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SECURe – Subsurface Evaluation of Carbon capture and storage and Unconventional risks

D6.1 Overview report of ethical issues associated with CCS and with Shale Gas R&D

Subtask 6.2.2 Overview of Ethical and Social Issues Associated with CCS

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Public introduction

Subsurface Evaluation of CCS and Unconventional Risks (SECURe) is gathering unbiased, impartial scientific evidence for risk mitigation and monitoring for environmental protection to underpin subsurface geoenergy development. The main outputs of SECURe comprise recommendations for best practice for unconventional hydrocarbon production and geological CO_2 storage. The project is funded from June 2018–May 2021.

The project is developing monitoring and mitigation strategies for the full geoenergy project lifecycle; by assessing plausible hazards and monitoring associated environmental risks. This is achieved through a program of experimental research and advanced technology development that includes demonstration at commercial and research facilities to formulate best practice. We will meet stakeholder needs; from the design of monitoring and mitigation strategies relevant to operators and regulators, to developing communication strategies to provide a greater level of understanding of the potential impacts.

The SECURe partnership comprises major research and commercial organisations from countries that host shale gas and CCS industries at different stages of operation (from permitted to closed). We are forming a durable international partnership with non-European groups; providing international access to study sites, creating links between projects and increasing our collective capability through exchange of scientific staff.

Executive report summary

This overview report of ethical and social issues associated with carbon dioxide (CO_2) capture and storage (CCS) and with Shale Gas R&D is divided into two Chapters which summarise the ethical and social issues raised in CCS and shale gas respectively. In Chapter 1, the approach taken in the case of CCS is to provide a plain English language account of CCS, explaining what it is, the reasons why it might need to be employed and arguments for and against CCS presented in the literature and wider public domain. The aim is not to answer the question of whether CCS should or shouldn't happen, but rather to present the most common arguments. To make the report as accessible as possible to non-specialists, we have avoided using technical and academic jargon in the main text. We have included the more academic content in a series of endnotes, together with references.

Chapter 2 contains the literature overview of ethical issues associated with shale gas development. The review is based on Evensen's (2016) analysis of ethical claims and Sovacool's (2013) energy justice perspective illustrated with reference to published research in the social sciences. Various concepts of social justice are brought to the readers' attention to shed light on unconventional hydrocarbon development as an issue which can be related to broader visions of social order and human rights. The aim of the report is to summarise and review the arguments and main issues that were raised by various stakeholders involved in shale gas worldwide.

This deliverable contributes to SECURe's Objective 6 of improving understanding of stakeholders', local residents' and community perceptions of shale gas and CCS and of contributing to better communication of the technical, socio-economic, regulatory and policy issues surrounding both sub-surface technologies (pages 3 & 4 of proposal). The intention is that the material can be used by other project partners in their work with communities and public agencies and when considering how to communicate complex scientific and technical material with the public (items 4 & 5 in explaining how SECURe will achieve its objectives, page 4 of the proposal). Under SECURe's

‘legacy’ items, (3) mentions ‘community engagement’ (page 4 of the proposal) and the work in WP6.2.1 will contribute here.

Within WP6.2, specifically, we will use the material to help develop the Responsible Research and Innovation (RRI) framework that will use a set of criteria in order to evaluate a set of potential research and development projects and proposals. The analysis of the issues has indicated the key technical, economic, ethical and socio-political issues at stake, hence is a good starting point for considering what criteria could be established to evaluate the social responsibility of projects.

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Introduction

SECURe's Objective 6 is stated as follows: "To understand the needs of a range of stakeholders, including local communities, and to engage them through the development of appropriate communication strategies, including participatory monitoring and through the education of early-career researchers" (pages 3 & 4 of proposal). This deliverable contributes to fulfilling this objective by:

a) Reviewing what we know already from the academic and 'grey' literature;

b) Organising and beginning to cluster arguments around both CCS and shale gas extraction; and

c) Applying ideas about 'justice' and 'ethics' from the social sciences and humanities to debates regarding the desirability or otherwise of CCS and shale gas extraction.

The intention is that the material can be used by other project partners in their work with communities and public agencies and when considering how to communicate complex scientific and technical material with the public (items 4 & 5 in explaining how SECURe will achieve its objectives, page 4 of the proposal). Under SECURe's 'legacy' items, (3) mentions 'community engagement' (page 4 of the proposal) and the work in Subtask 6.2.1 will contribute here.

Within Task 6.2, specifically, we will use the material to help develop the Responsible Research and Innovation (RRI) framework that will use a set of criteria in order to evaluate a set of potential research and development projects and proposals. The analysis of the issues has indicated the key technical, economic, ethical and socio-political issues at stake, hence is a good starting point for considering what criteria could be established to evaluate the social responsibility of projects.

Deliverable 6.1 on Ethics and Social Issues surrounding CCS and on Ethics and Social Issues surrounding hydraulic fracturing ('fracking') of rock formations for extraction of natural gas have been approached in a different way. This is a deliberate strategy that aims to explore different ways of interpreting 'ethics and social issues', therefore to learn from attempting implementation of the two different approaches. Aiming to cover 'ethics' within a project that is predominantly technical and scientific has rarely been attempted in the past (as opposed to including research on the issue of the public perceptions of new technologies such as CCS and shale gas which has become commonplace over the past two decades). There is no obvious exemplar of 'the correct way to do this' to refer to and there were different ideas within Task 6.2 on how this task should be achieved. Our preference has been to work by consensus and cooperation, rather than forcing all to follow the same approach, given that we do not have experience to draw upon to indicate 'what definitely works' and what doesn't. We therefore decided to adopt two different approaches to the task for the two areas of CCS and shale gas extraction.

The University of Edinburgh (UEDIN) approach to Deliverable 6.1. on CCS. The description of the task did not specify the audience that the deliverable is intended for. The UEDIN team, covering CCS (Subtask 6.2.1), chose to write for an audience of interested and curious members of the public, stakeholders, opinion-formers and members of local communities which might be affected by a CCS development. Previous research undertaken for the IEA GHG programme evaluated communication of expert information on CCS to the public and local communities and identified that there is a large gulf between expert information on CCS and information that is understandable, appropriate and useable for a lay audience (IEA GHG 2013). Focus groups with (a) science journalists and (b) students studying science communication at Masters level revealed confusion concerning the meaning of some of the key information that is commonly presented about CCS. A well-known example is the common visual presentation of CO_2 storage as occurring at a depth that appears to be 20 to 100m below the surface instead of the real depth of >800m (e.g. Figure 1). While this visual presentation is not confusing to CCS experts, because they are fully aware of the real depth at which CO_2 has to be stored, non-experts do not share this tacit knowledge of the geology behind CO_2 storage, which can then give rise to misplaced concerns over storage integrity. A further example is the common representation of stacked layers of rock formations below the surface, indicating, e.g. porous rocks, mudstone, halites, etc. While geologists are used to visualising and understanding the meaning of such layers of rock, those unfamiliar with geology do not necessarily understand what such layers mean as they are not aware that the sub-surface consists of such layered rock formations.

While it is known that lay and non-specialist publics (including stakeholders, local communities, etc.) often have a very low level of knowledge and understanding of the science and technology behind CCS (Terwel et al., 2009, De Best-Waldhober et al., 2009), we know less about how familiar such publics are with the specialist ideas and terminology of ‘ethics’ and ‘justice’. UEDIN made an assumption that technical concepts and terms that are utilised in the social sciences and humanities would also be unfamiliar and, quite likely, confusing to non-specialist publics. For instance, we know from working extensively with scientists and engineers that they are largely not familiar with technical terms such as ‘procedural justice’, ‘recognition justice’ or ‘distributional justice’ and that the social sciences and humanities are frequently perceived as encumbered with just as much jargon and opaque terminology and concepts as the sciences and engineering.

Given that UEDIN decided to write for non-specialist publics, the task of presenting ‘ethics and social issues’ surrounding CCS had to be approached in a particular way. This entailed presenting clearly the underpinning scientific and technical information (illustrated for CCS and shale gas below in Figure 1) in a comprehensible fashion alongside articulating the ethics and social issues. Ethics and social issues also had to be presented in a comprehensible fashion that did not assume any prior knowledge and/or understanding of the specialist concepts and terminology employed in the study of ethics. The assumption made was that some knowledge of the topic about which ethics are being considered is required, especially where the topic itself is not widely known about or understood. For example, the ethics of implementing CCS given the potential risks of CO_2 leakage is a hard discussion to entertain without knowing something about the science behind CO_2 storage.

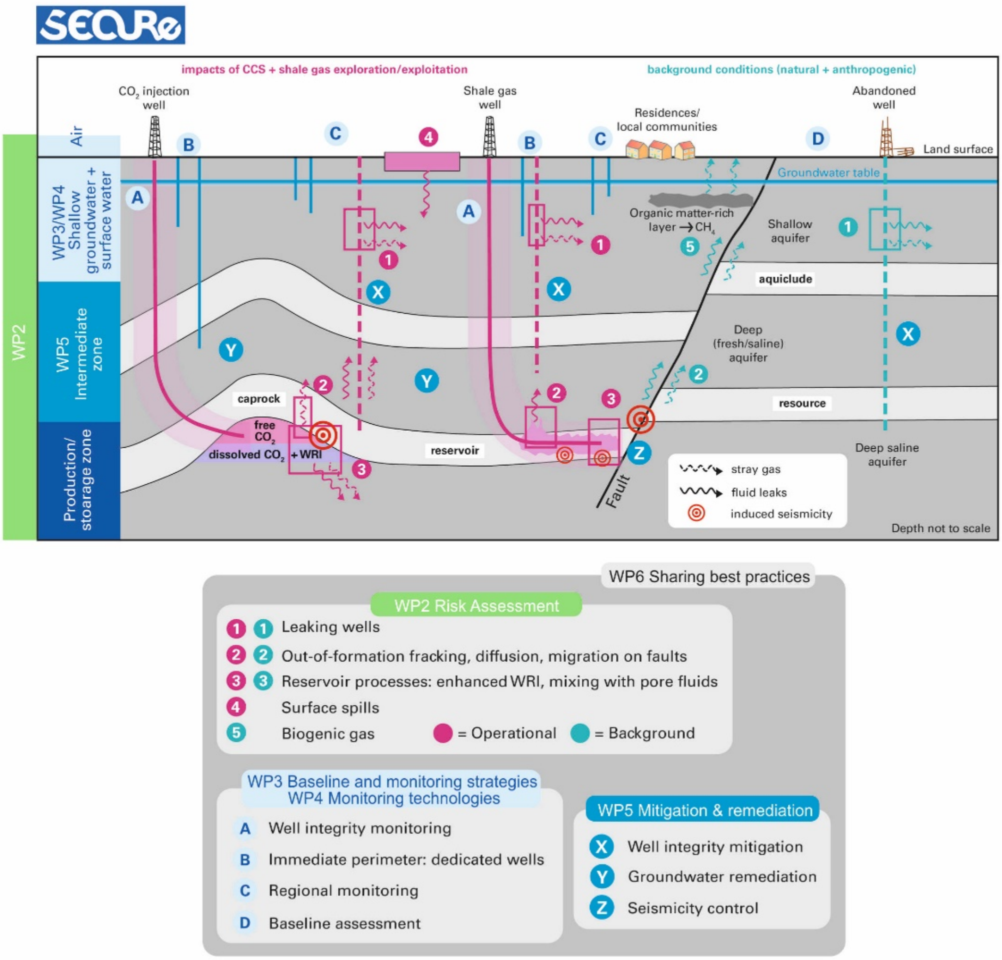


Figure 1 - The SECURe Concept – providing best practice recommendations across these domains for the protection of groundwaters, surface environments and local communities.

The repercussions of this approach are that less space and detail could be provided to cover the science and technology or to the consideration of ethics. This text is intentionally less academic and scholarly than were this written primarily for an audience of social scientists. The style is meant to be approachable and engaging. References in the main text have been avoided because long lists of authors' names disrupt the flow of text. Endnotes have been used in the text to provide additional detail and to allow inclusion of references and access to other literature sources. A glossary has also been included to allow clear definition of more technical terms and concepts.

The approach adopted by UEDIN aims to balance the needs of different communities and potential users, including local residents, stakeholders and members of the public. It would take a much longer document to fully present and justify in academic terms all the material covered here. Such long documents would not be read by non-specialist publics, who are most often undertaking such reading in 'their own time' rather than as part of their professional and salaried work role. We hope that the way that this report has been prepared and presented will enable the document to be used in other parts of the work in Task 6.2 and, possibly, in other elements of SECURe's work.

The Uniwersytet im. Adama Mickiewicza w Poznaniu (AMU) approach to Deliverable 6.1. on hydraulic fracturing ('fracking') was to interpret the audience for the deliverable 6.1. as researchers and specialists who want to recognize and familiarize themselves with specialist concepts and approaches from social science and humanities perspectives. This is the 'default' way in which such a task and deliverable would usually be interpreted and implemented as part of an EU project; i.e. social scientists with specialist knowledge and understanding are included in EU projects that also include scientists and engineers and will typically start from the presumption of writing to their own peer community[i].

Claims agnosticism. In one important sense these chapters shared a common approach which was to map out the existing perspectives that occur regarding both CCS and hydraulic fracturing for shale gas extraction. Both UEDIN and AMU drew upon academic and non-academic sources, though because of its greater academic focus, AMU relied primarily upon the published literature, while UEDIN relied more heavily upon non-academic representations of CCS, e.g. in trade journals, government reports, reports from think tanks, lobby and pressure groups, conference presentations, and so on. The aim of both chapters was not to find the 'truth' by confirming some perceptions of these technologies as 'correct' and dismissing others as 'incorrect'. Where perceptions exist (whether in the wider community or in the literature) we represented these perceptions and associated claims without judging whether they were 'correct' or 'incorrect', though we did aim to make some commentary where there are clear and obvious 'provisos' or counter-arguments to statements. This approach is consistent with the constructivist approach in the social sciences, which regards contending claims as valid evidence of perspectives which deserve to be explored, not dismissed for being 'wrong'. This is not the same as arguing that all perspectives are equally valid, but it does invite discussion which draws upon multiple sources – such as scientific and technical knowledge, values, beliefs, experience and practices, and so on. Invoking scientific 'truth' can all too easily shut down debate as in, 'that's technically wrong, argument dismissed', whereas better understanding arises from deeper engagement with someone else's perspective and argument. This approach has the potential to overcome intransigent positions and to enable reconciliation and compromise.

So what has been learnt by the two different ways of undertaking this work task? To an important extent, we will not know or be in a position to judge the effectiveness of each approach until further research within WP6 and within SECURe more widely has been undertaken. This includes the development of the Responsible Research and Innovation (RRI) framework within WP6.2. It also includes use of the material by other WPs of SECURe especially that concerned with communication with communities, stakeholders and the public. This argues for development of a systematic process by which we can monitor the use of each deliverable and collect feedback on how each deliverable has been received and utilised. Because of the different approaches taken, Chapter 1 should, ideally, meet the needs of non-specialist audiences but also needs to provide an account of the science, technology, ethics and social issues regarding CCS which is convincing to both scientists and social scientists. Chapter 2 must satisfy the social science community engaged in consideration of shale gas and of 'energy ethics and justice' more widely. Feedback will allow WP6.2 to determine whether and how further analysis and writing needs to modify the approach adopted in Chapters 1 and 2.

Chapter 1: ETHICS AND SOCIAL ISSUES SURROUNDING CO_2 CAPTURE AND STORAGE (CCS)

1.1 Introduction to CO_2 Capture and Storage (CCS)

1. Climate change, and how society might need to respond, is one of the most urgent as well as challenging issues facing society in the 21st Century[ii].
2. Climate change is largely caused by carbon dioxide (CO_2) emissions from burning fossil fuels – coal, oil and gas. We need to massively reduce these emissions in the next few decades to limit global average temperature increase at the earth's surface to 2˚C or 1.5˚C.
3. The IPCC Special Report provides plenty of scientific evidence that limiting increases to 1.5˚C will greatly reduce harm to humans, especially vulnerable persons, compared to the 2˚C target.[iii]
4. An approximate analysis of the implications of adopting a global target of 1.5˚C v. 2˚C for CO_2 emission reductions in European countries is illustrated below. [iv]

Table 1 - Comparison of CO_2 emission reduction targets required to limit global temperature increases by 1.5°C and 2°C (inferred from IPCC 2018, *Global Warming of 1.5ºC*).

Target for limiting global average surface temperature change	1.5°C	2°C
CO_2 reductions needed by 2030	45%	30%
CO_2 reductions needed by 2050	100% (net)	80%
CO_2 reductions needed by 2100	100% plus CO_2 removal	100% (net)

5. How the energy system might need to change in order to greatly reduce the emissions of carbon dioxide (CO_2), has been the subject of a lot of intense debate and controversy. The main options discussed are: limiting the use of energy (including greater energy efficiency), developing very low and zero-carbon sources of energy such as renewables (wind, solar, wave, hydroelectric, etc.) and nuclear power, and developing CO_2 capture and storage or CCS.
6. What is CCS? Fossil fuels (coal, gas, oil) contain 70% to 90% carbon. When fossil fuels are burnt they release energy and the carbon reacts with oxygen during burning to become CO_2. Additionally, some industrial process produce significant CO_2 emissions as part of the manufacturing process, for example, iron and steel, petrochemicals including fertiliser production, hydrogen production from natural gas, cement production.
7. The CO_2 can be captured from the waste gases that are produced using a chemical solvent. The solvent is then heated-up to release the CO_2 and the gas is compressed for transporting by pipeline or ship to a site where it is pumped underground into a special type of rock formation at least 800 meters (2600 feet) below the surface for permanent storage[v]. Some rock types[vi] are full of tiny interconnected holes or 'pores' into which the CO_2 passes and, if correctly chosen and monitored, are able to store CO_2 securely, for thousands of years[vii]. This is the opinion of many geologists who are experts in CO_2 storage[viii] but does not mean that there is no uncertainty and there is on-going debate amongst geologists on exactly how safe storage of CO_2 is and over what time period.
8. Many ethical and moral issues have been raised in discussions over whether to use CCS to reduce CO_2 emissions into the atmosphere. The following text tries to summarise these arguments in plain English while reflecting the debates between scientists, academics and other 'stakeholders' such as environmental organisations, industry and government over the past two decades.
9. The sections below present arguments that have been made in the literature, in reports and at conferences, which argue in favour of or against CCS. The claim is not that any specific individual is

making all or even a sub-set of these arguments. The presentation is a debating style of 'for' and 'against' arguments that does not require scientists to judge whether the claims made are false or correct. The fact of the argument having been made in a public setting, report or paper is sufficient cause for its inclusion.

10. The aim is not therefore to create a 'balanced' 'independent' or 'objective' account of CCS. It is not attempting to locate the position or role of CCS in the energy transition. To do that requires adoption of a neutral position of objectivity from which the role of CCS versus other technologies could be established. The role of CCS will also vary greatly depending on the specific context and that would require far more nuanced and detailed analysis, e.g. of each national setting and its technological competencies, energy policy, economic and regulatory context and choices, political party positions and so on. Consistent with the constructivist stance, we are intentionally avoiding adopting such a position, meaning that we are technology agnostics.
11. It is worth noting the recent opinion of the Chair of the WG3 of the IPCC, Professor Jim Skea, that responding to climate change and the challenge of reducing CO2 emissions is not a case of 'technology x, versus technology y'; instead we will need to explore all options and likely need to implement a large range of options due to the sheer scale of the decarbonisation challenge. That perspective is highly relevant and important, but does not solve the problem of the practical reality of implementing an option such as CCS which will require social and political dialogue.

1.2 Why do some people think that we need CCS?

1. Many experts believe that we will most likely need to continue to use fossil fuels for electricity generation in the next several decades. In their view, we are unable to limit our demand for electricity, or to develop alternative forms of generation such as renewables or nuclear, sufficiently and / or quickly enough at an affordable cost.[ix]
2. CCS would allow reductions of CO_2 emissions from burning fossil fuels in power plants and other large-scale industrial processes by 90 to 95% at the point of burning so would help towards reducing CO_2 emissions.[x]
3. Developing CCS now is believed to be a good insurance policy in case fossil fuels and other manufacturing processes cannot be reduced and then eliminated as quickly as preferred, e.g. by the roll-out of renewable energy and by reductions in energy demand through energy efficiency and conservation.[xi]
4. It is also a form of insurance against the possibility that we need to act more rapidly in limiting CO_2 emissions into the atmosphere. This need for urgent action could arise from the accumulating evidence of more rapid climate change impacts than previously envisaged, which could cause a lot of damage to human societies, economies and nature.
5. CCS is presented by advocates as a 'bridging' solution ensuring that energy demands are met for many years while simultaneously allowing alternative low and zero carbon technologies (renewables, nuclear, etc.) to develop to enable a smooth and affordable energy transition[xii]. It is nowhere stated how long this transition period is likely or needs to be.
6. If biomass is used as the source of energy in a power plant in place of coal, and then the CO_2 emissions are captured and securely stored, this could be a technology for removing CO_2 emissions from the atmosphere. Many experts believe that it will be necessary to start removing CO_2 from the atmosphere later this century to avoid dangerous levels of climate change. As well as capturing CO_2 emissions from burning biomass, CO_2 can be extracted directly from the atmosphere using a chemical process as well as more simply by planting trees
7. Some industries produce CO_2 emissions due to the inputs into the manufacturing process. Steel production, for example, uses a form of coal called coke not just for energy but also because it has chemical effects necessary in making steel. Other similar industries are cement making, fertiliser manufacture and petrochemical refining. Even with a 100% renewable energy system, these industries will continue to emit CO_2. CCS is the only way (presently) of reducing such CO_2 emissions and, since such industries will continue to be necessary in industrial societies, it is likely that CCS will be required, at least until very low or zero-carbon alternatives to steel and cement making have been developed.[xiii]

8. Natural gas burning in our homes for heating water, central heating and cooking is an important part of the energy sector in many European countries. Unfortunately, using natural gas in this way produces too much CO_2 per unit of heat and we could not readily meet our carbon reduction targets if this continues to be our major domestic fuel. One option is to switch to greater use of electricity, but this would increase demand for very low-carbon electricity so requiring even more renewables and this extra demand would be hard to fulfil quickly enough. Another option is to replace natural gas with another much lower-carbon fuel. Biogas from decomposing food waste is one option but could only supply a small percentage of total demand due to limited supplies. Another possibility is to convert natural gas (methane) to hydrogen and to use hydrogen in our homes instead for heating and cooking[xiv]. Converting natural gas to hydrogen requires removal of carbon as CO_2 and the gas can then be stored securely in rocks.[xv]
9. There are some existing uses of CO_2, e.g. in making drinks such as adding the 'fizz' to sodas and beer, although such uses do not reduce emissions to the atmosphere for very long. CO_2 is also piped into glasshouses where vegetables such as tomatoes, peppers and lettuce are being grown in order to enhance the plants' growth. While valuable, such uses are small in scale and it has been estimated that the most ambitious market for CO_2 demand given current uses represents only a few percent of global production of CO_2. Scientists and engineers are trying to find new large-scale uses of CO_2, such as attempting to create alternative fuels to fossil-fuel derived petroleum and diesel. If successful the demand for using CO_2 to make other products could greatly increase, but these ideas are a still long way from being viable technically and economically[xvi].
10. For all or some of the above reasons, it is proposed by many that we should invest in CCS technologies and begin to implement CO_2 capture and storage projects so that we can learn how to bring down the costs and manage any risks.
11. Given uncertainties in how to reduce CO_2 emissions, some even believe that it is irresponsible not to implement CCS. They believe that we have a responsibility to the current and future generations to limit the build-up of CO_2 in the atmosphere so that we begin to limit climate change and its adverse impacts.[xvii]

1.3 Why do some people think that we don't need CCS?

1. Others do not agree that we should invest a large amount of money (if any) into CCS. They argue that we should invest instead in technologies to limit use of energy (including energy efficiency) and in renewables and / or new nuclear power which are zero- or very-low carbon ways of generating electricity.
2. There is disagreement amongst energy experts regarding whether these actions will be adequate to cut CO_2 emissions to the extent required and fast enough. The extent to which we can greatly reduce our use of electricity, heating and transport in reality (rather than theoretically) is currently unknowable. There is a wide range of estimates of how much energy demand could be reduced based on different assumptions that are, in reality, 'educated guesses'.
3. Likewise there is considerable disagreement on the extent to which the electricity and energy supply can become 100% renewable (or 100% zero- or very low-carbon, e.g. with a possible role for nuclear) and how long this could take. As with energy demand reduction, a lot depends on what assumptions are made, e.g. about the speed of technical change, investment and costs and how demand and behaviours might change.
4. Views about renewables are also influenced by location. Some countries have better wind energy resource, while others have better solar energy resource. Some have very good hydroelectric power, while others have no such potential. The situation of each country varies and some countries will find it easier to reach a high percentage of renewable electricity and energy than others. If the electricity grids of different countries can be connected-up, however, then the relative strengths of different localities can be combined – e.g. Denmark has a lot of wind power but when the wind does not blow, it can draw upon hydroelectricity from Norway to balance the demand.
5. The view that CCS is *not* required is easier to hold where there is greater confidence that energy demand can be reduced and / or that renewables (and/or nuclear) can supply a large percentage of

the electricity and energy needs. In those circumstances, it is easier to ask – why do we need CCS? By contrast, if one's view point is that reducing energy demand and / or expanding renewables and/or nuclear is going to be tough (e.g. unpopular) and very expensive, the need for CCS becomes more evident.

6. Those critical of CCS argue that it only reduces emissions by about 70% when the extra fossil fuel required and the extra energy used in extraction and transport of fossil fuels is factored-in, whereas we need to limit emissions by 80 to 90% by 2050 (for a 2˚C target) or by 100% (for a 1.5˚C target).[xviii]
7. Opponents of CCS have sometimes argued that we should not risk diverting our limited funds for research and development away from renewables and energy efficiency in support of technologies such as CCS.[xix]
8. Those who are less convinced of the need for CCS question how long the 'CCS bridge' to a sustainable energy system will be and are suspicious that it might become a 'never-ending' bridge, meaning that we become locked-in to using fossil fuels. Some worry that the availability of CCS could deter efforts at decarbonising the energy system in other ways – access to the option could end up 'making us lazy' and putting off making the tough decisions and long-term investments that will result in the long-term solutions to decarbonising society.
9. There are concerns that the 'insurance policy of CCS' could become tempting as a rationale for continuing to build new fossil fuel power plants.[xx] I.e. the developers could argue that it is justified to build a new fossil fuel power plant on the basis that CCS could be installed at a later date. However, there is no guarantee that CCS would be installed and, without the enticement of 'CCS-readiness,' planning permission for the new build may not have been given in the first place.[xxi]
10. Some have argued that even if CCS is successful at reducing CO_2 emissions, it would not reduce, and could even increase, the use of fossil fuels.[xxii] To some, the negative impacts of fossil fuel extraction, such as the health and safety and environmental impacts of mines, mining and pipelines, the need for transport infrastructure and use of vehicles, are strong reasons to oppose CCS[xxiii].

1.4 Is CCS safe?

1. Some have argued that there are risks in CCS, such as possible leakage of CO_2 from pipelines or underground rocks in which CO_2 is stored. In order for CCS to be effective at limiting the build-up of CO_2 in the atmosphere, it will be necessary for the vast majority of the CO_2 to remain stored in rock formations deep underground (over 800m down) for thousands of years.
2. Secure storage relies upon a layer of compact rock that acts as a cap on the more porous rock in which the CO_2 is stored. Porous simply means rock that contains tiny interconnected holes into which the CO_2 is pushed and collectsSome are worried that the porous storage rocks and cap rock may contain 'faults' – weaknesses in the rock which would allow the stored CO_2 to seep upwards and, eventually, find its way into the atmosphere.
3. Another possible escape route for the CO_2 is the bore holes, known as 'wells', that have been drilled into the rock in order to extract oil and/or gases. When wells are 'retired' from use, the practice is to fill them with concrete to close them off which, where done properly, will prevent leakage of further gases such as CO_2. Sometimes, however, the condition of older or of abandoned wells is not well known and could pose a risk of CO_2 leakage if not properly scrutinised[xxiv]
4. Some are concerned that geologists do not fully understand how to evaluate the risks of leakage of CO_2 from these porous rock formations into the ocean or into the atmosphere.
5. Geologists consider that the risks of CO_2 leakage are very low to miniscule provided that the right type of rock formations are used and that appropriate information is collected in order to allow a thorough risk assessment to be undertaken[xxv].
6. Experts point out that over 20 million tonnes of CO_2 has been stored securely under the Norwegian North Sea at one storage site called Sleipner, starting in 1996 and still continuing (and that there is no evidence of leakage (.[xxvi]
7. Geologists argue that the moment of highest risk for a CO_2 storage site occurs during and just after the injection of the CO_2. This is when the highest pressure exists in the storage rocks and the risks of a breach is greatest[xxvii].

8. Geologists' confidence that the risks at the storage stage are very low arises from the evidence that the same or very similar rock formations have stored gas and oil under similar or higher pressures for millions of years until it was extracted by humans). Good knowledge of the safe limits to increasing pressure in a rock formation when injecting CO_2 in such rock formations is available according to geologists[xxviii]
9. CO_2 injected into rock will gradually react with minerals dissolved in water in those rocks forming new minerals, fixing the CO_2 in solid form and becoming, in effect, more rock. Where that takes place, the risks of CO_2 leakage will almost disappear.
10. Geologists are, however, unable to state that there will be **zero** leakage of CO_2 from rock formations because it is impossible to know everything about a large rock formation in such precise detail to be able to guarantee zero risk. It is largely accepted nowadays by engineers and scientists that it is never possible to claim that there is zero risk of technologies 'going wrong' because humans do not have perfect foresight of everything that could happen – in nature and in society.[xxix]
11. Nonetheless, it is widely considered by geologists that, provided formations are selected carefully and then monitored for any unexpected effects, leakage would be miniscule. Any leakage would be so tiny that it would not threaten the purpose of CCS in keeping CO_2 out of the atmosphere for thousands of years.
12. If leakage of CO_2 occurred from rock formations under the seabed, the CO_2 would enter the ocean and would have some impacts locally, though fish and many sea creatures are able to move away from such sites. Good monitoring systems need to be developed to detect any evidence of leakage on the seabed from a CO_2 storage site. If necessary, actions need to be taken to manage such leakage of CO_2.[xxx]
13. If the leakage of CO_2 occurred from rock formations below the land surface, the impacts would be different, with potential negative impacts on plants and animals, especially if the CO_2 was able to collect in hollows in the ground or basements of homes. CO_2 leaking out could also potentially get into underground water supplies, though would not be dangerous as it would be similar to sparkling water. Good monitoring systems are required which can detect any such CO_2 leakage on the surface or into underground water supplies. Actions need to be available to cope with CO_2 leakage at the surface.[xxxi]
14. Those sceptical about CCS question whether we need to take any risks (even if, according to many experts, those risks appear to be remote) if we have viable alternatives. For instance, some people might see CO_2 capture, transport and storage as riskier than, say, using wind turbines or solar PV panels, or nuclear power or reducing our use of energy. If we know that there are safer options which 'do the same job' in terms of reducing CO_2 emissions, why should we take unnecessary risks by using CCS?
15. The counter-argument is that we don't know for sure whether the other options, especially renewables, *would* do the same job. No one knows for certain whether a 100% renewable energy economy is possible, with good arguments both for and against. Given the rapidity with which the renewable energy technology costs are changing, the honest answer is that we just don't know whether it is possible and, if so, at what costs and by when.[xxxii] It is also important to recognise that there are currently no viable alternatives to the use of fossil fuels in industrial sectors such as steel, cement and some chemicals production.

1.5 Who pays for the additional costs of CCS?

1. CCS will add to the costs of electricity generation and of industries where it is used such as steel, cement and some chemicals. These costs will have to be paid by the end-consumer or tax payer. Where households are in 'energy poverty' – meaning that they need to spend more than 10% of their income on energy services such as heating – increasing energy prices could make it even harder for such poorer households to keep themselves warm enough.
2. Governments could, however, take measures to make sure poorer households are not affected by these price increases such as subsidising energy bills for low income households.
3. Supporters of CCS, in line with many economists and policy analysts, also note that it will inevitably cost money to reduce carbon dioxide emissions from our energy system whatever technology or

method we use so the same concerns for poorer households apply equally to greater use of renewable energy.[xxxiii] Once the 'easy wins' of improving energy efficiency have been reaped, improving energy efficiency yet further will also begin to incur greater expense.

4. If European industries such as steel were required to introduce CCS into their factories and front the full cost of CCS themselves (as proposed by the Polluter Pays Principle[xxxiv]) then this would likely lead to large financial uncertainty. This is because these industries whose products are traded internationally, would be at risk of becoming less competitive than steel production in other countries such as China or India that do not (presently) use CCS in their steel sectors. If no other policy measures were taken, this could result in shut down of more of Europe's steel sector with no change in global CO_2 emissions from steel production.
5. However, European politicians could instead decide to charge importers of steel into Europe a tariff[xxxv] to account for the lack of CCS in the producing countries. Because electricity cannot be imported into Europe from a long way away, there is no concern over the additional costs of CCS on electricity generation putting European generators at risk.

1.6 Where should new power plants such as fossil-fuelled and renewable facilities be located?

1. We all contribute to CO_2 emissions through our life styles – the use of electricity, transport, heating and consumption of goods and services. As global emissions are made up of the sum total of all our individual and collective uses of fossil-fuel based energy, some argue that we are all jointly responsible. They reason that we should, therefore, accept some responsibility to take actions and contribute towards paying for them, including accepting the need for things like wind turbines and solar panels where appropriate. This could also mean accepting the need for larger facilities such as adding CO_2 capture and transportation equipment on to power plants, steel and cement works. They argue that we should do this, even if not everyone in the community will like the look of such new equipment in the local area. The national, and ultimately global, benefits which arise justify the local costs according to this perspective[xxxvi].
2. Others disagree with this point of view, arguing that local residents should have the major say in whether a development in their area occurs or not, rather than the regional or central government, irrespective of whether it is a wind farm, onshore gas or oil development, fossil fuel power plant or other large equipment and facilities[xxxvii]. Furthermore, depending on the siting of the CCS facilities, transport and storage infrastructure may need to be established including pipelines, pumping stations and injection wells. This could impose disturbance such as noise and truck movements, upon local communities as a result of construction activities as well as visually in terms of adding additional industrial developments. From this perspective, the national or global benefit of a development does not in itself justify the disruption and costs to the local environment
3. Many people distinguish between different types of development and technologies, some of which would be more acceptable than others. So, for some, who perceive a need for a new highway, the visual intrusion and disruption entailed in constructing a new road, would be acceptable, whereas a wind farm or fossil-fuelled power plant may not be. A new road may be seen as meeting a local need whereas a wind farm or CCS facility may be regarded as meeting a need for someone else, somewhere else, e.g. helping to meet national CO_2 reduction targets or renewable energy targets which are established within national legislatures and are not necessarily endorsed locally.
4. However, others would perceive this as a form of 'cherry-picking' of developments that happen to be preferred by some, but not necessarily all, in the local community. A further criticism of this view is that it is overly selfish and puts local interests above all others, whereas we should, some argue, take a more public-spirited view which considers the interests of the nation and, ultimately, of the world into account. Those who oppose developments in their locality have sometimes been negatively identified as NIMBYS, standing for Not In My Back Yard. This negative portrayal has been challenged by others who have argued that having a strong attachment to the positive qualities of where you live can be regarded as an inherently good thing and should not be re-cast as something 'bad'[xxxviii]. What, they

argue, is wrong in protecting a valued local environment from development? Imposing unwanted development on a community could end up having a negative effect on that community's quality of life.

5. Given that citizens of European nations tend to enjoy high levels of wealth and affluence compared to the global average, simply trying to protect what we already have, resulting in resistance to new developments such as CCS, could be seen as too inward looking, and maybe even as somewhat selfish. The 'protecting my local patch' attitude could be seen as side-lining the inequality which is likely to emerge from global climate change impacts in poorer countries[xxxix]. Psychologists have shown, however, that action to avoid loss is a very frequent human response irrespective of moral arguments about what people 'should do'. Should we make decisions based upon our aspirations or based upon revealed preferences?[xl] Furthermore, inequality occurs within European countries and some opponents of new development may object on the basis that such development might increase inequality. Whose spatial boundary (global, national, regional, local, etc.) should be used in deciding on what is ethical however? Only a political process can come up with an answer to this question.
6. It can also be asked whether a local sacrifice of a valued environment would automatically result in benefits at a higher-up scale. For instance, should we continue adding new renewable electricity sources such as wind when we still have inefficient use of energy in buildings? Local residents where a new wind farm is to be built could point to the excessive waste of energy in domestic and commercial buildings and argue that we should cut back on energy waste first. A similar criticism could be made on installing CCS on inefficient power plants that are generating electricity which is then used inefficiently. CO_2 capture comes with an 'energy penalty' that reduces efficiency by a further 10 – 15%.

1.7 How Should the Public be involved in Making Decisions?

1. In the past, there have been problems with the way in which the public has been involved in making decisions on new energy and industrial infrastructure, including CCS projects in the neighbourhoods where they live. Despite such infrastructure such as new power plants (nuclear, fossil fuel, wind turbines, biomass based power plants, hydroelectric, etc.) and/or of industrial facilities affecting them, they have not always been given a chance to have their opinions properly heard and taken into account in the decision making process. This happened in the case of a proposed CCS facility at Barendrecht in the Netherlands which was subsequently cancelled. To increase the chances of a successful project, giving the public the opportunity to have their opinions heard and properly taken into account seems vital.
2. Furthermore, it has been recognised that there could be issues with how the debates surrounding energy production, carbon-intensive industries and climate change are communicated to the public (See Epistemic Justice[xli]) as the language and concepts related to these topics assume a certain level of scientific knowledge. This can create issues when people involved are not able to fully understand the issues of concern and therefore are limited in their ability to participate in the decision-making process. Additionally, the way in which scientists, engineers and policy makers view 'problems' and 'solutions' may not align with how the public would view and address the similar issues. For example, climate scientists/policy makers may have already deemed CCS to be one of the logical 'solutions' to tackle climate change and then only proceeded to consult with the public on siting issues. In regards to CCS, a lack of openness to effectively engage in discussion could be seen as unfair and deceitful (Dütschke, 2011; Terwel et al, 2012).
3. Another issue in regards to listening to public opinion arises from the opportunity for people to have their say in how energy policy is formulated at both local and national scales. At the local level, the basis for objecting to a new power plant or other infrastructure is typically local health, safety and environmental impacts. Not included are issues of national energy policy. However, if local residents did not have a sufficient opportunity to engage with, or influence, energy policy deliberations at the national level, they may resist the local development on the basis that it is, in effect, imposing a form of development upon them, the premise of which they do not agree with and have had no agency to influence. This is no different, in principle, from other policy decisions that are taken nationally and could be regarded as an inevitable consequence of how centralised representative democracies operate. This begs the question, however, of the legitimacy of such democracies compared to more

decentralised / federal systems of governance and/or of the wider use of more deliberative governance approaches[xlii].

1.8 Should financial compensation be made available to the public affected by local developments?

1. As renewable energy projects have expanded, it has become more common for compensation or community benefit payments to be made. Because local residents have to bear the costs of disruption, visual intrusion and new infrastructure disproportionately it is deemed appropriate to provide a financial compensation in order to redress the imbalance of costs and benefits to local communities compared to wider society.
2. For wind farms, this strategy has been successful in some countries and contexts and communities have responded positively to the additional finance available to them. Others, however, have objected to such compensation on the basis that it is a form of 'bribe' to try and sway local opinion.[xliii]
3. Further issues that have arisen from previous instances of providing community benefit schemes include matters such as: How to define the 'affected' communities? How much compensation should be given? How should funds be distributed? Who should decide how to spend the funds? Such processes can therefore add an extra layer of complexity to the issues surrounding new developments and raise new ethical and procedural issues. Furthermore with CCS, much of the physical developments would be permanent features of these areas and therefore begs the question: how long should compensation be provided?

1.9 Conclusions

1. The 'ethical issues' surrounding CO_2 capture and storage (CCS) cannot be neatly separated out from scientific, technical, economic and other dimensions and opinions on CCS. The questions about our energy future, and about the role of CCS in that, are irrevocably a mix of interconnected scientific, technical, economic, legal/regulatory and political dimensions; all of which have an ethics dimension.
2. How CCS is part of a low-carbon energy transition, what hazards and risks it poses to humans and the wider environment, how its deployment could influence other aspects of the low-carbon transition or society more generally, how much it costs and how those costs are shared within society – all these issues have an ethics dimension.
3. Arguments about ethics emerge from these multi-faceted debates, rather than being a set of *ex ante* principles which can be 'applied' to CCS. Nonetheless, previous studies of new energy technologies using ethics frameworks provide useful insights and analogues that can be used in better understanding ethics arguments surrounding CCS.
4. There are large uncertainties associated with CCS and its potential risks and benefits (technical, environmental, socio-economic, socio-political, etc.). These uncertainties have not declined much in the last 10 to 15 years due to very low levels of adoption of CCS, therefore less learning has occurred than would have been the case if implementation had been on the scale that was intended in the first decade of the 2000's.
5. very little learning has occurred which would have enabled uncertainties to be reduced.
   Due to the uncertainties, along with conflicting values as to the future direction of the energy system and society more generally, ethics cannot be used to rule in CCS as part of the response to decarbonising society, nor rule it out. CCS has been suggested to have potential positive and negative impacts at both the local, national and global levels scales.
6. For every argument in favour of CCS, a counter argument can frequently be provided. Recourse to 'the facts' or to 'the principles of ethics' are unconvincing in pronouncing CCS an 'in principle' valid or invalid option for decarbonising society.
7. A detailed, case-by-case analysis will be necessary that accounts for different spatial scales and the (sometimes contending) perspectives of different stakeholders regarding the specific proposal. The

value of such analysis is in promoting understanding of different perspectives: why do people disagree? What is the underlying roots of their disagreement? Are there areas of consensus and how could these be further developed?

8. Whatever the outcome of debates regarding the wisdom of CCS or otherwise, procedural justice requires that there are fair and transparent decision-making processes in place. This includes having arrangements in place to ensure that all relevant stakeholders, including the public, have an opportunity to participate in decision-making on the future role of CCS to ensure a mutually beneficial outcome.

Chapter 2: ETHICS AND SOCIAL ISSUES SURROUNDING SHALE GAS DEVELOPMENT

2.1 Introduction

Shale gas and oil development changed the global energy markets and the position of the United States within them at the beginning of the twenty-first century. At the same time, the production technology called hydraulic fracturing, practices of waste disposal and social impacts of the industry on local communities in the US raised many concerns about the viability of shale gas and oil as energy options. Moreover there are also other issues such as climate impacts, impacts on adopting renewable technologies, health and environmental impacts (Lazarus et al., 2015). The viability of using natural gas as a 'bridge' to a low-carbon energy system and other issues concerning climate solutions, are widely discussed.

When the U.S. Energy Information Agency (EIA) published a report with global assessments of shale gas resources in 2011[1], similar hopes and fears proliferated in countries with the highest predicted volumes, such as Argentina, Poland or France. In the European Union, where environmental and climate change policies are an integral part of energy production and consumption, potential shale oil and gas development was soon inscribed into debates about environmental risks and climate impacts. EU member states adopted different positions towards unconventional hydrocarbons. While France and Bulgaria introduced bans on hydraulic fracturing, Poland and the UK granted domestic and foreign companies with exploration licences.

Governmental decisions, however, did not end controversies and discussions about multiple impacts and ethical issues related to the development of unconventional hydrocarbons. Seen by some political and business actors as a transition fuel – a fuel which could help to phase out coal and back up energy production from renewable sources – it was perceived as a "non-option" by many commentators. For those opposing shale oil and gas extraction at large, any attention or resource allocation to understanding its impacts was framed as undesirable and unethical. However, for many who directly experienced impacts on their local communities, it was important to obtain some answers for many of their questions. Not only did the answers matter, but the process of interactions, the ways of asking and answering these questions, mutual trust and respect between communities, companies, experts and public administration were also important to them.

This report offers a review of ethical claims, in particular the ones which were coming from actors concerned with the consequences of fracking and the industry. We find it both important and useful to engage with these claims because they have a huge impact on how the oil & gas industry is perceived in public and/or policy makers. The use of social media and the ability for images and concepts to spread across different contexts – i.e. from the USA to Europe – weakens trust in the industry irrespective of how particular companies act in particular places. We thus highlight the ethical claims and issues without making a judgment about it ourselves and we do it in order to provoke a discussion about how the industry and experts involved in shale gas development could react if faced with the negative ethical claims.

Just to give some examples of the expressed concerns, in the closest vicinity of the shale gas and oil projects, many concerns were raised about water, soil and air pollution, noise, seismic activities induced by hydraulic fracturing, waste disposal as well as impacts of heavy truck transport which would always intensify whenever water, sand and waste had to be moved to and from the well pad. Some communities would also experience aggravating social conflicts between those who locally supported the new industry and those who opposed it. Growing tensions, stress and struggles with the company and between neighbours contributed to a negative picture of the unconventional hydrocarbons industry and multiplied concerns about ethical justifications for fossil fuel extraction at large. One of more specific issues debated by local communities was the ethical qualification of compensation schemes offered by companies and governments to the communities located at the extraction sites.

[1] https://www.adv-res.com/pdf/World%20Shale%20Gas%20Resources_An%20Initial%20Assessment%20of%2014%20Regions%20Outside%20the%20United%20States.pdf (viewed 20.11.2018)

The following report outlines the ways in which ethical concerns can be analysed in relation to shale gas and oil development and maps out the main issues that were raised by various stakeholders involved in this project worldwide. The review is based on the existing and published research in social sciences which proliferated in various academic journals over the last decade. Various concepts of social justice are brought to readers' attention to shed new light on unconventional hydrocarbons' development as an issue which can be related to broader visions of social order and human rights. It gives us better overview and awareness of what are critical issues that should be considered when planning the future SECURE tasks and our further work on shale gas.

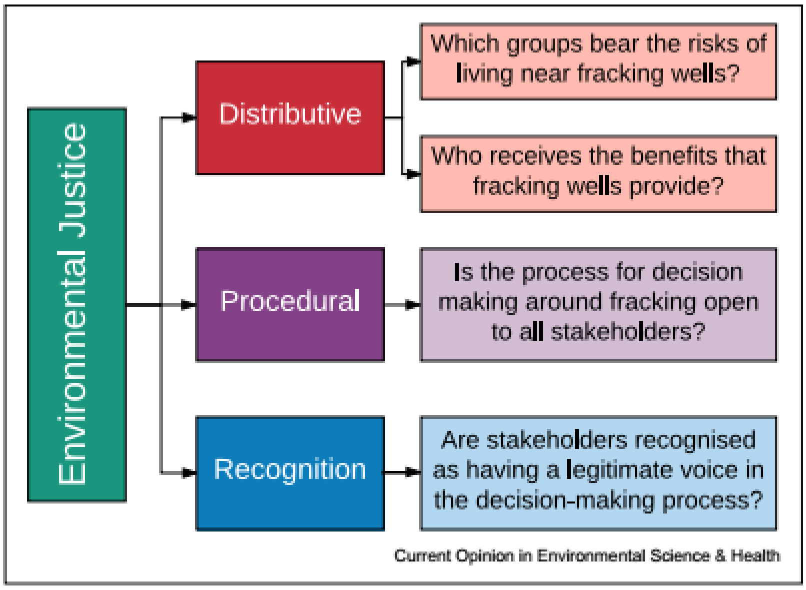
2.2 Ethical issues and energy justice associated with Shale Gas Research

The ethical perspective in the SECURe project starts from the "Energy justice decision-making" framework (Sovacool et al., 2016), which distinguishes the following key principles:

1. Availability - People deserve sufficient energy resources of high quality.
2. Affordability - The provision of energy services should not become a financial burden for consumers, especially the poor.
3. Due process - Countries should respect due process and human rights in their production and use of energy.
4. Transparency and accountability - All people should have access to high-quality information about energy and the environment, and fair, transparent and accountable forms of energy decision-making.
5. Sustainability - Energy resources should not be depleted too quickly.
6. Intragenerational equity - All people have a right to fairly access energy services.
7. Intergenerational equity - Future generations have a right to enjoy a good life undisturbed by the damage that our energy systems inflict on the world today.
8. Responsibility - All nations have a responsibility to protect the natural environment and reduce energy-related environmental threats.

As shale gas development is one of our main issues we compare Sovacool's key principles with ethical claims for fracking (Brunsting et al., 2015; Evensen, 2016) and more broader: shale gas use with energy justice.

Energy Justice is one of the normative approaches to studying fracking that has received increasing attention in recent years. It is a more recent concept which refers to the idea of Environmental Justice. The latter was developed to examine whether environmentally hazardous facilities were more likely to be placed close to neighbourhoods where different minority groups lived in the USA. As the work in environmental justice has grown, the definition has both expanded and become more sharply drawn, focusing on three different aspects of justice, as laid out in Figure 1: distributional, procedural and recognition (Clough, 2018).



Types of environmental justice.

Figure 2 - Types of environmental justice from Clough (2018).

The most common ethical concerns cited in research concerning shale gas are based on **distributive and procedural types of justice** (Clough and Bell, 2016; Cotton, 2017; Evensen, 2017; Sovacool, 2013), but Clough (2018) also adds **environmental justice as recognition**. It assumes that a special place should be granted to stakeholders to enable their participation in decision-making: "stakeholders must be recognized as having a legitimate seat at the table, and their attitudes and approaches respected" (Clough, 2018: pp. 14-15).

Considering our main ethical frameworks based on Sovacool's principles and justice claims (i.e. the precautionary principle, exposure to involuntary risks, rights-based arguments, and changes in community character and way of life), we also incorporate the right for recognition as equally important to be asserted within the procedural justice or rights-based claims. The claim behind the right for recognition is that "all stakeholders must be recognized as legitimate in order for a just procedure to be in place. Cross-national work on recognition suggests that stakeholders who have been opposed to fracking, either nationally or locally, have struggled to be recognized as legitimate by both local and national governments" (Clough, 2018: 17). Additional research hints implicitly at ethical dilemmas associated with shale gas development but does not openly identify these issues as having moral implications (Evensen, 2016).

Evensen (2016) highlights a range of additional ethical claims and concepts that deserve a special indication:

- **Involuntary Risks –** these risks to which one is exposed without knowledge or consent.
- **Precautionary Principle –** means no permission to any potentially dangerous action or process until society can be certain that harm will not arise (or it is outweighed by the benefits).
- **Rights** - Claims about rights, notably rights to clean air and water, can be considered as "human rights". Sometimes, these ostensible rights have a legal foundation, such as constitutionally guaranteed rights to a clean and healthy environment.
- **Perfectionism -** Perfectionism writ large is a philosophical approach that identifies the components of a meaningful, complete, and virtuous life; living ethically is then viewed as dedicating oneself to the pursuit of such an existence.
- **'The Good Life' -** it concerns the conditions which are necessary to achieve good quality of life as a necessity of clean air and water.

2.3 Ethical Frameworks in Comparison

The comparison of main frameworks for shale gas development is presented in the form of a table (Tab.2) to highlight the similarities and coherency between Sovacool's (Sovacool, 2013) energy justice principles and the ethical claims. The middle column shows how the issues overlap within contemporary real-based cases or concerns to illustrate what energy justice principles and ethical claims for fracking are associated with shale gas development in practice; it presents issues, which should be taken into account during decision making process. This comparison is useful for further elaborations on ethical concerns about shale gas development in the world.

Table 2 - Energy justice principles and ethical claims.

Principles **Sovacool, (2013) and Sovacool et al. (2016).**	**Contemporary applications**	ETHICAL CLAIMS for FRACKING **Evensen, (2016) + Clough (2018)**
Availability	Investments in energy supply and energy efficiency; upgrades to infrastructure	**Availibility** (Sovacool, 2013) relates to the **DISTRIBUTIVE justice** (Evensen, 2016; Clough, 2018) especially to the question: Who receives the benefits that fracking wells provide? Moreover, it also relates to ethical claims about **rights** (Evensen, 2016) as well as **Perfectionism and 'The Good Life'** (Evensen, 2016)
Affordability	Fuel poverty eradication efforts; low-income assistance for weather-proofing efficiency improvements; retrofits to older buildings	**Affordability** (Sovacool, 2013) relates to the ethical claims about **rights** (Evensen, 2016) and **DISTRIBUTIVE justice** (Evensen, 2016; Clough, 2018)
Due process	Social and environmental impact assessments; free, prior and informed consent	**Due process** (Sovacool, 2013) relates to the ethical claims about **rights** (Evensen 2016; Short & Szolucha 2017). It also relates to all kinds of **PROCEDURAL justice** (Evensen, 2016, Clough 2018)
Transparency and accountability	The Extractive Industries Transparency Initiative; independent accountability mechanisms; international accounting standards for energy subsidies	**Transparency and accountability** (Sovacool, 2013) relate to the **PROCEDURAL** and **recognition justice** (Evensen, 2016, Clough 2018).
Sustainability and Responsibility	Natural resource funds designed to save for future generations; system benefits charges UN Framework Convention on Climate Change; the Green Climate Fund	**Sustainability** (Sovacool, 2013) relates to the ethical claims about **rights** (Evensen, 2016). It also relates to the **distributive justice** (Evensen, 2016; Clough 2018) especially to the question: Who receives the benefits that fracking wells provide? It is very much connected with **Responsibility** (Sovacool 2013) that relates to the **Involuntary Risks and** and **the 'Precautionary Principle'** (Evensen, 2016)**.** Both sustainability and responsibility are closely related to **ENVIRONMENTAL justice.**
Intragenerational equity	The UN's Sustainable Energy for All initiative; Sustainable Development Goal 7	**Intragenerational equity** (Sovacool, 2013) relates to the ethical claims about **rights** (Evensen, 2016). It also relates to the **DISTRIBUTIVE justice** (Evensen, 2016; Clough 2018) especially to the question: Who receives the benefits that fracking wells provide? as well as to **Perfectionism and 'The Good Life'** (Evensen, 2016)
Intergenerational equity	Promoting environmentally friendly forms of low-carbon energy such as renewables or efficiency that can minimize externalities or prolong resource efficacy; implementing environmental bonds	**Intergenerational equity** (Sovacool, 2013) relates to the ethical claims about **rights** (Evensen, 2016). Specifically, to **Perfectionism** (Evensen, 2016). It also relates to the **DISTRIBUTIVE justice** (Evensen, 2016; Clough 2018).

Source: Own work based on: Sovacool et al. (2016), Sovacool (2013) and Evensen (2016).

2.4 Mapping ethical claims about shale gas development

2.4.1 Distributive environmental justice and fracking

Distributive justice can be simply conceptualized as the distribution of costs/burdens and benefits of shale gas development among different social groups. Cotton (Cotton, 2017: 9) explains, "distributive fairness concerns how positive and negative outcomes are shared between those who profit and those that bear the impacts" and identifies distribution as a "key driver of public acceptability in energy project siting". Studies in environmental justice have often found that hazardous facilities (Ogneva-Himmelberger and Huang, 2015; Willow and Wylie, 2014) are often placed in disadvantaged communities and that poor and ethnic minority groups must deal with the negative health and economic consequences which accompany this. Willow and Wylie (2014), for example, showed how shale gas development in Pennsylvania has not only resulted in an economic boom and jobs creation, but also generated inequalities amongst residents.

Concerns about **water quality and supply of water** are also linked with distributive justice. For example, some feared that **some people's water may become contaminated** (Evensen, 2016)**. Example:** Obtaining adequate amounts of water needed to carry out hydraulic fracturing operations in the shale rock may cause water shortage in some communities. Another problem is the management of the return water. Injection of contaminated water into the geological formations is impossible at any scale in Europe due to the Water Framework Directive of the European Union.

Distributive justice as a broader concept covers the **Availability Principle** (Sovacool, 2013) which involves the ability of an economy, market or system to provide sufficient energy resources. This principle is connected with various dimensions including how a region or country is able to produce, transport, conserve, store or distribute energy. This touches upon the problems of different levels of energy independence of a country and the levels of energy infrastructure in place. Also, it is partly connected to the **Affordability Principle** which assumes that all citizens should be able to afford to pay for energy costs. As Evensen (2016: 578) explains, the question: „who has to pay for shale oil and gas development" invokes further questions of distributive justice whereas the question „who gets to make it?" relates to procedural justice.

Example 1: The case study from Lancashire, (UK) concerning conflict over shale gas exploration in Lancashire where the company Cuadrilla was preparing to horizontally drill and hydraulically fracture the first shale gas wells in England. Although there were numerous protests of activists against shale gas development and cost was running into the hundreds of thousands of pounds both sides seem determined to carry on regardless. The initial planning applications were refused by Lancashire County Council but after a few turns concerning decisions the central Government over-turned the initial decisions at one site and gave Cuadrilla more time to address traffic concerns at the other. This case shows that unless the industry and decision makers can address growing public concerns about shale gas development, continuing conflict could constrain commercial development (Bradshaw and Waite, 2017).

Example 2: Two anecdotes from Pennsylvania (USA) are good illustrations of the contestable nature of shale gas and oil extraction projects. In 2012, Pennsylvanians earned some $1.2 billion in royalties after the state had issued permits for 2484 "unconventional" natural gas wells, with 1365 of them drilled. The inhabitants of Smithfield, Pennsylvania supported fracking to the degree that they named their local food delicacy the "frack burger". A totally opposite effect could be observed in a **community near Pittsburgh, Pennsylvania, "where shale gas production has transformed once-clear streams into muddy-swamps full of dead fish and flammable water"** (Sovacool, 2014)**.**

2.4.2 Procedural environmental justice and shale gas development

This focuses on access to decision-making processes about siting of the potentially environmentally hazardous facilities. Procedurally just systems open decision-making processes to allow all stakeholders to participate in them. It is also based on the principle of subsidiarity which holds that decisions should be taken wherever possible by the most affected communities rather than by the higher levels of government. In practice, it requires considering the diversity of opinions among (indigenous) communities (who might allow fracking on their lands under certain conditions). It is relevant also to European land owners who agree for fracking on their land without getting permission from their neighbours (thus setting up the potential conflicts).

Example 1: Water is a procedural justice concern to the extent that people feel disenfranchised by the ways in which water is used, transported, and disposed of – having no (or very little) say in this process. Although it does not concern UK or other EU countries, the lack of transparency about chemicals added to water for hydraulic fracturing raises procedural concerns and the lack of access to full information prevents citizens from taking well-informed decisions (Evensen, 2016; Finkel et al., 2013).

According to Evensen (2016) and Cotton (2017), "host communities seek both procedural and distributive fairness in the decision-making process". **Environmental justice as recognition** proved a perfect complement to the procedural and distributive environmental justice. Allowing space for stakeholders to participate in making decisions is not enough; stakeholders must be recognized as having a legitimate seat at the table, and their attitudes and approaches should be respected (Clough, 2018).

Sovacool (2013) explains the **Due Process** as well as **Transparency and Accountability** principles which in general should ensure participative decision-making processes with access to high-quality information about energy production and the environmental impacts. These principles also assume that the energy decision-making processes should be fair, transparent and accountable.

Some researchers revealed that their research participants shared a sense of powerlessness when faced with the multitude of changes in their communities. This was due to: "the immense power of large oil & gas companies, social norms, or existing regulations that marginalize certain actors" (Thomas et al., 2016:26).

The focus should also be put on the levels of activism among the general public (which in general terms tend to be low). According to M4ShaleGas reports (Brändle et al., 2016; Lis et al., 2015), levels of support/opposition vary across regions, and also between studies. Views on regulation also vary geographically, but there is a widespread distrust towards the responsible parties (particularly industry and government), stemming from perceived unfairness, heavy-handed corporate tactics, and a lack of transparency. According to Tawoezvi (Tawonezvi, 2017) The European Union's current regulatory system is enough for controlling the impacts of fracking on health and the environment however EU should make sure the high standards of transparency on project (within Strategic environment assessment and Environmental Impact Assessment) are implemented fully and strictly monitored.

In terms of decision-making processes **right-based claims** are also valid. Claims about rights, notably rights to clean air and water, are some of the most common ethical claims about development in mass media and public discourse on the issue of shale gas development (Evensen, 2016): "Whilst it seems that a right to clean air and water might be universally held, it is by no means clear how clean the air and water must be to lead a minimally good life or that shale gas development has the potential to realistically cause contamination to this level" (see Cotton et al., 2014; Evensen, 2016).

Another form of rights associated with shale gas development is **private property rights**, again, individual rights:

- to self-determination over the use of resources found on their territories leads to a requirement to consult people before decisions are made on resource extraction projects;
- to be full and effective participants in all aspects of the project;
- and to be able to grant or withhold free, prior and informed consent before fracking can take place on or near people's lands.

Cotton (2017) analyses the Principle of Prima Facie Political Equality (PPFPE) to critique policy and planning decisions in the U.K. in relation to shale gas development. The PPFPE focuses heavily on distributive and procedural justice and gives particular attention to the need for equitable compensation for any harms sustained, access to information about potential harms, and the ability to participate freely in decision-making processes. Any unequal treatment must therefore be compensated for "primarily through economic means of wealth redistribution or increased community economic opportunity" (Cotton, 2017; Evensen, 2016).

2.4.3 The Precautionary Principle in shale gas development

The precautionary principle holds that actions should not be undertaken if their consequences are uncertain and potentially dangerous. This is a fundamental tenet of ecological justice and often subject to scientific uncertainty. According to Evensen (2016), knowledge about potential harms and benefits from shale gas development can never be certain. This principle would require that no fracking is permitted until society knows that harm will not arise from the process or until society might be certain that harm is outweighed by the benefits. That is why a range of "harms" should be presented (harm to roads, harm to wildlife, harm to community character, etc.), and not only those in the area of human health (the most commonly cited potential harms stem from the potential air and water contamination). A frequent claim associated with appeals to the precautionary principle is that additional research must be conducted to reduce uncertainty about potential health impacts (Evensen, 2016).

More general concepts that suit the precautionary principle are simply **Sustainability** and **Responsibility.** As Sovacool (2013) writes, the challenge for Sustainability is to make sure that energy resources are not depleted too quickly. Similarly, the next principle proposes that nations are responsible to protect their own natural environment and energy-related social costs, as well as minimise the incursion of any negative consequences to others.

False Negatives versus False Positives is another principle that should be considered (de Melo-Martín et al. 2014). The authors argue that in reference to shale gas development, "false negatives" (situations where an effect or a relationship exists but is said not to exist) need to be limited more than "false positives" (situations when an effect or a causal relationship is said to exist when such is not the case).

Example of false negatives: Asserting that development does not lead to water contamination or negative human health outcomes when in fact it does (de Melo-Martín et al., 2014).

If legislators decide to minimize false negatives, they minimize a potential error of accepting a harmful procedure: "Under conditions of uncertainty, minimizing false positives might result in under-regulation of shale gas practices and this might lead to human health and environmental harms. Minimizing false negatives might, however, lead to overregulation, which may impose excessive costs on the oil and gas industry, and may jeopardize economic development" (de Melo-Martín et al., 2014:1115).

Evensen (2016) also explains that **Involuntary Risks** can occur in relation to shale gas development when citizens have no say over exposure to potential harm from development.

Example: Examples of involuntary risk could be water contamination and water shortage. These risks occur because surface and ground waters do not adhere to property boundaries: if one leases land for development, contaminated water from spills or leakage could affect drinking and surface waters in the surrounding area. "The public concerned with fracking activities are consulted only as a formality and not with the expectation of a constructive feedback that can be used in a decision-making process of which they are either given short period to review complicated documents. Some states are just transposing the Recommendations in their regulatory framework just to convince the EU Commission that they are complying with the EU law and not taking seriously the impacts of the fracking" (Tawonezvi, 2017).

2.4.4 Right-Based claims and discourse on shale gas development

Among the ethical claims, Evensen (2016: 582) classifies **right-based claims** focusing on questions: "What rights are most relevant to shale gas development? Where do these rights come from? What happens when different types of rights conflict? If one has a right to clean air and water, how clean is 'the clean'? If contaminated water is replaced by above-ground tanks of trucked-in water, has the right to clean water been violated or not?" In discourse on shale gas development, claims about rights are treated a little bit like assertions. Academic researchers and the United Nations made a claim for safe and clean drinking water as well as sanitation to be included into basic human rights which are essential for the full enjoyment of life and other human rights. Another form of rights associated with shale gas development is the private property right. Since they are legally based but also connected to moral claims, these rights can be considered under the **Intragenerational Equity Principle** (Sovacool, 2013): All people have a right to fairly access energy services.

Example 1 (connected to rights): "Pearson in a study of community responses to mining of silica sand that is used in hydraulic fracturing operations, identifies property rights as potentially violated by shale gas development. He elucidates, 'Frac sand has also stoked a broader debate about property rights, with some arguing that people can do whatever they want with their land, even if it creates problems for neighbors'" '" (Evensen, 2016; Pearson, 2013).

Example 2 (connected to cryptonormativism in discourse e.g. in academic research): To explore the presence of cryptonormative claims in scientific research, the author analysed 21 peer-reviewed publications (19 from U. S.) in academic journals that reported findings on environmental impacts related to shale gas development. Only three articles did not contain language about actions that should be taken to allow for better management or regulation of shale gas development (Evensen, 2015).

The USA examples cannot be directly extrapolated into European case studies as there are large differences in geological, economic, social and regulatory conditions between EU and USA. Anyway the right-based claims can occur and other issues already facing the shale gas industry in North America may reveal even more challenging in Europe due to higher population density, water and other resources shortage, and the greater sensitivity of local populations to large-scale industrial projects (see also: Papatulica, 2014).

Based on Economist's global public attitudes survey of fracking (2013) it seems people are divided equally between "pro-drilling" and "anti-drilling" groups. Sovacool (Sovacool, 2014) claims that it is hard to declare what is the genesis: "Are people opposing because they do not like shale gas or are they opposing because they have been scared by the newspaper articles, blogs, reports, and non-peer reviewed studies...?"

2.4.5 Perfectionism claims and 'The Good Life'

Perfectionism claims (or objective goods perfectionism) is consistent with a philosophical concept of perfectionism, which states that the moral life— the life worth leading— is defined by achieving/realizing things that are objectively good (Evensen, 2016). The question arises: what is the possibility or necessity of transforming oneself and one's society in respect to shale gas development? Researchers mention the "moral shock" is due to barriers to achieving perfectionist goals that can include aesthetic appreciation and a slow-paced, intentional lifestyle after transformation (Lis and Stasik, 2017; Szolucha, 2016).

These claims can also be addressed by questions: How do we compare radically divergent conceptions of the 'good life' to make decisions on development? What role, if any, do perfectionist considerations and virtue ethics have in policy on development? How do we account for and offer moral consideration to fundamental transformations in residents' way of life and place identities (for good or ill)?

Example 1 (place attachment): Physical space and social interactions change due to shale gas development, with effects on how residents connect with and value the locations in which they live. The resource exploitation, particularly fracking, has the potential to damage relationships within the community. When asked about shared social values, interviewees framed their responses in terms of shared values about fracking rather than other issues (Lis and Stasik 2017; Evensen, 2016; Morrone et al., 2015).

Example 2 (quality of life): The energy is broadly a commodity and a resource that improves the quality of life. Some share a belief that if fracking was ever banned, it would be unethical to deny our children the benefits that hydraulic fracturing has brought to our economies and the quality of life. Natural gas is seen by such people as a bridge fuel to a sustainable future and an alternative to coal that can reasonably fulfillfulfil the world's energy demand with a minimal impact on climate change (Brock, 2014; Evensen, 2016).

These ethical claims relate to Sovacool's: (1) **Intragenerational equity** (People have a right to access energy services fairly) and (2) **Intergenerational equity** (Future generations have a right to enjoy a good life undisturbed by the damage our energy systems inflict on the world today).

Example (1): The current global energy system does not distribute its energy services equitably, and in 2009 approximately 1.4 billion people lived without electricity, 2.7 billion depended on wood, charcoal, and dung for domestic energy needs, and a further one billion people had access to electricity networks that were unreliable or unaffordable (Sovacool, 2013).

Example (2): Once emitted, a ton of carbon dioxide takes a very long time to be processed through the atmosphere – according to the latest estimates, one-fourth of all fossil-fuel-derived carbon dioxide emissions will remain in the atmosphere for several centuries, and complete removal could take as long as 30,000 to 35,000 years (Sovacool, 2013).

2.5 Conclusion and practical questions

Energy is a necessary input for improving quality of life and economic growth – since populations and economies grow and living standards improve for billions, energy consumption will continue to rise. ExxonMobil's most recent Outlook for Energy projects that global energy demand is expected to increase about 25% from 2016 to 2040 – even after considering large savings due to efficiency improvements (ExxonMobil 2018).

Amongst the main arguments in favour of shale gas development are:

1) It is a natural gas, so the development of shale gas will have an impact on the CO2 reductions targeted under the Kyoto Protocol (Gas could displace coal and even lead to low-carbon fuels if used to make H2);
2) It can significantly contribute to the future energy needs in many countries: fracking has beneficial impact on supplies and consumer prices for natural gas;
3) It can ensure independence from gas imports delivered from a single source, i.e. the possibility of access to gas on lower prices compared to the current import price from Russia;
4) It can establish the possible economic impact i.e. fracking shale gas can create employment. Claims about the economic benefits of shale gas – economic growth, job creation, lower gas prices, and financial benefits for local communities – form the main part of the pro-fracking argument (see also: Howell, 2018).

The general main arguments against the shale gas are:

1) There is lack of trust in independent national and international analyses and monitoring on the environmental, economic, social and production of shale gas (Papatulica, 2014);
2) There are risks to health and water pollution (fears of potential local impact on water and seismicity, as well as human health);
3) It is a fossil fuel, and its extraction associated with fugitive methane emissions, and as such leaves a greenhouse gas footprint on the climate (it is causing carbon emissions and noise pollution);
4) Local concerns also regard the monitoring of extraction sites during exploration phase and after completion.

The European Commission's Energy Roadmap 2050[2] identifies natural gas as a critical fuel for the transformation of the energy system towards lower CO_2 emissions and more renewable energy. Shale gas and CCS may contribute to this transformation. Shale gas is helpful also like a bridge and can play an important role in sustainability development (energy security, economic and environmental pillars). Since the economically reliable energy source is needed now (before renewable energy develops fully) and shale gas can give time for this transition.

[2] https://ec.europa.eu/energy/sites/ener/files/documents/2012_energy_roadmap_2050_en_0.pdf (viewed 9.10.2018)

Therefore, this energy change opens up many questions concerning ethics and justice, which we propose to analyse in a broader context with assurance of the aforementioned principles:

Distributive justice

What are the positive and negative outcomes of shale gas development?
Who has to pay for shale gas development?
Do we have public acceptance for shale extraction of those who profit and those who bear the costs?

Environmental justice as recognition

Are all the stakeholders recognized and do they have a legitimate seat at the table?
Are their attitudes and approaches respected by the decision-makers?

Due process and Transparency and Accountability

Are all stakeholders well- and equally- informed about the processes?
Do they have access to high-quality information about energy production and the environmental impacts?
Is energy decision-making processes fair and transparent?

Right-based claims (also: private property rights, individual rights):

Were public consultation with stakeholders organized before decisions about resource extraction were taken?
Are we able to grant or withhold a free, prior and informed consent before fracking takes place in the neighborhood?

Intragenerational equity

Do all stakeholders have a fair access to energy sources and services?
What is the level of life quality among different groups of stakeholders?

Intergenerational equity

How do we account for and offer moral considerations to fundamental transformations in residents' way of life and place identities?
How shale development has influenced natural environment?
In what way could the environment and energy related threats be reduced?

The overall conclusion is that the ethical issues in energy transition should be always recognized and thoroughly analysed within the local community. Shale gas development opened up many concerns about water, soil and air pollution, noise, seismic activities induced by hydraulic fracturing, waste disposal as well as social struggles and community conflicts. Growing tensions, stress and struggles with the company and different stakeholders have to be properly identified from the very beginning and can be reduced by using these ethical frameworks. Nonetheless there are arguments for (and against) development of unconventional hydrocarbons which decision makers should be aware of. Therefore, the more attention is put on ethical questions and moral aspects in policy and decision making the better the outcome is for social, economic and environmental perspectives.

Section 3: COMPARISON AND NEXT STEPS

The late Mary Midgley used a metaphor of a large, rather poorly-lit aquarium to help understand the human person. When the same fish which live in an aquarium are viewed through different panes of glass (windows) they can look completely different to the point that it is hard to see any similarity[xliv]. Neuroscience is one such window, while genomics is another, physiology another, cognitive and behavioural psychology others, etc. In a similar way, the 'same' technology can look very different when viewed from different, but equally valid perspectives, such as engineering, environmental, social, ethics, economic, political, etc. The assumption here is that there is no automatic hierarchy in accounts of technology, i.e. in which technical accounts automatically take precedence over non-technical ones, just as there is no single 'correct' vantage point for viewing the fish and other creatures in the aquarium.

CCS and shale gas can be envisaged as two separate tanks in the aquarium which share some common design features. How they are both perceived depends greatly upon the aquarium window through which we are viewing them. When viewed from the perspective of geology, sub-surface engineering and environmental science there are obvious similarities between the two technologies and common technical methods, e.g. in monitoring, evaluation of the risks of subsidence and earthquakes, risks of affecting underground hydrology, risks of gases leaking from the sub-surface (CO_2 / CH_4) and so on.

When viewed from the perspective of attributed environmental and health impacts, shale gas and CCS look quite different because there is polarisation of opinions around the impacts of shale gas extraction resulting in disagreement and controversy, whereas this is much less the case for CCS. In this respect, the two aquarium tanks look quite distinct in shape and form, since shale gas has a considerable history over the past few decades with many thousands of wells having been drilled. This is not the case with CCS where very few actual realisations of the technology have occurred globally since the idea was first proposed in the late 1970's. To continue the metaphor, some believe they have viewed a large predator lurking in the vegetation of the shale gas aquarium, whereas others deny that such a predator exists and insist that it is being mistaken for a small rather insignificant bottom-dweller.

Turning to the perspective on the low carbon and sustainable energy transition, things look very different to viewers of the shale gas aquarium. Those who insist the large predator lives in the tank also believe that shale gas is leading to higher carbon emissions compared to not extracting and using shale gas. From their perspective, it seems counter-intuitive to extract yet *more* fossil fuel from the sub-surface when it is clear that we will need to greatly restrict use of the *existing* reserves. This group is also concerned that the fugitive emissions of methane may result in shale gas extraction and use having an even higher carbon intensity than use of conventional piped natural gas.

The alternative perspective views shale gas as better than coal (which they believe is the fuel that would otherwise be used), while another group peering into the aquarium tank argues that shale gas can be utilised with CCS in order to bring its carbon intensity down to acceptable levels such that it contributes to rather than hinders the sustainable energy transition. Viewers through different windows of the aquarium are bringing a set of assumptions and 'future scenario likelihoods' along with them, akin to putting on a set of 3-D glasses before peering into the aquarium. These assumptions and scenarios include things such as: likely future fugitive methane emissions from a shale gas extraction process; steam reformation of methane combined with CCS to produce H_2 for heat networks in place of natural gas as well as low-carbon industrial applications such as producing fertiliser and for reducing steel so avoiding use of coking coal; life cycle CO_2e emissions from the use of LNG; and so on. Those sceptical about the carbon implications of extracting and using shale gas do not find the optimistic scenarios of shale gas being integrated with CCS credible based on their past experience of policies in these fields. Where some see gloomy policy waters in the tank, others see rays of light shining through. How one views the aquarium here and now depends in part on the experience of one's past visits and whether this was led to a favourable impression or otherwise.

Those viewing the CCS aquarium (currently) have less polarised and contentious views, perhaps in part because CCS is as yet a less developed technology compared to hydraulic fracturing for shale gas extraction. Perhaps also it is because the only rationale of CCS is decarbonisation. And, as yet, no one can envision decarbonised industries to the extent that is going to be necessary without using CCS. Still, there are markedly different takes on what the CCS aquarium tank contains. For some it is a tank they would rather not have to look at, containing fish and other creatures that are not agreeable to the viewer. Others, however, are fascinated by the very same creatures.

Energy security is a further window into the aquarium that is especially relevant for shale gas. Some viewers see important benefits for energy security by extracting shale gas as it reduces dependency upon supplies of natural gas from volatile and potentially hostile political entities, especially Russia. Others believe that this is ignoring the energy security which arises from having globalised suppliers of natural gas, including LPG from the Middle East and US shale gas. Those who promote the energy security benefits of shale gas also tend to point to the important economic benefits arising from shale gas extraction and use. The windows for economic growth and new jobs into the shale gas aquarium are especially enticing to some and can dominate what is viewed. Just as limiting viewing to the 'environmental impacts' window tends to result in some having negative impressions of shale gas, those who spend most of their viewing time in front of the growth and jobs windows tend to have a much more favourable impression of shale gas. Such bias is not necessarily intentional or 'wrong'. Rather it comes from peering through one window to the exclusion of others.

A final window into the aquarium that is worth mentioning is that into the decision-making and policy processes involved in deciding whether to allow a development such as shale gas extraction and CCS. Some will focus attention on local decision-making, engagement and local democracy, while others will instead focus upon representative forms of democracy at the centralised state-level. Some will focus attention on the national costs and benefits, while others focus largely upon those that are local; they do not neatly coincide unfortunately.

3.1 Next Steps for Task 6.2

1. Technology assessment has been a key topic of interest for policy makers in developed countries since the 1970's. With increasingly large public RD&D expenditures, and with innovation in science and technology exerting ever greater social, economic and policy impacts, the need to understand the impacts of new technologies has never been greater. Various governments established offices to undertake this work, including the Office of Technology Assessment (OTA) in the USA (now closed) and the Danish Board of Technology Foundation (Grunwald & Achternbosch, 2013).
2. In the 1990s, evaluation systems such as Technology Foresight and Constructive Technology Assessment (CTA) were developed by scientists, policy makers and social scientists whereby it was proposed to examine a comprehensive set of impacts arising from new technologies including technical, environmental, economic, social, political, ethical impacts and implications, etc. The aims of such investigations were numerous, including allocation of RD&D funding, identification of impacts requiring specific attention, e.g. commissioned research or consultancy, new policy and regulatory focus, skills development, general awareness raising amongst industry, government and academia, etc. (Schot & Rip, 1997).

3. Collingridge (1980) introduced his 'control dilemma' in relation to evaluating the impacts of new technologies. Due to the size of the uncertainties regarding the impacts of many new technologies, in particular disruptive, radical and generic technologies, foresight concerning their impacts is frequently limited. The scale and nature of impacts is frequently only revealed once technologies are more widely implemented. Yet, by this stage of deployment, the opportunities to regulate and co-design technologies may already be severely limited. In short, at the time when we can most effectively control technologies, we do not know enough about their impacts to implement meaningful control; by the time those impacts are better understood, it is too late as the technology is already widely implemented. Collingridge's work warns against presuming we can know what the future impacts of new technologies will be before they become more widely deployed. Given the extensive deployment of unconventional gas exploitation in some regions, this problem is more pertinent to CCS than to shale gas, though controversy over the impacts of shale gas extraction in some European countries might imply that the control dilemma may vary across place and nations.4. In the past decade, a new framework has emerged called Responsible Research and Innovation (RRI) which builds upon the work of the past 30 or so years (von Schomberg 2011, 2013). RRI involves establishing a set of criteria by which proposed research, development and

demonstration (RD&D) can be assessed. An example is assessment of a potential climate engineering R&D proposal (Macnaghten & Owen, 2011; Stilgoe et al. (2013). What criteria are selected and how they are applied will depend upon the design of each RRI process, but it might entail establishment of an expert panel composed of technical experts, social science experts and independent lay members who will undertake the review and oversee and direct the work of a secretariat. This will likely involve review of the literature around critical questions, and may involve undertaking or commissioning new empirical research, such as asking members of the public or local communities affected for their perceptions of new technologies, e.g. via survey, interviews or focus groups, etc. A stage-gate process might be used, whereby an adequate response to specific issues and a satisfactory achievement against each criterion is necessary prior to progression to the next stage.

3. The next task for WP6.2 is to develop a RRI framework which can be applied to the issues of monitoring CCS and shale gas developments. The arguments and literature that has been reviewed in this Deliverable will form the basis for the RRI framework, i.e. establishing the list of candidate criteria which will be employed to assess whether technology developments in monitoring of CCS and shale gas can be regarded as 'responsible' and how they might be re-designed or re-formulated in order for them to meet these criteria more adequately.

3.2 General ethics commitments

In order to strengthen further the commitment that the SECURe consortium's participatory research approach follows good ethical practice and ensures fair and equal power relationships between researchers and participants, the consortium can look to principles laid down in the European Code of Conduct for Research Integrity (*The European Code of Conduct for Research Integrity*, n.d.), published by the European Science Foundation'. A further set of ethical principles for conducting community-based participatory research, which can be drawn upon is that provided by the National Co-ordinating Centre for Public Engagement of Durham University, UK (NCCPE n.d.). These principles include:

- Honesty in communication of the research's goals and intentions, in reporting methods and procedures and in conveying interpretations;
- Reliability in performing research;
- Objectivity, which requires facts capable of proof, and transparency in the handling of data;
- Impartiality and independence;
- Openness and accessibility;
- Duty of care - all researchers have a duty of care for the humans, animals, the environment or the objects that they study;
- Fairness in providing references and giving credit for the work of others;
- Responsibility for the scientists and researchers of the future; and
- Care taken to minimise the potential impacts arising from collection of personal data, e.g. while taking photos and/or videos during events.

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4 Appendix

Table 3 - Glossary of terms

Distributional Justice	Concerns the distribution of costs/burdens and benefits among different social groups
Epistemic Justice	Seeks to identify whether alienation and marginalisation could occur due to way in which information is communicated.
Intragenerational equity	Concerned with equity between people of the same generation and aims to assure justice among human beings that are alive today.
Intergenerational equity	A concept of fairness among present and future generations in the use and conservation of the environment and its natural resources.
Moral hazard	Concept from economics in which an agent increases their exposure to risk because they are insured; hence someone else will bear the costs of the increased risk. Within climate engineering, moral hazard has been used to refer to the situation where the existence of effective climate mitigation technologies (insurance) might result in society taking greater risks such as not investing sufficiently in CO_2 mitigation technologies and options.
Polluter pays principle	Supports the practice that only polluters should bear the costs of managing or preventing pollutants or waste that they produce.
Procedural justice	Advocates that policy decisions should be made in a fair and inclusive way so that diverse interests are considered and addressed and just outcomes are produced.
Responsibility principle	That all nations should be willing to ensure protection of their own natural environment but also to minimise the incursion of any negative consequences on others.
Tariff	A charge that can be added on to the import or export of certain goods. This measure can be used by governments to protect domestic industries from external competition.

***The 'good life'* principle**	Concerns the conditions necessary to achieve a good quality of life.

Table 4 - Ethical principles and claims with examples of shale gas cases

Ethical areas/principles	Ethical claims	Examples of shale gas (SG) related claims
Distributive Justice		
Availability	Right-based claims: **right to have access to resources**	**Water quality and supply** (Evensen, 2016; Uliasz-Misiak et al., 2014; Upham et al., 2015)
Affordability	Right-based claims: **right to energy without high environmental costs**	**Benefits for the SG owners and environmental costs for the non-owners** (Evensen, 2016; Lis and Stasik, 2017; Schafft and Biddle, 2015; Szolucha, 2016)
Procedural Justice		
Due process	Right-based claims: **right to have a voice, right to have power**	**Sense of powerlessness on the side of local communities and citizens** (Evensen, 2016; Lis and Stasik, 2017; Szolucha, 2016; Thomas et al., 2016)
Transparency and accountability	Right-based claims: **right to fair treatment and compensation; right to hold actors accountable at the scale of incurred costs**	**Distrust of the responsible parties (particularly industry and government), perceived unfairness, heavy-handed corporate tactics, and a lack of transparency** (Bradshaw and Waite, 2017; Cotton, 2015; Materka, 2012; Thomas et al., 2016; van der Voort and Vanclay, 2015; Verschuuren, 2015) **The Principle of Prima Facie Political Equality (PPFPE)** (Cotton, 2017; Evensen, 2016)
Environmental Justice		
Sustainability	Right-based claims: **right to local models of development**	**Right to use local resources (i.e. water) for local development (i.e. agriculture):** (Bradshaw and Waite, 2017; Cotton et al., 2014; Lis and Stasik, 2017; Short and Szolucha, 2017; Szolucha, 2016)
	False negatives and false positives	**Need to balance between claims about what we know and what we do not know in terms of impacts of SG extraction** (de Melo-Martín et al., 2014; Lis and Stasik, 2017; Wagner, 2015) (Cuppen et al. 2013;
Responsibility	Involuntary risks claims: **right to assign responsibility to public risks**	**Experience of communities where shale gas production destroyed their environment** (i.e. near Pittsburgh, Pennsylvania, USA; near Neuquen, Argentina) (Cotton et al., 2014; di Risio, 2017) (Sovacool, 2014);
	Precautionary principle claims: **right to know the risks and impacts**	**Recommendations for more research on environmental and health impacts prior to exploration** (Naumann and Philippi, 2014) (Exxon Mobil Expert Panel Report 2011; Naumann et al. 2014) **Need for more research on climate change impacts of shale gas development** (Finkel and Hays, 2013)
Intragenerational equity		

	'The Good Life' claims: **right to a good quality of life** Perfectionism claims	**Reports of increased stress and trauma related to industry operations in the area** (Evensen, 2016; Short and Szolucha, 2017; Szolucha, 2016; van der Voort and Vanclay, 2015) **Intragenerational solidarities** (Lis and Stasik, 2017; Stasik, 2017)
Intergenerational equity		
	Perfectionism claims: right to security of energy supplies at different societal levels' right to protect natural resources for the next generations	**Energy security claims (Jaspal and Nerlich, 2014; Wagner, 2015); Jaspal et al. 2014)** **Intergenerational solidarity expressed by local communities (Lis and Stasik, 2017; Szolucha, 2016)** **Concerns about long term climate impacts (Finkel and Hays, 2013)**

Source: Own material.

Table 5 - The main literature on shale gas ethical issues divided in categories

No.	AUTHOR	TITLE	YEAR	TITLE JOURNAL / SOURCE LOCATION	KEY WORDS
Literature on ethical and moral issues related to shale gas extraction					
1.	de Melo-Martín I et al.	The role of ethics in shale gas policies	2014	Science of the Total Environment, 470:1114-1119.	
2.	Evensen D	Policy decisions on shale gas development ('fracking'): The insufficiency of science and the necessity of moral thought	2015	Environmental Values Refereed journal	Content analysis of newspaper coverage;
3.	Evensen D	Ethics and 'fracking': a review of (the limited) moral thought on shale gas development	2016	WIREs Water 2016, 3:575–586. doi: 10.1002/wat2.1152	
4.	Szolucha A	The human dimension of shale gas developments in Lancashire, UK: Towards a social impact assessment	2016	http://appgshalegas.uk/wp-content/uploads/2016/05/The-Human-Dimension-of-Shale-Gas-Developments-in-Lancashire-pdf.pdf	
5.	Short D, Szoluch A	Fracking Lancashire: The planning process, social harm and collective trauma	2017	http://dx.doi.org/10.1016/j.geoforum.2017.03.001	'Fracking', extreme energy, planning policy, corporate influence,

					social harm, collective trauma
6.	Clough E	Environmental justice and fracking: A review	2018	Current Opinion in Environmental Science & Health	Fracking, Hydraulic fracturing, Environmental justice, Distributive justice, Procedural justice, Recognition justice
Literature review reports from the H2020 project M4ShaleGas					
7.	Mastop J, Rietkerk M	Review of lessons learned on public perceptions and engagement of large-scale energy technologies	2015	M4ShaleGas D19.1	Perceptions relating to local energy projects, stakeholder engagement
8.	Lis A et al.	Existing European Data on Public Perceptions of Shale gas	2015	M4ShaleGas D17.1	
9.	Thomas M et al.	PUBLIC PERCEPTIONS OF SHALE GAS OPERATIONS IN THE USA AND CANADA – A REVIEW OF EVIDENCE	2016	M4ShaleGas D18.1	levels of awareness of shale operations, risk/benefit perceptions and acceptability
10	Brändle C et al.	Prerequisites for a Social Licence to Operate in the (Shale) gas Industries	2016	M4ShaleGas D17.2	methods to balance out public concerns with industry interests, stakeholder's involvement, CCS, EJ
11	Brunsting S et al.	Final report on the lessons learned from related energy technologies and on the implications from these lessons for future approaches to shale gas, both for public engagement activities as well as for public perceptions research	2017	M4ShaleGas D19.3	methods for public perceptions measurement, informed/uninformed public opinion, public engagement

[i] The separation of the 'humanities' and 'sciences' was famously documented by C.P. Snow (1959) *The Two Cultures and the Scientific Revolution*, Cambridge University Press. The debate has continued in the current era within the speciality known as 'science and technology studies' or as 'social studies of science and technology'. The so-called 'Science Wars' of the 1990's and 2000's represented a flaring-up of the controversy between science and social scientists, e.g. Jay Labinger and Harry Collins (2001), *The One Culture? A Conversation about Science*, University of Chicago Press.

[ii] For an introduction to the climate change issue see *The Hot Topic* by Gabrielle Walker and David King (The UK's former Chief Scientist) (Bloomsbury, 2008). For a visual guide to the climate change issue, see *Dire Predictions* by Michael Mann and Lee Kump (Penguin Random House, 2015). For online resources try: https://climate.nasa.gov/evidence/ ; https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/basics-of-climate-change/ ; https://www.nytimes.com/interactive/2015/11/28/science/what-is-climate-change.html

[iii] IPCC SR1.5 (2018) http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

[iv] World governments signed up to the Paris Agreement in December 2015 agreeing to limit increase in the average global surface temperature to 2ºC. This committed countries to work together through the United Nations Framework Convention on Climate Change (UNFCCC) to reduce greenhouse gas emissions throughout the coming century so that they reach net zero. The Intergovernmental Panel on Climate Change (IPCC) is the scientific body which provides advice to the UNFCCC and it has recommended cuts of at least 80% by 2050 for industrialised countries, including the UK, as a fair contribution to the global target of staying below 2⁰C. 'Net zero' means that there can still be some greenhouse gas emissions in the future but for each one kg of emissions, there has to be an equivalent removal of greenhouse gases from the atmosphere. For instance, planting trees would absorb CO_2 from the atmosphere by the process of photosynthesis and this uptake of one molecule of CO_2 would balance the release of one molecule of CO_2 emitted from burning fossil fuels. In October 2018, the IPCC released its Special Report on limiting global average surface temperature change to 1.5ºC instead of 2ºC and this would require more rapid cuts in CO_2 and other greenhouse gas such that we are at 'net zero' by 2050.

[v] At this depth or deeper, the CO_2 is a gas but behaves likes a liquid (a state that is known as 'super-critical'). Because it behaves like a liquid, a lot more CO_2 can be stored in the tiny pores in the rock. Furthermore, storing CO_2 at a depth less than 800m could increase the risk of CO_2 leakage as it would behave like a gas.

[vi] Rock formations from which oil and gas has been extracted are potentially valuable storage formations, as are so-called 'deep saline aquifers', which are porous rocks containing saline water in their pore space.
[vii] A good introduction to CO_2 Capture and Storage (CCS) can be found at these

websites:https://www.globalccsinstitute.com/understanding-ccs ; http://documents.ieaghg.org/index.php/s/YKm6B7zikUpPgGA/download?path=%2F2013&files=2013-16_Information_Sheets_for_CCS_All_sheets.pdf

Links to two short films which help to explain CCS are provided below.

https://www.youtube.com/watch?v=lH3hgqLM94U

https://www.youtube.com/watch?v=GLVp_1MjEKA

[viii] e.g. Alcade et al. 2018
[ix] See, for example, IPCC Special Report on CCS: https://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf; Shackley, S. & Gough, C. (Eds.) (2006), *Carbon Capture and its Storage: An Integrated Assessment*, Ashgate, London; Markusson, N., Shackley, S. & Evar, B. (Eds.) (2012), *The Social Dynamics of Carbon Capture and Storage*, Routledge, London; IPCC SR1.5 (2018) http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

[x] IPCC Special Report on CCS: https://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf

[xi] The idea behind buying insurance is that a large number of people spend a relatively small sum of money to protect against a large loss which would arise from a rare event. Because that event is rare, the collected

monies can be used to cover most of the costs arising from the event. The chances of your house flooding is very small but the costs would be huge if it were to happen so it makes sense to pay the insurance premium and spread the risk with all the other policy holders. Insurance can be seen as a form of *intragenerational equity*, since the costs are spread across potential beneficiaries. An ethical problem with insurance is that the poorer households may not be able to afford the premiums or may choose not to given other budgetary demands. Premiums may also be higher in neighbourhoods where there are higher risks of crime, which tend to be the most disadvantaged ones, so poorer households end up paying higher premiums than wealthier households. This increases yet further the disproportionate percent of income poorer households have to expend on insurance relative to wealthier households. Climate change damages could potentially be vast and we are unable to provide any certainty on the quantitative risk level or where and how the damages would unfold (unlike car and house insurance, where a long history of accidents can be used to calculate the likely damage costs and hence be used to calculate the premium). A bit like a flood event, a lot of chance event are likely to be involved in extreme weather events along with more predictable trends and patterns, such as more intense storms and rainfall events, higher temperatures, etc. An insurance policy against climate change damages would involve expenditure now on measures that would limit the risk of climate change occurring or, more likely, would limit the risks of additional climate change from that which is already going to occur. If enough money is spent on CCS now, then it could be deployed rapidly to quickly reduce emissions of CO_2 from the use of coal, gas and oil, so limiting the rate of climate change. The analogy breaks down when the unknown damage costs are considered meaning that we don't know what the insurance premium should be. Nor is it clear what other measures might be included in the insurance portfolio along with CCS.

[xii] There are several versions of a CCS bridge: the simplest is use of CCS in electricity generation while renewable electricity technologies are further developed. The end of the bridge then occurs where such renewable electricity technologies (or other very low or zero-carbon power generation options) are able to supply 100% of the demand on the electricity grid. A second CCS bridge might involve steam reformation of methane to produce H_2 and CO_2, with use of H_2 as a fuel for heating or to power fuel cells, with storage of CO_2 in rock formations. In this case, the end of the bridge would occur where generation of H_2 is 100% powered by renewable (or nuclear) electricity, eliminating the need to use CH_4 and capture and store the CO_2.

[xiii] A summary of how we can reduce carbon emissions from the cement and steel sectors is provided by Climate Action Tracker (2017).

[xiv] An example of such a plan is the H21 Leeds City Gate Project.
https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf

[xv] A further idea is to produce 'natural' gas by capturing CO_2 from the gases released when burning fossil fuels (or directly from the atmosphere) and combining the CO_2 in a chemical process with hydrogen. The hydrogen can be produced by using 'spare' electricity from renewables such as wind and solar energy.

[xvi] For a brief technical and economic assessment of various CO2 utilisation development can be found in, Styring, P., Jansen, D., De Coninck, H., Reith, H. and Armstrong, K., 2011. *Carbon Capture and Utilisation in the green economy* (p. 60). New York: Centre for Low Carbon Futures. http://co2chem.co.uk/wp-content/uploads/2012/06/CCU%20in%20the%20green%20economy%20report.pdf

[xvii] More detailed reviews of the arguments surrounding CCS can be found in Markusson, N., Shackley, S. & Evar, B. (Eds.) (2012), *The Social Dynamics of Carbon Capture and Storage*, Routledge, London.

[xviii] CO_2 capture removes about 90% to 95% of the CO_2 from fossil fuels such as coal and gas when they are burnt in a power plant. However, to get a more accurate sense of the change in carbon emissions from using CCS we need to look at the full 'life-cycle' from 'cradle-to-grave'. CO_2 capture involves additional use of energy and this comes from using more coal, which means that more coal needs to be mined, transported and processed for use in the power plant, all of which means greater use of energy and further CO_2 emissions. Also, CCS requires new equipment – new capture units, compressor plants, pipelines, pumps, etc. Producing all this new steel and cement and so on requires use of energy and yet further CO_2 emissions. Once we add in all these additional sources of CO_2 that would not have taken place without CCS being implemented, the realistic reduction in CO_2 emissions is reduced from c. 90% to c. 70%. (Ricardo-AEA, 2013; Personal communication, Professor Stuart Haszeldine, University of Edinburgh, 16th October 2018). Another source states that the carbon intensity of CCS with coal is 100 gCO_2/kWh and 70 gCO_2/kWh for gas on a life-cycle

basis) (Pehl et al. (2017). However the target in the UK, proposed by the Committee on Climate Change (CCC), is for a carbon intensity of below 50 gCO_2/kWh to meet long-term carbon reduction targets (CCC (2012). This compares with much lower levels for nuclear, wind, PV solar and CSP (all under 10 gCO_2/kWh on a lifecycle basis) (Pehl et al., (2017).

[xix] It is difficult to find convincing evidence that funds have been diverted away from renewables to fund CCS (Shackley & Thompson, 2009, 'Lost in the Mix', *Climatic Change*, DOI 10.1007/s10584-011-0071-3). If clear evidence could be identified of countries diverting energy R&D away from renewables and to CCS then this would support 'moral hazard' type arguments. While this argument and concern may have been valid 10 or 15 years ago, because so little CCS development has in reality taken place, it is not a very credible argument to make in the current context. Meanwhile, there has been an explosion in renewable energy – especially in wind power and solar PV – such that a huge investment into renewables has occured globally, including in reseach & development.

[xx] CCS can be perceived as a type of insurance that reduces the perceived urgency and need for other CO_2 mitigation technologies (energy efficiency, renewables, low-carbon transport and buildings, etc.). This is known as a 'moral hazard' type of argument. Generalising, CCS faces the criticism that it is 'treating the symptoms, not the cause' (analogous to a sticking plaster on a wound) and this is regarded by many as a moral failing and a sign of not wishing to 'face up to the real problems'. A morality consisting of turpitude, laziness, 'wanting our cake and eating it' and so on is evoked. If CCS had indeed been more widely implemented in the past decade, the moral hazard argument would be more convincing; the lack of activity renders it a less convincing argument.

[xxi] Although CCS has been designed for the sole purpose of preventing CO_2 emissions into the atmosphere, there have also been claims of ulterior motives influencing the endorsement of CCS as a climate mitigation option. The most dominant claim is that mentioning the potential implementation of CCS would provide energy companies with a suitable 'smokescreen' or 'greenwash' to justify the ongoing use and even expansion of current fossil fuel energy consumption. These concerns were highlighted during debates a decade ago concerning capture-readiness' in response to requirements being considered by some national legislators. This is a further example of the use of a moral hazard type of argument.

[xxii] The difference between, and implications of, carbon lock-in and fossil fuel lock-in, is explored in detail in Shackley & Thompson 2009).

[xxiii] Those using this argument would need to recognise that large amounts of non-fossil fuel minerals and other materials are extracted through mining for use in manufacturing, which also causes environmental damage. This point does not invalidate the concern over fossil fuel mining, processing and transport, however.

[xxiv] The condition of older or of abandoned wells can increase the probability of CO_2 leakage for instance through cement-free zones and gradual degradation of wellbore materials (IEAGHG, 2012). Therefore wellbore integrity is an important factor to consider for long-term CO2 storage.

[xxv] E.g. Bachu et al, 2009; Alcalde et al, 2018

[xxvi] Rutqvist et al, 2018; Chadwick et al, 2012; Verdon et al, 2013

https://www.bgs.ac.uk/science/CO2/home.html; https://sequestration.mit.edu/tools/projects/sleipner.html

[xxvii] Anderson, 2017

[xxviii] Holloway et al, 1996; Eiken et al, 2011

[xxix] The question is raised of whose risk acceptance is to be followed? Should the risk perceptions of experts be dominant? Or should non-experts perceptions be given equal weight to that of experts? There are many different potential answers to these question. Whatever the substantive position adopted, a due process, the

integrity of which is trusted by the main stakeholders, needs to be in place in order to come to some decisions on such difficult questions. The process needs to fulfil the criteria of procedural justice.

[xxx] http://www.eco2-project.eu/; https://phys.org/news/2018-02-carbon-dioxide-leakage-seabed.html

[xxxi] https://www.bgr.bund.de/DE/Themen/Nutzung_tieferer_Untergrund_CO2Speicherung/Downloads/RISCS_Guide.pdf?__blob=publicationFile&v=1

[xxxii] The costs of solar PV have come down by 90% in the past 10 years, while the costs of wind power have halved or more over the same time period. This is the result of 'learning by doing' and economies of scale – i.e. building more units reduces cost of production per unit. Because CCS has had very limited application, such cost reductions have not taken place. This makes CCS relatively more expensive compared to renewables than it was 10 or 15 years ago. Further investment in renewables is far more attractive to private investors because of the cost reductions, suggesting that Governments would have to create much stronger incentives for CCS. Governments have to justify subsidies for new technologies such as CCS and renewables in terms of what is in the best public interest. Subsidies are ultimately paid by energy customers or by tax payers. Higher energy bills for poorer households risks exposing such households to further energy poverty – i.e. where people are not able to keep themselves warm enough because they cannot afford to spend more money on heating.

[xxxiii] E.g. Stern (2007); Michael Grubb (2015); IPCC (2014).

[xxxiv] Measures such as stricter regulations and green taxes are examples that could be used to enforce the polluter pays principle, if CCS or other approaches were not introduced.

[xxxv] In regards to CCS, a tariff could be applied to the import of products such as high carbon steel or chemicals from other countries where it would be cheaper to produce such products, due to less strigent environmental quality regulations.

[xxxvi] This raises the point about how should benefits and costs be considered. In regards to energy production, the benefits of CCS could be viewed as national in terms of ensuring energy security through continued utilisation of fossil fuels. However CCS would also have global benefits, due to mitigating global climate change which could impact vulnerable populations who do not have the means to introduce such measures. It therefore is difficult to define who 'society' applies to in this context and whether boundaries should be applied to arguments relating to distributional justice.

[xxxvii] Ensuring procedural justice principles In relation to CCS would require that all relevant stakeholders (e.g. from industry, government (local/national), public, NGO's etc.) would be fairly represented and have equal opportunity to be involved in the decision making process

[xxxviii] In relation to the 'good life' principle, individual or collective 'wellbeing' looks at what may impact on a person's (or community's) ability to do or be what they have reason to value (Deneulin, 2014) . For example the introduction of wind turbines into rural areas could be thought by some to depreciate the aesthetic value of the area. However, others may regard the same wind turbines as enhancing the value of their local area. CCS could also be claimed to have a similar visual impact for local communities – some viewing it negatively, others positively. The problem with the 'good life' argument is that we don't all agree on what the 'good life' is and may frequently have incompatible opinions. Who's version of the 'good life' should win out in such situations? This is where the necessity of a political process of mediating between competing opinions is crucial.

[xxxix] Under the 'Responsibility' principle as described by Savacool (2013), it is deemed that nations should be willing to ensure protection of their own natural environment but also to minimise the incursion of any negative consequences on others. CCS could be viewed as following this principle as it would aid in preventing the release of greenhouse emissions and therefore mitigating the impacts of climate change for all nations.

[xl] This was the crux of a major disagreement in the response to the Stern report on the economics of climate change (Stern, 2007). One group of economists argued that policy should focus on the values that we aspire to hold and that politicians should focus on realising a vision of a better society. A contending group of economists argued that it is more sensible to base policy on the evidence of real choices that people have taken on the assumption that such choices better reflect people's true values and priorities.
[xli] Where ineffective communication occurs, this can impede on people's ability to engage and participate in the decision-making process and therefore is also linked to procedural justice.

[xlii] There is a very large literature concerning both deliberative and more participatory forms of democracy and on the issue of centralised versus more federal and decentralised forms of governance. David Held's *Models of Democracy* (London: Polity Press) (2006, 3rd Edition), is a useful introduction.

[xliii] See, for example, Aitken (2010), Kerr et al. (2017), Cass et al. (2010), Strachan & Jones (2012)

[xliv] Midgley, M. (2000), 'Consciousness, Fatalism and Science', in N. Gregersen, W. Drees & U. Gorman (Eds.), *The Human Person in Science and Theology*, T&T Clark: Edinburgh: 21-40.