership. Following this, taking into account the existence of cleaner alternatives that cause less risk to the environment and support the

mentioned policy considerations, such as renewable energy technologies, the backing for carbon capture and storage appears disproportional.

By promoting CCS policies, the focus is on the polluter pays principle where the polluter should pay for damage that it causes to the environment. However, rectifying environmental damage at its source should be a priority.

3.3. The Precautionary Principle and CCS

A consensus has yet to emerge from the vast literature on the precautionary principle with regard to its definition. For some, in international law, the principle has already achieved the status of customary law (McIntyre and Mosedale 1997; Trouwborst 2002). This view is supported by decisions, such as in the case *Pulp Mills on the River Uruguay, Argentina v Uruguay [2006] ICJ Rep 113*) where Judge Trindade provided a lengthy analysis as to why the precautionary principle is a general principle of international environmental law. This notion, however, was rejected, for example, in *New Zealand v. Japan; Australia v. Japan* (2001) ILR 148 (the Southern Bluefish Tuna cases) under the International Tribunal for the Law of the Sea. For others, the precautionary principle essentially carries a duty of care and should be applied to situations where there is a 'reasonable scientific plausibility' of the risk (de Sadeleer 2002).

The precautionary principle plays a key role in international and European environmental law cases with detailed reasoning about its legal role being given in some cases. The same cannot be stated about UK case law where references to environmental principles are usually brief.

Following the precautionary principle applied in the European case *Waddenzee* (C-127/02) [2005] 2 C.M.L.R. 31, where the most reliable information available leaves obvious doubt as to the absence of possible significant adverse effects on the ecosystem, the benefit of the doubt will favour conservation of the environment.

If the reasoning in *Waddenzee* is applied to the deployment of CCS in the United Kingdom, reliable information leaving obvious doubt as to the absence of possible significant adverse effects on the environment would need to be available in order to stop the development and deployment of CCS. In this sense, environmental protection measures should always be adopted unless it can be scientifically proven that particular activities will not cause environmental harm. As such, long-term storage of CO2, for example, would need to demonstrate acceptably low or no measurable impacts to health, safety, the environment, or existing resources in order to be able to be operational.

Alternatively, as per the United Kingdom's argument in the case *Ireland v. United Kingdom* (2002) 41 ILM 405 (the MOX Plant case) under the International Tribunal for the Law of the Sea, the United Kingdom may choose the approach that if there is no evidence of serious harm, the precautionary principle will not apply. This means that in the absence of this evidence, it is unlikely that CCS development in the United Kingdom would be considered by domestic courts as being at odds with the precautionary principle. Like the decisions in *Preston New Road Action Group v Secretary of State for Communities and Local Government and Cuadrilla Bowland Ltd.* [2018] EWCA Civ 9 and *Gayzer Frackman v. Secretary of State for Communities and Local Government, Lancashire County Council, Cuadrilla Bowland Ltd., Cuadrilla Elswick Ltd.* 2018 WL 00398402, which challenged the use of hydraulic fracturing, the existence of uncertainty in relevant scientific knowledge would not render unlawful the approach adopted to support CCS when it is satisfied that the relevant regulatory controls would operate effectively to prevent harm to the environment and to human health arising from the proposed development. Since CCUS has been heavily regulated under the Energy Act 2008, Energy Act 2010, Energy Act 2011 and the storage of carbon dioxide (licensing etc.) regulations 2010, si 2010/2221, regulatory issues, such as site selection, risk assessment, monitoring and verification and remediation, have been mostly dealt with.

Other previous case law on energy also demonstrates that when turning to the balance of considerations, decisions have fallen in favour of fossil fuel development due to economic growth and energy security considerations. In *Stephenson v Secretary of State*

for Housing, Communities and Local Government [2019] EWHC 519 (Admin) and *Friends of the Earth Ltd. v Secretary of State for Communities, Housing and Local Government [2019] EWHC 518 (Admin)*), for example, there was support for the benefits of on-shore oil and gas development, including unconventional hydrocarbons, for the security of energy supplies and the transition to a low-carbon economy. Therefore, due to the fact that the development and deployment of CCS would itself favour in a way a reduction in carbon emissions, energy security and economic growth it is likely that significant weight will be given to such benefit on the balance of considerations.

However, while there are quantitative methods for assessing CCS risks, the objectivity and reliability of these methods in providing all of the answers can be flawed, particularly if incorrect assumptions are made when undertaking a scientific risk assessment. At the moment, different CCS techniques are at different stages of development, and many are considered to be of doubtful effectiveness at the global scale and not well-researched (UNEP 2012).

Storing carbon emissions raises concerns, such as liability, accounting issues, monitoring and risk of leakage. Many forms of carbon capture and storage keep the CO2 as gaseous CO2, which can be challenging to store and transport, and prone to leak back into the air. Damen et al. (2006) suggested that CCS techniques give rise to several risks, i.e., CO2 leakages due to an escape from the reservoir, CH4 leakages due to the injection, seismicity due to the injection and the generation of micro earth tremors, ground movement after a subsidence due to pressure changes and displacement of brine as a consequence of the CO2 injection. All these potential risks may provoke negative effects on the environment. Potential impacts on the environment deriving from possible CO2 leakages related to CCS are becoming better understood by the scientific community; however, there is still a lack of knowledge and data (Almagro-Pastor et al. 2015; Borrero-Santiago et al. 2016; Gilfillan et al. 2017; Morkner et al. 2022).

Ultimately, the application of the precautionary principle to CCS will be subject to what is considered the significance of risks and the acceptability of scientific evidence as 'proof' having regard to considerations concerning reduction of carbon emissions, security of energy supply, economic growth and technological leadership.

3.4. The Polluter Pays Principle and CCS

The polluter pays principle stems from the notion of punitive measures for those who cause environmental harm, as the costs of pollution prevention, control and remediation should be borne by those who cause pollution. Polluters are responsible for internalisation of external costs, for example in the form of taxes, emission allowances ("cap and trade") and complying with command-and-control measures, such as prohibitions, restrictions of activity levels and installation of avoidance and abatement devices (Schmidtchen et al. 2021). While the prevention and precautionary principles follow a preventive logic by seeking to achieve environmental protection before the occurrence of damage, the polluter pays principle is traditionally seen as a cost allocation mechanism (de Sadeleer 2002).

Whilst calculating and apportioning such damages can be difficult, such an approach is necessary to both deter individuals and organisations from polluting excessively and to ensure that the burden of repairing such damage lies with those who committed the act rather than the community at large (Costanza et al. 1997; Ambec and Ehlers 2016).

The rationale of the polluter pays principle was incorporated into the regulatory framework for carbon capture and storage in the United Kingdom. The storage of carbon dioxide (licensing etc.) regulations 2010, si 2010/2221, for example, cover the requirements relating to the licensing of CO2 storage and to the liabilities of the storage operator both during and after the active operation of the store. In cases of leakages, it is the operator's obligation to take necessary health and corrective measures. If the operator fails to take these measures, the authority must do so itself, but the costs must be recovered from the operator.

At first sight, the polluter pays principle provides appropriate incentives for the use of CCS as CCS reduces carbon dioxide emissions. Emissions reductions through CCS and the ability to achieve negative emissions in the national energy system were modelled by the UK Energy Technologies Institute (ETI) as essential. Their analysis shows that the use of CCS is beneficial on a cost basis, reducing the cost of decarbonisation. Omitting CCS would double the cost of meeting climate change targets to more than 2% of GDP (ETI 2015).

The question is whether a CCS policy guided by the polluter pays principle, as typically understood, delivers socially and economically optimal solutions to the problem of environmental protection. In a scenario in which a company producing electricity from gas would have to cover the full costs of CCS, including the storage costs of CO2 for decades and insurance for possible leakages, this would make energy production from gas simply very expensive. In another scenario, if damages caused by the storage of carbon dioxide are so great or irreversible that companies could not pay for them or they could only be rectified at considerable costs, then there would be no environmental benefit, social gain or economic gain. The operator of the storage facility could go bankrupt leaving, as such, the environmental damage as well as the economic costs for the public to pay. The application of PPP, therefore, would not lead to efficient outcomes, leaving room for other policy options to perform better in terms of social, economic and environmental welfare.

4. Conclusions

This paper delved into the application of principles of UK environmental law included in the Environment Act 2021 to carbon capture and storage policies. As principles should be applied in balance with other considerations, firstly, this work sought to examine the policy considerations used to support CCS development in official government documents. In total, four factors were discovered: reduction of carbon emissions, security of energy supply, economic growth and technological leadership.

The analysis then focused on how the principle of preventative action, the precautionary principle, the principle that environmental damage should as a priority be rectified at source and the polluter pays principle could be interpreted and applied when taking into account CCS policy considerations. It showed that arguments can be raised concerning the incompatibility of CCS policies with the preventative principle, the rectification at source principle and the precautionary principle.

Environmental principles should be proportionately interpreted and applied. As such, the environmental impact of CCS policies, the value of any mitigating actions, the associated costs and benefits to society of the policy's primary objectives and the financial and economic costs and benefits must be taken into account. Many of the debates about CCS centre on the relationship between risk and the perception of that risk. One may argue that by deploying CCS and storing carbon dioxide permanently in artificial reservoirs, preventive action is being taken to avert immediate environmental damage with the removal of carbon dioxide from the atmosphere. However, it would be in the public interest if policies aimed at observing the preventative principle focused on the source of pollution by encouraging the development of technologies that prevent the emissions in the first place. Considering that CCS does not avoid the production of harmful emissions but instead buries them, there may be a substantial risk to the environment and burden on future generations. By burying harmful emissions, a substantial amount of funds is being used to support policies that do not tackle environmental damage at its origin, being, therefore, incompatible with the rectification at source principle.

While there are quantitative methods for assessing CCS risks, the objectivity and reliability of these methods in providing all of the answers can be flawed, particularly if incorrect assumptions are made when undertaking a scientific risk assessment. At the moment, different CCS techniques are at different stages of development, and many are considered to be of doubtful effectiveness at the global scale and not well-researched. However, if there is no evidence of serious harm, it is unlikely that CCS development in the United Kingdom would be considered by domestic courts as being at odds with

the precautionary principle. Other previous case law on energy also demonstrates that when turning to the balance of considerations, decisions have fallen in favour of fossil fuel development due to economic growth and energy security considerations. Therefore, due to the fact that the development and deployment of CCS would itself favour in a way a reduction in carbon emissions, energy security and economic growth, it is likely that significant weight will be given to such benefit on the balance of considerations.

By promoting CCS policies, the focus is on the polluter pays principle where the polluter should pay for damage that it causes to the environment. However, the analyses also revealed that a CCS policy guided by the polluter pays principle may not be cost effective. These findings of the UK case study are relevant because they may be applicable to other countries that have similar domestic environmental laws and legal interpretation, or which have signed and incorporated international agreements containing such principles.

This paper also demonstrated that the exact obligations entailed by the application of these principles remain unclear under English jurisdiction and more light will be shed when the final version of Environmental Principles Policy Statement is published. It seems that the principles' prescriptions will amount to mere due diligence obligations under domestic law. They are to be applied differently in accordance with the level of risk to the environment and in balance with other considerations. Therefore, although CCS initiatives can be at odds with the preventative principle, the rectification at source principle, the precautionary principle and the polluter pays principle, economic and energy security considerations may be prioritised over uncertainties surrounding environmental impacts caused by CCS.

In addition, there is the possibility of CCS policies being excluded from the duty to have due regard to the environmental principles by associating the use of CCS with national security. Energy security is one of the policy considerations used by the UK government to justify the implementation of CCS and a rich literature associates energy security with national security on the basis that energy products and services are absolutely essential for society to function. In this sense, the excluding clause under article 19(3) of the Environment Act 2021 may apply.

English courts have not been very prolific in building environmental principles into their case law. It would be interesting to explore the environmental case law and the role played by environmental law principles in judicial reasoning and within the English legal system since the Environment Act 2021 has been enacted in order to examine whether or not and in which ways the courts would be progressive in their reasoning concerning environmental principles. It would also be important to make comparative analyses with other legal jurisdictions to evaluate the standard of application of environmental principles in different countries, contributing, as such, to comparative law. This would also contribute to examining the legality of CCS policies not only in line with principles of environmental law in the United Kingdom, but also under other legal jurisdictions worldwide.

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