Lampkin, Jack (2023) The Harms and Crimes of Fracking. In: Oxford Encyclopedia of Criminology and Criminal Justice. Oxford University Press

The Harms and Crimes of Fracking

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Summary

A plethora of academic research into fracking for shale gas suggests the practice leads to a variety of social and environmental harms and crimes. Social harms involve the impacts that fracking has on the lives of local communities that adopt fracking. This involves the impact of "boom and bust" cycles on communities, the adverse impacts of fracking activities on property values, the impact of corporate financial bribery on physical and mental health, and other disturbances such as heavy truck traffic, dust, noise and light pollutions. Environmental harms include the ability of fracking to create earthquakes, the potential contamination of natural water systems, problems around the creation and disposal of hazardous wastewaters, and the climatic impacts of flaring and venting waste gases.

Fracking is also directly linked to crime in a myriad of different ways including through crimes of the powerful, consequential crimes, and indirect crimes. Crimes of the powerful include fraud, corruption and the violation of environmental laws and regulations. Consequential crimes are a by-product of fracking exploration and production, such as protest-related crimes and state crimes. Conversely, indirect crimes are committed as a result of fracking activity. This includes street-level crimes, violent crimes and domestic assaults, all of which are found in higher prevalence in locales that experience fracking operations, compared to those that do not. Overall, prospective governments and policy-makers should carefully weigh up any potential economic benefits of fracking with the possible ensuing social and environmental harms and crimes the process produces, prior to legislating in favour of the process.

Key Words

Environmental Crime; Extreme Energy; Fracking; Shale Gas; Social Harm.

Introduction

Since its establishment in the 1980’s, unconventional hydraulic fracturing has proliferated despite research that indicates the process is littered with a multitude of social and environmental harms (Jackson et al. 2014; Lampkin, 2018). It can also be argued that fracking is a form of white-collar crime, with corporations repeatedly breaking environmental laws and regulations (Bernstein, 2021). The purpose of this encyclopaedia entry is to guide the reader through these arguments. This will be done through five sections:

1. Defining quintessential terminology relating to fracking and unconventional hydraulic fracturing.
2. Summarising the global historical development of fracking.
3. Highlighting the impact that fracking can have on social life, including community disturbances.
4. Analysing the environmental impacts of fracking, specifically focussing on contamination of natural water systems, well integrity failure, earthquake creation, and the unsafe disposable of wastewaters and dangerous greenhouse gases.
5. Assessing the relationship between fracking and crime, including corporate criminal behaviour and rule-breaking, as well as consequential and indirect crimes caused as a result of fracking activities.

Defining Fracking

The word *fracking* is a colloquial umbrella term used to describe a variety of distinctive natural resource extraction processes that involve the deliberate cracking, or *fracturing*, of diverse rocks and geological formations both onshore and offshore (Speight, 2013). Usually, fracking is conducted to access oil or gas that is trapped deep underground and is employed when conventional techniques yield low, or no, supply. Conventional drilling merely involves a vertical well drilled deep into the subsurface with the intention of accessing hydrocarbons. Fracking is usually considered an unconventional technique as it combines this vertical drilling (a *conventional* practice) with horizontal drilling (an *unconventional* practice), enabling a well to be fractured many more times than a conventional well. This enables operators to extract larger quantities of oil and gas, thus making each well more profitable (Warner and Shapiro, 2013).

The term *unconventional* can also refer to the type of resource being extracted. Conventional fracking, for instance, targets traditional natural resource reservoirs such as sandstone and limestone. These are known as relatively porous, high-permeability formations meaning hydrocarbons flow well and are easily released from the rock (Prud'homme, 2014). Consequently, only minor drilling and stimulation is required for conventional drilling. In contrast, unconventional resources (such as coal and shale) have low-permeability, high-porosity characteristics, implying hydrocarbons do not flow easily from the rock into a drilled well (Lampkin, 2020a). Consequently, the rock needs to be fractured and stimulated to release the gas or oil trapped inside. As such, unconventional fracturing is used when conventional drilling is unsuccessful, or when preliminary forecasting of underground resources predicts a difficulty in extracting the resource through conventional means.

Another salient characteristic of unconventional fracking is that it requires high volumes of water, sand and chemicals in the extraction process, to allow trapped oil and gas to be released from an underground geological formation (Prud'homme, 2014). Chemicals are used to facilitate the process, enabling the various elements to move with greater ease up and down the well. Water is pumped, at very high pressure, to force rocks to crack thereby allowing oil or gas to escape. Sand is used to prop open fractures in the rock (caused by the extreme pumping of water) as fissures begin to close over time when under geologic pressure (Sharma and Manchanda, 2015). Sand is therefore used as a proppant, to help keep fractures open for longer, enabling oil or gas to flow for a lengthier period of time (Speight, 2013). It is this unique mix of horizontal drilling in low-permeability formations, and the deployment of water, sand and chemicals that is distinctive to unconventional, horizontal, hydraulic fracturing.

While the term *fracking* can be employed to different types of drilling and extraction processes, this encyclopaedia entry will focus solely on the unconventional version as described above. This is because this particular process has been associated with a variety of different social and environmental harms and crimes, and remains a topic of great debate from both an engineering perspective, and a political and criminological viewpoint. As such, the term *fracking* from this point forward conforms with Lampkin's (2018: 29) definition, which refers to fracking as:

> “(Anthropogenically) induced multiple stimulation of an onshore well drilled in an unconventional fashion (vertically then horizontally) using high-volumes of fluid at high-pressures. This is specifically undertaken for the purposes of releasing gas trapped in... low-permeability, unconventional, geologic formations (shale only).”

While humans have searched and drilled for oil and gas for over 200 years (Montgomery and Smith, 2010), unconventional fracking is a relatively new phenomenon that began only in the late 20th Century. The following section will outline the development of fracking which originated in the United States (US), and has since become a global phenomenon. This historical understanding will provide the requisite context needed to analyse the various social and environmental harms and crimes created by the fracking process in the remainder of this entry.

The Global Historical Development of Fracking

Originally, conventional drilling for oil and gas would involve forcing a vertical hole deep underground. Deep drilling alone is enough to cause disturbance to the sub-surface environment, and, if oil or gas are present, some will flow up and out of a well at the point of drilling. It is this primitive form of drilling that dates back to the early 19th Century when petroleum products came to be widely traded commodities across the world (Falola and Genova, 2005). However, human societies did know about oil and gas before the shift towards commercial drilling. As Falola and Genova (2005: 6) suggest:

> “The oil that seeps to the surface (naturally) is what people in ancient times first discovered... Around 3,000 B.C.E., ancient peoples of the present day Middle East traded bitumen to be used as building mortar, medicine, and lighting fuel. Starting in 900 B.C.E., the Chinese began using natural gas from wells.”

In the 1930’s “the idea of using acid alongside water to stimulate onshore wells began to emerge, but it was not until 1947” that the Stanolind Oil company used the combination of sand, water and chemicals to stimulate a well (Lampkin, 2018: 40; Montgomery and Smith, 2010). This led to an increase in the commercial development of fracking, and conventional, vertical-only drilling remained the main source of onshore fracking in the United States for the following forty years (Cahoy et al. 2013).

Unconventional fracking was developed in the United States by the Mitchell Energy and Development company in the 1980’s as a method of extracting more shale gas from a single drilling well (Fry et al. 2015). Operating in the Barnett Shale region of Texas, Mitchell Energy found that they were able to turn the drill bit underground in a manner that enabled it to continue on a horizontal path, thereby accessing more of a shale formation than traditional, vertical-only, drilling techniques. Accessing a greater quantity of a shale gas through horizontal drilling and fracturing enabled Mitchell Energy to extract more gas per well, subsequently increasing well productivity and profitability (Warner and Shapiro, 2013).

Perhaps unsurprisingly, the United States are the largest producers of natural gas through unconventional hydraulic fracturing (Siddik et al. 2020). Having developed the technology, companies have had longer to research, develop and experiment with fracking processes, leading to sophisticated engineering that has fostered an economically thriving industry. Lax environmental laws and regulations have also helped, preventing time consuming legal hurdles and barriers (Prud’homme, 2014). Furthermore, North America has a geological advantage to most of the rest of world in that their shale plays often exist remarkably close to the Earth surface. Jackson et al. (2015) surveyed 44,000 fracking wells in the US between 2010 and 2013 and found the average depth of drilling to be 2.5 kilometres, with 6% of wells being fracked at less than 1 kilometre. This shallowness makes the shale relatively easily accessible. Comparatively, many other shale formations around the world are found much deeper, making them more difficult, costly, and energy-intensive to extract. In the United Kingdom (UK), for instance, shale has formed much deeper into the Earth than the United States, at distances of between 2 and 5 kilometres (Lampkin, 2018). Similarly, shale plays are very deep in China at 2.3 to 3 kilometres in the Sichuan basin (Lei et al. 2017), and in Poland, three boreholes were drilled in the Stara Kiszewa concession area outside of Gdańsk at 4 kilometres in depth (Montcoudiol et al. 2017). Therefore, fracking has developed at a greater rate in the US than anywhere else in the world owing to a combination of unique factors, including firstly developing the technology, and then favourable geological conditions.

However, despite the recent proliferation of unconventional fracking, research suggests the process is tainted with a multitude of social and environmental harms (Jackson et al. 2014; Lampkin, 2018). This has led unconventional fracking to be banned over different time periods by several national and subnational governments. As Paylor (2017: 343) recounts, fracking has been “banned in countries such as Bulgaria, France, Germany, Luxemburg and

Romania, as well as in regions such as Vermont in the USA, Quebec in Canada and Cantabria in Spain." The United Kingdom (Szolucha, 2018), South Africa (Warren, 2013), and the State of New York (Simonelli, 2014) have also banned fracking at various intervals.

The reasons behind fracking bans and moratoriums are complex and vary across space and time. However, the environmental and social impacts of fracking are cited regularly as reasons for halting the process, or denying operators permits for conducting fracking. A study by Lampkin (2018) examined the social and environmental harms of fracking in a UK context. They conducted 20 semi-structured interviews between 2016 and 2017 with *key informants,* a mixture of people with different personal and professional relationships with fracking including: anti-fracking campaigners, regulators, oil and gas professionals, gas company directors, geologists and academics. After a comprehensive literature review, they split social and environmental harms up into eight key areas, and published the findings over three separate academic publications (Lampkin 2018, 2020a; Lampkin and Hall, 2021). These key areas are outlined in Table One:

Fracking and Social Harm	**Fracking and Environmental Harm**
1. Boom and bust cycles	5. Induced seismicity
2. Local community disturbances	6. Contamination of natural water systems and comprised well integrity
3. Adverse impacts on property values	7. Creation and disposal of wastewaters
4. Corporate financial bribery	8. Flaring of waste gases

Table One: *The Social and Environmental Harms of Fracking* (Adapted from Lampkin, 2020b: 66-67).

The following two sections will discuss the literature relating to these eight areas in a global context. It is important to note that not all of these issues are prominent in all unconventional fracking processes, due to the differences in production techniques and geology from place to place, around the world. However, intentions of production always remain the same. That is, to extract oil or gas from underground, using horizontal and unconventional drilling techniques. Consequently, fracking usually has a combination of some, or all, of the above social and environmental harms, irrespective of the physical location of production.

The Social Harms of Fracking

As described in Table One, four key social harms often created by unconventional fracking are boom and bust cycles, local community disturbances, property value impacts and corporate financial bribery. This section will consider these social harms in turn.

Boom and Bust is a term synonymous with fracking in the United States. It is used to describe a situation where an energy company arrives in a local community providing jobs and wealth and enhancing the local economy (known as a fracking *boom*). Since the amount of hydrocarbons underground are finite, energy companies move on from a booming location once the well (or series of wells) become unprofitable (Marcus, 2019). This results in the cessation of the jobs and wealth created, leading to a *bust*, whereby the local area sees a decline in economic opportunity and income generation.

Fracking undoubtedly provides short-term economic advantages which vary in magnitude from place to place. For instance, Faulkner (2014) suggests that fracking in the US contributes to the nation's Gross Domestic Product (GDP), government revenue streams, and balances the national deficit. There is also an argument that fracking displaces jobs lost in other similar declining industries, such as coal production (Faulkner, 2014). Furthermore, it has been suggested that all industries, including fracking, go through periods of "expansion and recession" and that, consequently, there is nothing particularly unique in that regard about fracking (Miller and Bolton, 2016: 218).

Ultimately, the economic benefits of fracking would not have taken place without the industry, and management principles can be applied to extend the boom and minimise the impacts of the post-fracking recession. Such principles include the diversification of the workforce and supply chains, enhancing and extending productivity, and providing skills training for local people (Miller and Bolton, 2016). Ultimately, the economic advantages associated with fracking booms are often related to job creation, wage income and financial royalties for local communities that accept fracking in their area. As Feyrer et al. (2015) suggest:

> "Every million dollars of oil and gas extracted produces $66,000 in wage income, $61,000 in royalty payments, and 0.78 jobs within the county. Outside the immediate county but within the region, the economic impacts are over three times larger. Within 100 miles of the new

> production, one million dollars generates $243,000 in wages, $117,000 in royalties, and 2.49 jobs."

Despite these advantages, the same claims of job creation, wage income and financial royalties are not found consistently outside the United States. For instance, community financial incentives for fracking in the UK have been described by local people as a form of corporate financial bribery (Lampkin, 2020a), payments to accept an industrial process laden with social and environmental harms. Consequently, local communities have been found to experience a sense of *collective trauma* even at preliminary exploration stages where a company simply surveys the area to determine whether fracking may be profitable or not (Short and Szolucha, 2019). Even within the United States, the number of jobs created directly from fracking has been described as "modest," with the realisation that most jobs will be created indirectly through fracking's close relationship with other industries such as processing, manufacturing, waste disposal and service sectors (Miller and Bolton, 2016: 202).

When a fracking boom ends, there is an inevitable period of economic decline. Jobs, wage income and financial royalties stop contributing to the local economy, and communities may feel a sense of collective trauma as the shock of rapid industrial advancement and cessation impacts people's lives (Davidson, 2018; Perry, 2012; Short and Szolucha, 2019). Individual and collective trauma can manifest in a variety of different ways, including negative impacts on people's mental health (i.e. anxiety and depression), excessive alcohol consumption and substance abuse (Aker et al. 2022; Mayer and Hazboun, 2019) and physical health consequences (i.e. stress and reduced quality of life). As Hirsch et al. (2018: 1-2) comment:

> "Although persons living in fracking communities may experience some minimal, initial benefits such as land lease income or infrastructure development, they may also experience worry, anxiety, and depression about lifestyle, health, safety, and financial security, as well as exposure to neurotoxins and changes to the physical landscape. Indeed, entire communities can experience collective trauma as a result of the "boom/bust" cycle that often occurs when industries impinge on community life. Impacted communities are often already vulnerable, including poor, rural, or indigenous persons, who may continue to experience the deleterious effects of fracking for generations. An influx of workers to fracking communities often stokes fears about outsiders and crime; yet, it must be recognized that this population of mobile workers is also vulnerable, often ostracized, and without social support.'

Another factor in the mental health impacts of boom and bust cycles is the potential fluctuation in property prices. During a fracking boom, communities may see an increase in house prices and rental incomes as more people move into the area (Witt et al. 2018). However, such benefits may be short lived as property loses value when demand reduces and the landscape or environment is negatively impacted from the fracking activity. Those properties within close proximity to extraction sites may be particularly impacted in this way (Lampkin and Hall, 2021). A UK study published in 2016, for instance, found that whilst there was no difference in house price impacts in areas with licences for both conventional and unconventional fracturing, there was a 5% decrease in house prices in areas impacted by seismic activity (Gibbons et al. 2016). Similarly, in Texas and Florida (United States), Throupe et al. (2013: 205) reported "a 5-15% reduction in bid value for homes located proximate to fracking scenarios" according to a survey of 570 residents.

Concerns around the impact of fracking on property go beyond the influence the technology might have on prices. Jones et al. (2014) cite the difficulty of acquiring insurance for properties in close proximity to fracking sites, and the confusion around whether an insurance company would pay out for a property damaged by fracking technology. Furthermore, there is also evidence to suggest that it may be difficult to obtain a mortgage on a property situated near a fracking site due to instability around prices and possible damage (Jones et al. 2014).

Despite these property concerns, some studies have reported positive impacts on property values. For instance, interviewees in a study by Lampkin and Hall (2021) recalled the very high property prices found in areas of the UK with a history of conventional offshore drilling, such as Aberdeen (Scotland) and Pool Harbour (Dorset). In the United States, Duke University (2014, in: Jones et al. 2014: 357) found "that houses within a one mile radius of fracking developments had experienced an 11 per cent boost in value, largely due to lease payments." Interestingly, they also reported that houses with "access to piped water had experienced an increase in their property value (whereas) those that depended on ground water resources had witnessed a decrease in the value of their property" (Jones et al. 2014: 357). This is possibly due to the impact that fracking has on groundwater due to the innate requirement to drill through water aquifers in order to access shale formations underground.

Ultimately, it is difficult to quantify the impact of fracking on property value due to the varying nature of fracking over time and space. What is more certain is that fracking companies often have to invest financially in communities where they operate in return for the communities willingness to accept fracking. Sometimes this financial investment is required under law. In the UK for instance, the *Infrastructure Act 2015* required “fracking companies to make financial payments to communities as a requirement of their fracking operations. These payments consist of £100,000 per well site (where fracking occurs) and an additional 1% of revenue once fracking is underway” (Lampkin and Hall, 2021: 2). In other parts of the word, community payments are not as generous. In Argentina, the crianceros community received just 15,000 Argentinian pesos per month (equivalent to around US$870), from an oil company for access to part of the Vaca Muerta shale basin. At times anecdotal evidence suggested the company did not pay up on time, or at all (Hadad et al. 2021).

Despite the global fluctuations in money paid by fracking companies to local people and communities, it is landowners in particular that have the most to gain from accepting fracking practices. This usually comes in two forms. The first is temporary, non-permanent lease payments for use of land that may be impacted by fracking. An example of this is in the United States where a US$75,000 annual payment was made to the Pronschinske family for access to sand, stone and rock products existing on their property, and US$1.50/ton of product thereafter (Hawkins, 2018). The second form encompasses permanent buy-outs for land that needs to be used directly for fracking, such as where the wellhead is situated (Sher and Wu, 2018). Due to such income generation, some communities that collectively prioritize economic reward over environmental and social issues have welcomed the interest and arrival of fracking companies (Jerolmack and Walker, 2018). However, many communities around the world have resisted fracking advancements due to economic uncertainty, and the potential for fracking to disturb the local area (Brock, 2020; Carter and Fusco, 2017).

Such disturbances are myriad and again vary over time and space depending on the type and extent of operations conducted. However, the most commonly cited community impacts include increases in industrial transport and traffic, anxiety around seismic activity, visual disturbances from fracking sites and flaring, and negative public health impacts (as described in Table Two):

Community Impact Issues

1. *Transport* Intensive heavy truck traffic is required to transport machinery, water, sand and chemicals to and from fracking sites impacting traffic and congestion (Fisher et al. 2018), deteriorating road quality (Rahm et al. 2015), increasing air pollution (Goodman et al. 2016), and increasing road traffic collisions and deaths (Johnson, 2010). A study conducted in North Dakota, US, found that “an additional post-fracking well within six miles of a road segment led to 8% more fatal crashes and 7.1% higher per-capita costs in accidents” (Xu and Xu, 2020: 1).
2. *Seismic Activity* Fracking disturbs the underground geology which can create earthquakes of varying size. Magnitudes vary across locations and operators due to the unique nature of each fracking operation. However, earthquakes of 2.3 Richter scale magnitude have been recorded in the UK, and 5.8 magnitude in the United States following wastewater re-injection (Aczel and Makuch, 2019).
3. *The Visual Impacts of Fracking* Fracking sites themselves have a visual impact on the landscape, particularly in rural areas and where flaring processes are adopted (a process whereby waste gases are burned using an open-air flame) (Twumasi et al. 2020). Additionally, the excessive truck movements may create visual disturbances, particularly in rural areas not designed for industrial traffic (Rahm et al. 2015).
4. *Negative Public Health Impacts* The most pervasive public health issue pertaining to fracking is in relation to air pollution (Srebotnjak and Rotkin-Ellman, 2014). This is both a local issue that impacts communities, and also a global climate change issue. There are two main culprits to air pollution in fracking processes. The first concerns gases that are released in the process, through natural escapage or purposeful flaring and venting to get rid of unwanted excess or low quality gases (Lampkin, 2018). Secondly, the excessive (often diesel-powered) truck movements create dust, noise and air pollutions to and from fracking sites (Lampkin and Hall, 2021). There are, however, other public health impacts from fracking, such as the potential for water aquifer and groundwater contamination that affects water systems (Jackson et al. 2014), and the impact that stress and other mental health factors may have on local communities (Hirsch et al. 2018).

(Table Two: *Fracking Community Impacts*).

The social harms and public health risks discussed so far are not exhaustive because every fracking occurrence is different in terms of the processes and methods employed by operators, and geological variance. However, they give a snapshot as to what the key issues are. In a similar vein, the following section will discuss a multitude of environmental harms associated with fracking. These harms vary from place to place depending on processes employed and the geology involved.

The Environmental Harms of Fracking

As depicted in Table One, this section will focus on four areas synonymous with environmental harms created from fracking processes and includes an examination of wastewater creation and disposal, induced earthquakes, the contamination of natural water systems, and the flaring of waste gases.

Wastewater Creation and Disposal

Unconventional hydraulic fracturing takes place in low-permeability, high-porosity shale formations, which means the target resource (shale gas) is trapped within the shale rock (Prud’homme, 2014). Consequently, the aim of fracking is to fracture, or crack, the rock creating fissures which enable shale gas to escape. Due to the depth of shale formations, and the toughness of shale rock, force is required to create the fractures that release the gas. In order to create that force, shale gas companies employ a mixture of fracfluid, a combination of elements designed to force rock to crack when it is pumped at high pressure (Lampkin, 2018). Fracfluid varies depending on the operator conducting the fracking, and the amount of pressure required to force the rock to split. However, fracfluid almost always contains three key elements: water (which creates the requisite pressure when pumped at force), sand (also known as “proppant” which literally “props” the fractures open for long enough to allow gas to escape) and chemicals (used for a variety of reasons, usually to reduce friction in the wellbore enabling the fracfluid to create greater pressure) (Lampkin, 2018).

Fracfluid does not remain underground after operations cease. Much of it returns to the surface creating wastewaters (also known as flow-back waters) that are problematic to dispose of safely. The amount of fracfluid that returns to the surface varies over different locations making it difficult to predict, plan and accommodate for (Mohajan, 2012). Brzycki et al. (2014) estimate that around 10-30% of water used returns to the surface, whereas

Howarth et al. (2011: 272) argue that most fluid "returns to the surface over the lifetime of the well."

Ultimately, it is inevitable that some flow-back water will appear during and after fracking operations, and this waste must be disposed of. The difficulty is that fracking wastewaters are different in constitution to the original fracfluid because they contain a variety of compounds used in the process, as well as elements found underground. The composition of wastewater varies between locations depending on how operators conduct fracking (for instance, which procedures and chemicals are used), and the unique makeup of the underground geology. However, in order to provide an insight into what may be included in wastewater, Shaffer et al. (2013: 9573, in Lampkin, 2018: 61) give a succinct explanation, suggesting wastewaters contain:

> "dissolved and suspended organics, measured as total oil and grease; suspended solids, such as formation solids, corrosion and scale products, and bacteria; production chemicals, which may contain proppants, friction reducers, biocides, and corrosion inhibitors from the hydraulic fracturing fluid; naturally occurring radioactive material, specifically barium and radium isotopes; and total dissolved solids (TDS), including hardness and heavy metals."

Because of this configuration, it is not safe to release wastewaters back into natural water systems such as rivers, streams, canals, reservoirs or oceans, because doing so could impact human and non-human animals and ecology that rely on fresh water. Consequently, the disposal of wastewater at specialist treatment facilities is usually a legislative or regulatory requirement. This has not, however, stopped companies from breaking those requirements and illegally dumping fracking wastewaters in order to avoid the costs associated with disposing of it lawfully and safely (Angeles, 2018). Even where law-makers are involved in decision-making regarding wastewater disposal, safe treatment is not always required. For instance, in the UK the "Environment Agency permitted disposal of waste water from the first exploratory fracks into the Manchester Ship Canal contrary to US industry best practice" (Beebeejaun, 2016: 426).

These cases are exceptions to the rule and most regulators around the world require safe wastewater disposal. There are two main topics of academic and operational debate in this area, topics that have both environmental and social impacts. The first requires the aforementioned heavy truck movements that are required to transport billions of gallons of wastewater to specialist treatment facilities that could be hundreds of miles away from the location of the fracking site (Korfmacher et al. 2015). This problem leads onto the second topic which surrounds avoidance of wastewater treatment altogether by re-injecting the wastewater back into the well in the hope that it will then remain underground and the well can be plugged and subsequently decommissioned. There are two problems with re-injection. Whilst it is clearly a much cheaper option than proper treatment (Cotton, 2017), it does not get rid of the problem as wastewater may continue to escape the well via the Earth surface, or through compromised well integrity (Chittick and Srebotnjak, 2017). The former could impact surface water, and the later could impact groundwater and water aquifers that exist beneath the Earth’s surface. The second problem is that re-injection has been associated with much higher levels of earthquake activity than the actual act of hydraulic fracturing itself (Ellsworth, 2013).

Induced Seismicity

A certain amount of seismic activity is natural and commonplace. Some places in the world experience more earthquakes than others, and some places experience earthquakes of greater magnitude than others. Earthquakes are a result of the underground geology which varies drastically around the world. However, they occur when fault lines are under so much stress that the rock on either side slips causing movement. With regards to fracking, the act of splitting rock creates micro-seismicity which is used by engineers to monitor the process (Speight, 2013). However, the levels of seismicity are so small that they are very difficult to detect, and are rarely felt by humans. There are, however, two set of circumstances that can lead to larger earthquakes.

The first is if a fracking company operates through an active fault line resulting in seismic movement when the well is drilled or fracfluid is pumped at pressure down the well (Atkinson et al. 2020). This occurred in Blackpool (UK) in 2011 where operations at the Preese Hall-1 wellsite resulted in earthquakes of 2.3 and 1.5 magnitude (Green et al. 2012). Operations were found to cause the seismic activity, which led to a temporary moratorium being implemented by the UK government, pending further research and investigation (Green et al. 2012).

The second circumstance is where wastewater is re-injected into a well as a form of storage. Often the waste is not reinjected into the same well it came from, but is transported to injection wells that are specifically selected for low-seismic risk (Price and Adams Jr, 2016). Earthquakes can be triggered by the re-injection of wastewater because, if millions of gallons are injected permanently into a well, the pressure can build up so much that it weakens the rock (Prud'homme, 2014). Rock may be weaker in some areas over others, which is why carefully selecting appropriate injection wells is important in the prevention of seismic activity. However, if a suitable reinjection well is not available, or selection is flawed, earthquakes can result. In Canada, a reinjection well in the Holt River Basin created a 3.8 magnitude earthquake and in Oklahoma, US, a 5.7 magnitude earthquake. The Oklahoma earthquake was reported to have destroyed 14 homes and caused damage to 200 other buildings, with tremors felt across 17 different US states (Prud'homme, 2014: 90).

There are other complications surrounding wastewater and seismicity that are beyond the scope of this entry. For instance, the concept of dry hydraulic fracturing may go some way to mitigating the social and environmental issues described above, whereby large quantities of water are replaced by other chemicals and foams (Lin et al. 2018). Similarly, instead of reinjecting or treating wastewater at a treatment facility, *storage ponds* are often used, particularly in the United States, as a temporary solution (Speight, 2013). This involves leaving wastewater in a surface tank on the fracking site. This creates problems regarding the long-term feasibility of controlling the storage pond. Finally, managing water, chemicals and wastewaters on a fracking site, and through the transportation of such elements, creates the risk of spills and subsequent environmental contamination and human or environment exposure. Spills are most likely the result of handling errors or well-pad equipment failure. A study in Pennsylvania, for instance, found that for every 100 fracking wells there were 12.2 spills, leading to the release of 19,000 gallons of fluid on average per spill (Chittick and Srebotnjak, 2017: 506). Such spills have the ability to contaminate natural water systems in a multitude of different ways.

The Contamination of Natural Water Systems

Water management and contamination is a problem through the entire life-cycle of a hydraulic fracturing operation. The first problem is that, historically, only fresh water can be used for fracking as chemicals used in the fracking process work best in fresh water compared to other used, produced or brackish waters (Nicot and Scanlon, 2012). Seawater, for instance, is too saline and may subsequently cause well integrity failure, although similarly saline wastewaters are being increasingly used in fracking operations in place of fresh water (McIntosh et al. 2018: 1067). This is usually due to competing demands for fresh water. In the United States, wild fires, droughts and freshwater shortages are now commonplace leaving homeowners, farmers, small businesses and large corporations competing for water, often in areas where supply fails to keep up with demand, such as in Texas and California (Prud'homme, 2014).

The second problem is that water systems can become contaminated with either fracfluid or deep geological components. A common misconception is that the fissures created by the act of fracturing shale rock can cause those fissures to extend vertically upwards to such a degree that they crack rock immediately below a water aquifer. Technically this could happen but, in practice, this is very unlikely because of the depth of most underground shale formations (as discussed above, in the UK for instance they reside at 2-5km). Data on induced fracture propagation suggests fissures rarely extend more than 600m (Jackson et al. 2014), and most water aquifers in the UK exist only between 100-200 metres below Earth's surface (UK Groundwater Forum, no date; in Lampkin, 2018). It is also possible that fracfluid and underground components could intersect with geological faults that connect with water aquifers, or that they intersect with old abandoned wells, creating a pathway for water contamination (Stephenson, 2015). However, seismic testing, mapping and underground surveying can identify such potential problems.

There are two more likely ways that groundwater and water aquifers may become contaminated by fracking operations. The first is through accidental spillages, or intentional illegal discharge into natural water systems, as previously discussed. The second is through compromised well integrity whereby corrosion, improper installation, or disintegration over time can lead to well casings failing (or breaking), creaking a pathway for fracfluids and wastewaters to escape the well and flow into water aquifers. Most researchers agree that poor well integrity is the most significant factor that leads to wells leaking (Davies et al. 2014; Jackson et al. 2014; Pandurangan et al. 2018). Others go further than that by suggesting well integrity failure is always likely at some point, whether it be at the point of fracking operations, or in the future after wells are decommissioned (Esterhuyse et al. 2022; Lampkin, 2018; Scientific and Technical Advisory Committee, 2013). In terms of statistics, Davies et al. (2014: 239) found that "of the 8030 wells targeting the Marcellus shale inspected in

Pennsylvania between 2005 and 2013, 6.3%... have well barrier or integrity failure." Consequently, poor well integrity not only creates the potential for water contamination, but it is also associated with the escape of gases trapped within the well. However, there is another way in which gases produced from fracking operations can be released into the atmosphere consequently contributing negatively to climate change through greenhouse gas emissions. This is through the venting or flaring of waste products.

Flaring Waste Gases

The object of fracking is to collect shale gas that is trapped deep underground. Such gas can be sold, transported and used for various domestic and commercial purposes, such as for heating and cooking (Gorski and Schwartz, 2019). Shale gas varies depending on the place that it is collected, but typically contains methane along with small amounts of other gases such as butane, ethane, propane and carbon dioxide (Lampkin, 2018). Some argue that utilising methane as a source of energy is preferable to other energy components because it is more efficient when used (i.e. there is more energy contained within methane than carbon dioxide) (Karion, et al. 2013). However, methane is a powerful greenhouse gas which is approximately 34 times more potent that carbon dioxide over a twenty-year period (Belack, 2020). Therefore, when discussing the environmental impacts of fracking it is important to consider how, and the extent to which, shale gas can be released into the atmosphere and the challenges that this generates for climatic change.

There are two methods for intentionally releasing waste gases from fracking operations into the atmosphere, flaring and venting. Venting is simply the release of waste gas products, untreated. Comparably, flaring is intentionally burning waste gases in an attempt to convert potent greenhouse gases (such as methane) into less harmful byproducts, such as carbon dioxide (Willyard, 2020). The flaring and venting of waste gases may happen for a variety of operational, economic and regulatory reasons that differs from place to place. In terms of operational reasons, venting and flaring may occur due to a lack of infrastructure setup to gather, transport and process waste gases (Lorenzato et al. 2022). Depending on constituents, fracked gas may not be 'clean enough,' or of sufficient quality to be sold for commercial use (Lorenzato et al. 2022), and the cheapest disposal option for a fracking company may be to vent or flare the gas. Furthermore, the regulatory framework of the jurisdiction where fracking is taking place may permit venting or flaring, or enable it to occur at certain maximum levels. However, regardless of why venting and flaring processes take place, it is clear that such processes create a significant amount of environmental harm, contributing substantially to global warming. As Willyard (2020: 1) states:

> "In 2005, 7743 million cubic feet of natural gas worth nearly $57 million was wasted by flaring or venting at extraction sites in Texas; by 2015 the amount grew over tenfold to 100,388 million cubic feet worth over $427 million. (Interestingly), Texas residents consumed 211,379 million cubic feet of gas in 2015. So in 2015, the amount of gas wasted from venting and flaring in Texas could have provided nearly half of the natural gas consumed by its residents."

While venting is heavily restricted in regulatory and legal regimes around the world due to significant environmental impact concerns, flaring waste gases from fracking is much more commonplace and often a perfectly legal industrial practice. This state of affairs suggests that it is not an environmental crime to flare waste gases, despite the environmental harm created. However, crimes have been committed by individuals and companies as a result of unconventional hydraulic fracturing. It is important to discuss these issues in order to understand how crimes can be prevented and the environment protected.

Is Fracking a Crime?

The issues discussed in this entry so far are a good example of how the social and environmental harms of fracking can overlap. White (2020: 69) characterises this interplay between social harm, environmental harm and the exploitation of natural resources as a form of "social conflict." Indeed, all the environmental harms described by Lampkin (2018) in Table One can be viewed as examples of social conflict. Well integrity issues, for instance can create problems with contaminated water supplies, ongoing impacts to water aquifers, and climate change, all of which negatively impact humans. Seismicity can impact the structural integrity of buildings (Sarhosis et al. 2021), flaring of gases creates visual disturbance and climatic impacts, and fracking wastewater is problematic to dispose of safely. These are all forms of social conflict that have direct impacts on the quality of life of people in areas undergoing unconventional fracking. These create resistance toward fracking processes around the world, and has even been debated as conflicting basic human rights, such as the right to respect for private life, home and correspondence (Article 8), and the right to peaceful enjoyment of one's property (Protocol 1, Article 1) (Aczel and Makuch, 2018; Short et al. 2015).

Despite the social and environmental problems associated with fracking there have been few studies that have analysed fracking-related crimes (Ruddell, 2017; Short and Szolucha, 2019). This is despite numerous legal proceedings against fracking companies, mainly in the United States. Crimes that are linked to fracking generally fall into three categories: *Crimes of the Powerful, Consequential Crimes* and *Indirect Crimes*:

1. *Crimes of the Powerful* include crimes committed by companies that break local or national laws, policies or regulations. Crimes might involve improper disposal of wastes, a failure to decommission an abandoned fracking site, or using banned chemicals during fracking operations. These can be described as direct crimes as they result directly from the fracking process itself.

2. *Consequential Crimes* include crimes committed by those protesting against fracking (i.e. contravening trespass laws), or by states and police forces abusing their powers to use force or restricting a person's right to freedom of speech, thought and expression. These can be considered as consequential crimes, those that are committed as a consequence of fracking production.

3. *Indirect Crimes* include crimes created as a result of a fracking production processes, for instance, by employees committing crimes when engaged in contractual or time-specific fracking operations in a local community. These could involve traditional, street-level crimes, public order offences, or domestic incidents and could be described as indirect crimes. They are crimes that would not have occurred in that location without fracking, but involve separate issues from the act of hydraulic fracturing itself.

Crimes of the Powerful

Crimes committed by fracking companies can be described as a form of corporate crime or white collar crime, defined by Sutherland (1949: 9) as "crime committed by a person of respectability and high social status in the course of his occupation... (meaning) principally business managers and executives." With respect to fracking, corporate crimes often result from the intentional breaking of environmental laws or regulations, usually in an attempt to extract more gas (i.e. conducting more fracking than permitted), or to save money by improperly disposing of wastes. This happened in 2010 when ExxonMobil's subsidiary XTO

Energy dumped approximately 50,000 gallons of fracking wastewater in the Marcellus Shale region, United States. While “a Pennsylvania judge ruled that enough evidence exits to try Exxon in court for the dumping,” big companies like ExxonMobil are largely unaffected by financial penalties incurred through criminal prosecutions due to large profit-making capability (Humenik, 2014: 11). ExxonMobil, for instance, has revenue that is greater than the gross domestic product of some countries, such as Thailand (Short et al. 2015: 28).

The disposal of fracking wastes such as produced waters and gases are usually subject to environmental legislation, regulation and monitoring, all of which varies from place to place dependent upon the laws and policies of the jurisdiction. However, environmental regulators often do not have the time or resources to track and oversee the waste management of all fracking companies and operations, creating a dark figure of environmental crime (Ospal and O’Connor Shelley, 2014). This can lead to crimes of denial and omission whereby fracking companies fail to accurately report waste management practices (a crime of *omission*), or they deny responsibility for creating environmental harm (a crime of *denial*) (Kramer and Bradshaw, 2020). This happened in the United States where the Environmental Protection Agency has been criticised for failing to safely regulate the fracking industry. As Bernstein (2021: 36-37) states:

> “The case law shows that those charged with environmental crimes often committed crimes of omission by failing to report and dispose of wastes and pollutants properly. Comparably, the grand jury report describes numerous instances where the agency’s negligent and knowing lack of action in regulating fracking led to injury to citizens and their property.”

Crimes of the powerful relating to fracking also include tax evasion, fraud, bribery and health and safety violations. For instance, Boyce (2016) reported that Halliburton failed to pay US$18 million dollars of wages to over 1000 employees. Similarly, Chesapeake Energy’s former Chief operating Officer “was charged with conspiring to rig bids (as well as price fixing and other anti-competitive conduct) for the purchase of oil and natural gases in northwestern Oklahoma” (Ruddell, 2017: 100).

In terms of health and safety, employees of gas companies working at fracking sites are exposed to health risks from impacted air quality and exposure to dust, chemicals and silica sand which impact the human respiratory system (Esswein et al. 2019). These unique exposure risks have led to fracking workers being described as a *vulnerable population* (Korfmacher et al. 2013), working in one of the most dangerous industries in America. Although there are around 9.8 annual fatalities for every 100,000 workers in US mining, quarrying and oil and gas extraction industries, “rarely do crimes resulting in worker injuries or deaths result in prison sentences for corporate executives, as fines are imposed for most (health and safety) violations” (Ruddell, 2017: 103). Consequently, whilst regulations exist to protect oil and gas industry workers, there is a lack of accountability and deterrent effect to ensure that those regulations are effectively enforced and monitored.

Consequential Crimes

The previous section discussed crimes of the powerful that are a direct consequence of fracking operations. However, crimes are also committed because fracking has occurred (or is likely to occur), but that are not directly related to unconventional drilling itself. For instance, fracking protestors are often arrested on suspicion of crimes relating to trespass, highway obstruction, and street crimes when attempting to disrupt fracking production operations (Gilmore et al. 2019). Conversely, the police have been found to act unlawfully and abuse their powers (such as to detain and arrest) during anti-fracking campaigns, infringing the rights of citizens to protest peacefully. Following anti-fracking campaigns at Barton Moss near Manchester (UK) in 2014, the protest was found to be “underpinned by a disproportionate policing operation by GMP (Greater Manchester Police), repeatedly violent and aggressive (tactics, which was) incompatible with the size and nature of the protest” (Gilmore et al. 2016: 43). Similar studies relating to the disproportionate use of police presence and violence in anti-fracking campaigns have been found around the world such as in Maryland, US (Finley-Brook et al. 2018), Canada, Romania and Argentina (Environmental Defence Canada, 2020). In the Argentinian case:

> “Mapuche communities protested the development of a potentially huge fracked gas field in the Neuquén basin. In 2013, 5000 people came out to protest shale gas exploration in the region and met a violent police response, with four houses burnt to the ground” (Environmental Defence Canada, 2020: 13).

A further consequence of natural gas production relates to the impact such activity may have on future generations of humans. While fracking is legally permitted in countries like the United States, Canada, the Netherlands and Australia, their clear contribution towards harmful climatic change has led some to label fracking as a form of climate crime (Bloom, 2013; Kramer and Bradshaw, 2020). Agnew (2011: 38) defines climate crimes as "any behaviour classified as a blameworthy harm, subject to at least modest condemnation by a significant portion of the public, or classified as a crime or 'crime-like' civil violation by the state". Consequently, Kramer and Bradshaw (2020) make the argument that fracking meets this definition because it is a blameworthy harm involving intentionally harmful behaviour that is purposeful, knowledgeable, reckless and negligent. In the UK, fracking was originally legislated for through section 43 of the *Infrastructure Act*, enacted by the UK government in February 2015. This was in spite of other legislation that committed the UK government to address activities that contribute to climate change. For instance, the UK government passed the *Climate Change Act 2008* which was to ensure that "the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline" level (Lampkin, 2018: 65). While the UK government's justification for supporting fracking used the *bridge fuel* narrative (Nyberg et al. 2018), arguing that the increased efficiency of gas as a fossil fuel compared to other resources (i.e. coal, oil) legitimises the exploration and production of natural gas, this was in spite of the known risks associated with uncontrolled and natural release of gas through fracking processes. For instance, it is estimated that methane is "25 times more potent than carbon dioxide over a 100-year time horizon" (Karion et al. 2013: 4393). Consequently, it is clear that the UK government supported the creation of a fossil fuel industry in the UK, in spite of known contributions to climate change, and in spite of public opposition to a shale gas industry. The Department for Business Energy and Industrial Strategy (2017) reported public support for shale gas to be at just 13% in 2017, in comparison to 36% opposing the industry. This situation is aligned to Kramer and Bradshaw's (2020) definition of a climate crime.

Indirect Crimes

Indirect crimes are those crimes that are not directly related to a fracking activity (such as the illegal dumping of wastes), but that occur as a general consequence of fracking operations occurring in a particular area. For instance, Shaka and Sohag (2021) studied crime rates in rural US states with high incidences of fracking activity, such as West Virginia, North Dakota and Arkansas. They found that shale booms increase crimes, and especially violent crimes, in rural US states, compared to other rural US states that do not experience high levels of fracking activity. Their explanation for the increase in crime is due to the fracking industry recruitment of "low-skilled and temporary migrant male workers with criminal records (who are) inclined to commit crimes" (Shaka and Sohag, 2021: 8). Such findings are supported by other research that has found increases in female rates of victimization in high-fracking areas. For instance, Barry (2011, in: McHenry, 2017: 90) found "a steady increase in crimes against women such as domestic violence and sexual assault... (that was) correlated to communities where fracking occurs" (Barry, 2011 in: McHenry, 2017: 90). James and Smith (2014, in: Tosh and Gislason, 2016: 5) also showed "that young men are responsible for around 90% of (reported) violent crime, particularly young men." This is due to the fracking workforce being dominated by those with a criminal history who "are more likely to work in the industry due to difficulties in gaining employment with a criminal record" in other occupations (James and Smith, 2014 in: Tosh and Gislason, 2016: 5).

While Street (2018) found that fracking may initially decrease crime in an area beginning a shale gas boom, Stretesky and Grimmer (2020) found that 24 of 25 empirical US studies researching the relationship between fracking and crime all found a positive relationship between fracking and crime. In particular, they found that "a majority of studies... (suggest) shale gas development increases total crime, violent crime, property crime, social disorganization crimes and violence against women" (Stretesky and Grimmer, 2020: 1154). Ultimately, the relationship between fracking and indirect crimes will vary depending on the scale and duration of fracking activities, as well as a variety of other factors such as local community cultures, the composition of the workforce, and previous experiences with natural resource boom and bust cycles (O'Connor, 2017, in: Stretesky and Grimmer, 2020: 1154). However, there is overwhelming evidence of a positive correlation between fracking and crime.

Conclusion

This encyclopaedia entry has provided an introduction to arguments concerning the social and environmental harms and crimes associated with unconventional hydraulic fracturing. It is clear that fracking creates a multitude of harms that vary over time and place, and the industry is associated with a variety of different crimes. This entry divided crimes into three main crime types (crimes of the powerful, consequential crimes and indirect crimes) showing the complexity of the relationship between fracking and crime.

Despite the known social and environmental impacts of crime, many national and sub-national governments continue to support fracking operations, arguably prioritising wealth and profit-making over social and environmental disorganisation. A useful mechanism for government's pondering the implementation of fracking activity, may be to take a utilitarian approach and conduct a cost-benefit analysis considering the social, environmental and economic gains and consequences of fracking. The principle of utility acknowledging that actions should result in the greatest amount of good for the greatest number of stakeholders (in this case, local communities, workers and the environment) would most likely conclude that fracking creates so much social and environmental harm that other forms of energy generation should be considered first. When applying a utilitarian philosophy to unconventional fracking practices, Lampkin (2016) proposes the adaption of more renewable forms of energy to overcome the social and environmental problems associated with non-renewable resource extraction. Investing in renewable energy will likely result in lower levels of social and environmental harm (Akella et al. 2009).

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