Northern Ireland Assembly

Research and Information Service
Research Paper

27 January 2023

Bea Baharier

Reducing and offsetting methane emissions

NIAR 5-23

The following paper explores a number of different options to reduce and offset methane emissions.

Paper 02/23 27 January 2023

Key Points

- The Climate Change Act (Northern Ireland) 2022 calls for an overall net-zero emission target by 2050. However, methane will not be required to be reduced by more than 46% to achieve the overall target due to the impact it has on the agriculture sector.
- This paper examines a range of methane mitigation measures posited by local companies, non-governmental organisations and academics. The potential role to be played by peatlands – as either a sink or an emitter of greenhouse gases – is also summarised.
- The main methane from agriculture originates directly from animal digestive systems and their waste. Both can potentially be reduced by improving the animal's health, giving them food additives and waste management. Manure can be used as an additional source of income through the production of energy and fertilizers.
- Alternative protein sources with lower emissions are an international growing market and may have a global impact on the agriculture sector by producing cheaper alternatives and may result in less demand for animal protein.
- Restoring peatlands can be a net CO_2 sink over a 100-year horizon and a methane emitter over the short term. Managing the peatland water table depth and vegetation can mitigate methane emissions and allow economically viable peatlands to continue being utilized for agriculture.
- Climate engineering solutions such as Iron Salt may be a low-cost solution for methane emissions in the atmosphere and within peatlands.
- Methane leakage from the energy sector is particularly under-reported, and better management of energy lost within the sector can further reduce emissions.
- Surveying 'cleantech' local expertise and innovation companies located within Northern Ireland, such as CATAGEN and Artemis Technologies, provides further insights into potential mitigation possibilities and ways to offset emissions from other industries within and outside Northern Ireland.

Contents

1 Background

At the 2021 COP26 summit in Glasgow, the Methane Pledge was launched and signed. The pledge aims to combat the climate crisis by reducing 30% of methane emissions by 2030 to reduce 0.2˚C warming by 2050[1]. The UK is amongst the 130 countries which have signed the pledge. The pledge has a range of direct political, cultural and economic implications.

The economist William Nordhaus has suggested that climate policy could be studied within a cost-benefit framework. He describes emissions as an 'external cost'[2]:

> "*The problem is that those who produce the emissions do not pay for that privilege, and those who are harmed are not compensated. Economists call such costs externalities because they are external to (i.e., not reflected in), market transactions or prices. An externality is a by-product of economic activity that causes damage to innocent bystanders."*

While the Methane Pledge has environmental importance, it could also have a significant effect on the livelihood of rural communities and on cultural heritage.

Until recently, Northern Ireland has been an outlier in the UK and Ireland as it did not have climate change laws. However, in 2022, the Climate Change Act (Northern Ireland) was passed in the Northern Ireland Assembly[3]. Before the Act, there were concurrent bills, firstly a Private Member's Bill introduced by Clare Bailey MLA calling for net zero by 2045, and an Executive Bill brought forward by DAERA Minister Edwin Poots MLA calling for an 82% reduction in emissions by 2050[4]. One of the major debates during the passage of these bills

---

[1] Global Methane Pledge

[2] Prof. Nordhaus, William. *The climate casino: Risk, uncertainty, and economics for a warming world*. Yale University Press, 2013 (pp 18-19)

[3] Climate Change Act (Northern Ireland) 2022

[4] Clements, A. 22.3.22. 'We have a Climate Change Act! (well, nearly)', Ulster Wildlife

was around methane emissions as agriculture is the largest methane producer within Northern Ireland (NI)[5]. As a response to the Private Member's Bill, the Ulster Farmers Union (UFU) commissioned KPMG to produce an economic impact assessment of net zero by 2045[6]. According to the report, the bill had the potential to bankrupt the agriculture industry, lead to substantial job losses and result in a reduction of around £11 billion in economic yield. However, the report only addressed the agriculture sector, whereas the bill would have impacted all sectors, thus introducing potential biases. Nevertheless, it is the only NI impact assessment done to date. Moreover, the KPMG report was produced using limited data, without a baseline for NI and did not account for the different mitigations available, such as nature-friendly farming[7]. The final Climate Change Act (Northern Ireland) 2022 has an overall 2050 net zero target with methane required to be reduced by up to 46%[8].

By way of comparison, in October 2022, New Zealand farmers protested the government's plans to tax agricultural emissions to support the country's pledge to become carbon neutral by 2050[9]. The farmers claim the taxation targets livestock methane gases that could put them out of business[10]. In Northern Ireland, 77% of methane emissions are produced by agriculture, presenting a significant challenge for climate policymakers here also (for a full report on Northern Ireland methane emissions, see Briefing Paper NIAR 175-21).[11]

Within this research paper, the subject of methane emissions will be discussed to understand some of the scientific options for reduction or mitigation. A summary of different potential solutions is provided with a cost-benefit framework exploring their potential economic and cultural impacts on local businesses and communities.

---

[5] Northern Ireland Statistics and Research Agency. 2021. Northern Ireland Greenhouse Gas Emissions 1990-2021.

[6] Ireland's 2030 Carbon Emissions Targets - An Economic Impact Assessment for the Agriculture Sector

[7] BBC New, 2021 Climate bill will be ruination of NI agriculture, says UFU

[8] Poots welcomes ground-breaking Climate Change legislation for NI

[9] Farmers protest 'unworkable regulations' of New Zealand's proposed farm levy

[10] Nineteen years after the 'fart tax', New Zealand's farmers are fighting emissions

[11] Methane and Biogenic methane – an overview. NIAR 175-21. Research and Information Service Briefing Paper

2 Introduction to methane

Methane (CH_4) is the second most significant greenhouse gas (GHG) after carbon dioxide (CO_2). It is one of the short-lived climate pollutants, which account for up to 20–30% of the global warming effect[12-13]. Although the lifespan of CH_4 in the atmosphere is just ~8 years, due to its strong capacity to trap heat in the first 20 years, it is 84 times more potent than CO_2, and in the following 100 years, it is 28 times that of CO_2[14]. Methane is a natural gas released predominantly by microbial activity[15], with 62% of natural emissions sourced from wetlands and the rest is from different geological sources, vegetation, terrestrial arthropods, wild animals, natural water bodies (such as oceans and rivers) and wildfires[16-17].

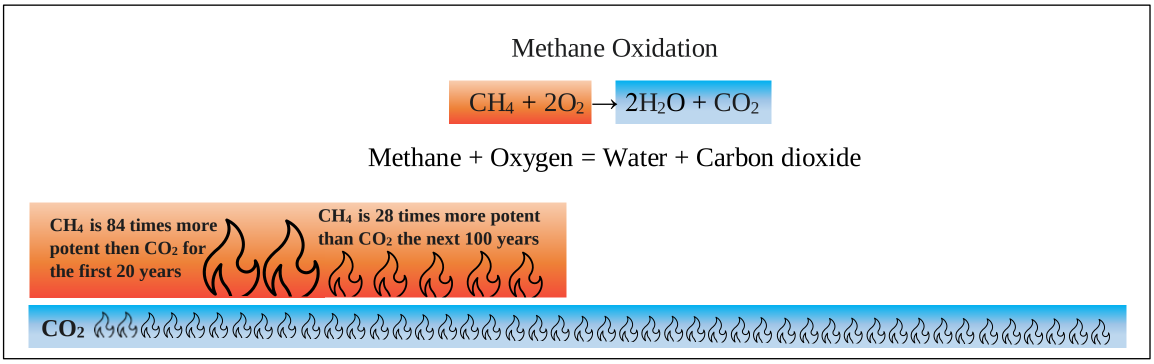


Figure 1. The top equation illustrates the oxidation of methane to carbon dioxide. Bottom illustration of methane versus carbon dioxide potency over time. Illustrated by Bea Baharier based on Jackson et al., 2019[15]

Since the industrial revolution, anthropogenic (man-made) methane production has increased, with global anthropogenic activity accounting for 63% (566 Tog CH_4/year)[17]. The majority of emissions are from the northern hemisphere and

[12] IPCC (2001) Climate change 2001: the scientific basis. In Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Chang

[13] Eusufzai, Moniruzzaman Khan, et al. "Methane emission from rice fields as affected by land use change." *Agriculture, ecosystems & environment* 139.4 (2010): 742-748.

[14] Jackson, R. B., et al. "Methane removal and atmospheric restoration." *Nature Sustainability* 2.6 (2019): 436-438.

[15] Conrad, R. (1996) Soil microorganisms as controllers of atmospheric trace gases (H2, CO, CH4, OCS, N2O, and NO). Microbiol Rev 60: 609–640.

[16] Kirschke, Stefanie, et al. "Three decades of global methane sources and sinks." *Nature geoscience* 6.10 (2013): 813-823.

[17] Bousquet, Philippe, et al. "Contribution of anthropogenic and natural sources to atmospheric methane variability." *Nature* 443.7110 (2006): 439-443.

sourced from the fossil fuel industry, livestock, landfills, rice agriculture and the burning of biomass[18]. Around 60% of methane production derives from agriculture and the fossil fuel industry[19]. With the growing global population and the increased demand for food, fossil fuels and the resultant waste, anthropogenic emissions are likely to increase further. In addition to direct emissions, it is estimated that if the oceans continue warming, within the next 100 years, around 473 tons of CH_4 dissolved in seawater will be released into the atmosphere[20]. Therefore, reducing the amount of methane released into the atmosphere in the short term versus CO_2 can have a positive impact in helping to keep the global temperature down.

Methane is produced by microbial anaerobic decomposition of organic matter accumulating in anoxic environments (with very little to no oxygen). Methane can then be oxidised microbially to CO_2 in oxic environments (with oxygen). As Earth's atmosphere has oxygen, for methane to reach the atmosphere it needs to be transported from the anoxic environment it had formed in. The transition of CH_4 to CO_2 can happen during that transport on the boundary of anoxic/oxic environments before it is released into the atmosphere.

Tackling methane emissions can be done in three ways:

1. Cessation of methane-producing activity/industry by creating alternative industries and practices within the different trades.
2. *In situ* methane transformation before atmospheric release to mitigate emissions from point sources such as landfills, agriculture and peatlands.
3. Geoengineering is the human manipulation of the climate system. These include methods such as metal catalysts associated with zeolites and iron-salt aerosol formation.

It is important to note that geoengineering is of relevance for policymakers as it has ethical and long-term concerns including the overall effect it may have on

[18] Lelieveld, J. (2006) Climate change: a nasty surprise in the greenhouse. Nature 443: 405–406

[19] Saunois M, Stavert AR, Poulter B, et al. The global methane budget 2000–2017. Earth Syst Sci Data. 2020;12(3):1561-1623

[20] Kretschmer K, Biastoch A, Rüpke L, Burwicz E. Modeling the fate of methane hydrates under global warming. Global Biogeochem Cycles. 2015;29(5):610-625.

the environment. Such effects may be destructive, agreeing to take local risks that may have a devastating effect on a broader area than intended. Geoengineering may also involve avoiding solving the root of the problem which creates a reliance on technology that will be inherited to future generations. It has been proposed that as the current ecological crisis is due to the use of technological innovations and the attempt to control nature, keeping the same line of thought and action may increase the climate crisis[21].

Moreover, although geoengineering is considered part of a global agenda as discussed during COPs 26 and 27, this may not be a viable solution on the local scale for Northern Ireland, financially and the overall global effect.

In November 2022, the London-based think tank Green Alliance published a paper, 'The Global Methane Pledge – How the UK can meet its commitment'[22]. In this paper, they have looked at the main UK methane emission sectors: agriculture, forestry and land use, energy and waste. Green Alliance propose a number of mitigation measures designed to reduce 43% of emissions in 2030[23].

3 Agriculture and methane reduction methods

This section summarises some of the methods that have been proposed to reduce agriculture's levels of methane emissions. Green Alliance proposes, for example, that across the UK, methane emissions from agriculture could be cut by 15% by increasing food system productivity, giving feed additives to dairy cows, managing slurry and transitioning to plant-based alternative protein sources[22].

3.1 Enteric methane

Enteric methane refers to that which is produced in the intestines of farm animals, predominantly ruminants. Ruminants are an important part of the

[21] Scott, D. (2012) Geoengineering and Environmental Ethics. Nature Education Knowledge 3(10):

[22] The Global Methane Pledge – How the UK can meet its commitment

[23] Department for Business, Energy and Industrial Strategy (BEIS), 'National Atmospheric emissions

global food supply as they can convert fibre-dense feeds that are inadequate for human consumption to bioavailable nutrients[24]. Globally, the livestock sector supplies 51% of all protein, out of which 67% is from milk and 33% from meat[25].

Within the ruminant sector, cattle contribute about 64 and 600 million tonnes of meat and milk. Respectively, this is about 79 and 83 per cent of total meat and milk production from ruminants globally[26-27]. Consumer demand for beef is projected to increase by 80% by 2050[28]. Global milk production is ~83% cattle-based and is predicted to increase by 33% by the end of the decade[29] . Moreover, animal protein production supports the livelihood of millions of farmers worldwide and around 430 million rural and marginal communities are livestock farmers[25]. Although ruminants are incredibly important to the global food supply and livelihoods of rural areas, they utilise more land than any other livestock and produce enteric methane, which accounts for ~39% of the sector's total emissions[30]. Enteric fermentation happens within the digestive system of ruminants as microbes decompose the food ruminants. The fermentation process creates enteric methane, which is released into the atmosphere when the animal burps. Although this is a natural reaction, the higher global demand for ruminants will increase the amount of enteric methane. Moreover, the amount of enteric methane created is directly associated with the feed quality and type, animal size, energy intake, growth rate and environmental temperature. Therefore, it is possible to improve ruminants' conditions to reduce enteric methane. The question is whether there could be a mutually beneficial solution for farmers and the environment.

---

[24] Mottet A, de Haan C, Falcucci A, Tempio G, Opio C, Gerber P (2017) Livestock: on our plates or eating at our table? A new analysis of the feed/ food debate. Global Food Security 14, 1–8.

[25] Reducing Enteric Methane for Improving Food Security and Livelihoods, Food and Agriculture Organization of the United Nations (FAO), New Zealand., 2016

[26] Opio C, Gerber P, Mottet A, Falcucci A, Tempio G, MacLeod M, Vellinga T, Henderson B, Steinfeld H (2013) 'Greenhouse gas emissions from ruminant supply chains: a global life cycle assessment.' (Food and Agriculture Organization of the United Nations: Rome, Italy)

[27] Ritchie H, Roser M (2019) Meat and dairy production. Our World in Data

[28] Nadathur SR, Wanasundara JPD, Scanlin L (2017) Proteins in the diet: challenges in feeding the global population. In 'Sustainable protein sources'. (Eds Nadathur SR, Wanasundara JPD, Scanlin L) pp. 1–19.

[29] OECD/FAO (2018) 'OECD–FAO agricultural outlook 2018–2027.' (Organization for Economic Cooperation and Development Paris, Food and Agriculture Organization: Rome, Italy)

[30] Knapp, Joanne R., et al. "Invited review: Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions." *Journal of dairy science* 97.6 (2014): 3231-3261.

According to the Food and Agriculture Organization of the United Nations, this is possible by improving feed and nutrients, animal health, genetics, and breeding[25]. They suggest that feed can be improved by grassland management improvement, refined species selection, and the use of local supplementation. Consequentially, the animals' health improvement will result in increased reproduction rates, limiting diseases and premature animal death, nutrient uptake resulting in weight gain and enhanced milk yield and quality. This, in turn, may benefit both farmers and a growing population. Moreover, they suggest that animal genetic selection and breeding are key to breeding animals to adapt to climate change[25].

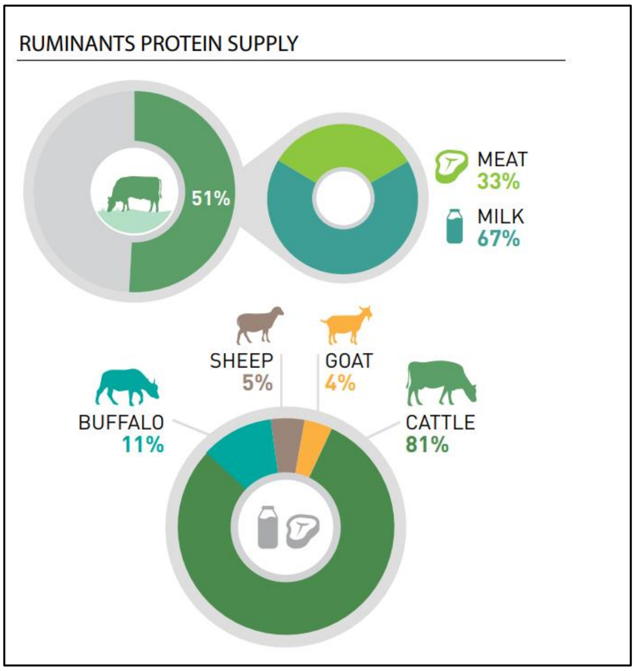


Figure 2. Illustration of the ruminants' supply of protein Source: Food and Agriculture Organization of the United Nations (FAO), New Zealand., 2016

It has been suggested that reducing the overall incidence of disease among ruminants will help reduce methane emissions. As the UK system is predominantly pasture-based, it is especially vulnerable to endemic diseases such as Infectious Bovine Rhinotracheitis (IBR)[33]. It has been suggested that improving their health conditions will lead to improvement in production, and fertility rates, reduce abortion rates and increase growth rate[33-31]. Scotland's

[31] Skuce, P J et al. 2016. 'Livestock health and greenhouse gas emissions'. ClimateXChange. Edinburgh.

Rural College estimated that the cost and effect of health improvement to be around a +6.38% productivity improvement in beef and +10.45% in sheep, including milk yield and beef liveweight, and will cost around £27.8 head^{-1} and £7.70 head^{-1}, respectively[32].

3.1.1 Food additives

Several food additives for reducing enteric CH_4 are being researched. This section provides some examples of this ongoing area of research. Table 1 below summarises the current state of research into a number of different examples of potentially methane-reducing food additives.

The Dutch multinational corporation Royal DSM has developed an enteric methane-reducing feed additive which claims to reduce dairy cows' methane emissions by at least 40%. Moreover, with further research, the use of 3-NOP has the potential to further cut emissions by 60-90%[33]. The restriction on dairy cows is due to feed distribution as it needs to be given regularly, which is challenging with outdoor grazers.

The marketing of DSM feed additive Beaver/3-NOP was officially approved by European Union (EU) Member States in February 2022[34].

Currently, it has not yet been approved by the UK Food Standards Agency. According to the Green Alliance report, adding Bovaer® to feed will cost the consumer 33p a year. They based their calculation on the proposed minimum methane reduction (20-30 %) to the cost of carbon (£85/t CO_2) and the yearly cost per head (38 head^{-1})[35].

However, as the Royal DSM is located in the Netherlands and is produced and distributed within the EU, there are potential other cost-effect implications. The transport of the supplement may by itself have an effect on its carbon footprint.

[32] Non-CO2 abatement in the UK agricultural sector by 2050 Summary report submitted to support the 6th carbon budget in the UK December 2020

[33] N Walker, June 2021, Methane inhibitors: Update on the methane inhibitor Bovaer® (3-NOP)

[34] DSM receives landmark EU market approval for its methane-reducing feed additive Bovaer®

[35] Non-CO2 abatement in the UK agricultural sector by 2050 Summary report submitted to support the 6th carbon budget in the UK December 2020

Researchers from Australia have investigated the addition of marine red seaweed *Asparagopsis taxiformis* in livestock feed and found promising evidence it can essentially remove enteric methane emissions. In a 2020 study, they found that by feeding as little as 0.2% of *Asparagopsis* there is a 98% enteric methane reduction[36]. Over the 90 days, the taste quality was not harmed. Such a small amount added to the diet would suggest small additional costs. Moreover, although *Asparagopsis* is endemic to the southern hemisphere, it arrived in the seas around Ireland in the last century and is commercially cultivated on a seaweed farm[37]. However, there are still potential health risks for the animal and food consumption, such as selectively increasing other elements found within the seaweed, such as iodine within the meat. Moreover, although the Irish waters were found suitable for *Asparagopsis* growth, survival and asexual reproduction, but may be too cold for sexual reproduction[38]. Further research on the *Asparagopsis armata* anti-methanogen properties and cultivation is currently taking place at the Bantry Marine Research Station[39]. A report for the Global Research Alliance (GRA) of agricultural greenhouse gases (GRA) in 2021, has graded the confidence in efficiency of all potential supplements and *Asparagopsis* was given low confidence (see Table 1) due to the small amount of peer-reviewed papers and unknown health side effects[40]. Moreover, large-scale farming of non-native seaweed may have its downside on biodiversity and GHG emissions. This may be an option for further investment in the research and development of *Asparagopsis* cultivation and use as a feed additive.

The native seaweed of Ireland and the UK are brown and green variants, which have additional benefits as they contain anti-bacterial phlorotannins[41]. Feeding

---

[36] Kinley RD, Martinez-Fernandez G, Matthews MK, de Nys R, Magnusson M, Tomkins NW (2020) Mitigating the carbon footprint and improving productivity of ruminant livestock agriculture using a red seaweed. Journal of Cleaner Production 259, 120836.

[37] Kraan, Stefan, and Kelly A. Barrington. "Commercial farming of Asparagopsis armata (Bonnemaisoniceae, Rhodophyta) in Ireland, maintenance of an introduced species?." *Journal of Applied Phycology* 17.2 (2005): 103-110.

[38] Kraan, Stefan, and Kelly A. Barrington. "Commercial farming of Asparagopsis armata (Bonnemaisoniceae, Rhodophyta) in Ireland, maintenance of an introduced species?." *Journal of Applied Phycology* 17.2 (2005): 103-110.

[39] Bantry Marine Research Station, Cultivation of the seaweed Asparagopsis armata in Ireland

[40] An evaluation of evidence for efficacy and applicability of methane inhibiting feed additives for livestock, November 2021

[41] Seaweed supplements could significantly reduce livestock methane emissions, School of Biological Sciences, Queen's University, 2021

livestock phlorotannins may improve overall animal health. Research on the use of local seaweed to reduce emissions is currently being conducted and trailed by the Institute for Global Food Security (IGFS) and the School of Biological Sciences researchers at Queen's University Belfast. Moreover, the Northern Ireland Agri-food and Biosciences Institute (AFBI) and the IGFS have joined a collaboration with Teagasc (the Irish state agency for research and development in the agri-food sector). This is a €2 million project aimed at studying the effect of feeding seaweed to Northern Ireland dairy cows.

Additive	Efficacy: CH_4 reduction potential [1]	Efficacy: No. of academic papers [2]	Efficacy: Confidence in efficacy [3]	Potential animal welfare risks	Potential food safety risks	Potential co-benefits	Production system applicability [4]	Development needs
3-Nitrooxypropanol	Very High	> 20	5	None known	None known	Improved feed efficiency.	TMR systems immediately. Grazing systems in future.	Validation in large-scale TMR systems required. Formulation for grazing systems.
Asparagopsis	Very High	< 10	1	Damage to rumen wall	Bromide & iodine residues in animal tissue/products	Improved feed efficiency.	TMR systems immediately. Grazing systems in future.	Validation in large-scale TMR systems required. Formulation for grazing systems.
Nitrate	High	< 20	4	Toxicity in non-adapted animals	None known	Can reduce need for urea supplementation in animal feed.	TMR systems immediately. Grazing systems in future.	Validation in large-scale TMR systems required. Formulation for grazing systems.
Essential Oils	Low	< 20	2	None known	None known	Improved milk productivity (limited evidence & indication of reduced body growth).	TMR & grazing systems (where supplements are administered)	Peer reviewed studies of mitigation potential and productivity within TMR & supplement systems.
Saponin	Low	< 15	1	None known	None known	Improved protein supply by protozoa control.	TMR & grazing systems (where forage crops containing saponin are utilized)	Further research into CH_4 reductions, productivity impacts & saponin chemistry required.
Tannins	Low	< 15	2	None known	None known	Shift from urine to faecal excretion of nitrogen reducing risk of N_2O emissions.	TMR & grazing systems (where forage crops high in tannins are utilized)	Tannins may have a stronger role in forage-based mitigation than as feed additives.
Monensin	Low	> 20	5	None known	None known	Improved weight gain. Reduced risk of bloat & acidosis.	TMR & specialized grazing systems	Few needs – already a widely used product.
Microalgae	Low	< 5	1	None known	None known	PUFA levels in meat improved. Enhanced antioxidants in food products.	TMR & grazing systems (where supplements are administered)	Microalgae supply dependent on use in renewable energy sector.
Biochar	Low	< 5	1	None known	None known	Toxins & heavy metals absorption prevention in animals. Enhanced soil quality when excreta is applied to soils.	TMR & grazing systems (where supplements are administered)	Engineering of an acidified biochar required to achieve adequate efficacy.
Bacterial Direct Fed Microbes	Low	< 15	2	None known	None known	Improved productivity (though inconsistent). Improved calf health. Reduced incidence of E.coli in manure.	TMR & grazing systems (where supplements are administered)	Development of high efficacy bacterial strains.
Fungal Direct Fed Microbes	Low	< 15	1	None known	None known	Improved productivity (+ 3% in milk observed). Improved feed efficiency.	TMR & grazing systems (where supplements are administered)	Development of high efficacy fungal strains.

Table 2. Summary of feed additives mitigation efficacy. Source: The Global Research Alliance (GRA). "An evaluation of evidence for efficacy and applicability of methane inhibiting feed additives for livestock"

3.1.2 Managing slurry

One of the methane-producing 'ecosystems' is animal dung, making this an additional CH_4 source from agriculture. The rate and the amount of CH_4 production in animal dung are relative to the animal type, increasing temperature, the organic material available and different physical, chemical and biological factors. Furthermore, animal dung can emit ammonia (NH_3), which can indirectly promote N_2O emissions, which is a potent GHG and can react with the Earth's ozone layer[42]. Both CH_4 and N_2O can be released at the excretion location and later when the manure is applied to crops as a fertiliser[43].

Animal dung is divided into a liquid slurry and solid manure, with slurries having a higher CH_4 production and manure being a higher source of N_2O[44]. Thus, manure type and agriculture type would have different mitigation management requirements. Intensive dairy farming commonly forms slurries[45], which, due to their liquid nature, are anaerobic, the perfect environment to form CH_4. As the formation of CH_4 is inhibited by oxygen, it needs to form and travel through the slurry before it is released into the oxygenated atmosphere.

Two of the main ways to reduce CH_4 emissions is by creating a natural or artificial crust over the liquid slurry and manure acidification which is already a regular practice in Denmark and is approved Best Available Technology (BAT)[46].

[42] Aronson, Emma L., and Steven D. Allison. "Meta-analysis of environmental impacts on nitrous oxide release in response to N amendment." *Frontiers in microbiology* 3 (2012): 272.

[43] Jayasundara, Susantha, et al. "Methane and nitrous oxide emissions from Canadian dairy farms and mitigation options: An updated review." *Canadian Journal of Animal Science* 96.3 (2016): 306-331.

[44] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 10: Emissions from Livestock and Manure Management

[45] VanderZaag A. C., MacDonald J. D., Evans L., Verge X. P. C., Desjardins R. L. (2013). Towards an inventory of methane emissions from manure management that is responsive to changes on canadian farms. Environ. Res. Lett

[46] Habtewold J., Gordon R., Sokolov V., VanderZaag A., Wagner-Riddle C., Dunfield K. (2018). Targeting bacteria and methanogens to understand the role of residual slurry as an inoculant in stored liquid dairy manure. Appl. Environ. Microbiol. 84:e02830–17. 10.1128/AEM.02830-17

3.1.3 Manure acidification

Some methanogens[47] have optimal growth in a pH of 7. As slurry acidification lowers the pH, it inhibits some of the growth and activities of the microbes, resulting in lower CH_4 emission[48]. Research has indicated that the acidification of cattle slurry with sulphuric acid (H_2SO_4) reduced 68% of emissions[49], over 90% of pig slurry emissions[50] and around 80% of fresh dairy slurry[47]. After initial acidification, H_2SO_4 reacts to form plant-available sulfate and can be further used[51].

Furthermore, research conducted in Denmark found that sulphuric acid acidification of pig slurry can reduce NH_3 emission by 70% and at the same time, substantially increase the nitrogen content of the slurry, making it a higher potent fertilizer than non-treated slurry[52]. In a cost-benefit analysis by the think tank Green Alliance, it was estimated that this method would cost farmers an additional €40 per animal per year[51].

3.1.4 Slurry cover

Creating a natural or artificial crust over liquid slurry may also have a cost-benefit as it can be used to generate useful energy for the farmer's consumption or traded commercially. By oxidising the manure, it can be composted and used as a fertiliser which in effect reduces methane emission. However, storing manure in an anoxic, warm environment creates anaerobic digestion (AD) which will further promote methane production that can potentially be used as biomethane fuel. This research would suggest that by improving slurry management, the farmer can potentially increase profit and reduce energy and

---

[47] A ‘methanogen’ is a micro-organism that lives on carbon dioxide and hydrogen and gives off methane.

[48] Habtewold, Jemaneh, et al. "Reduction in methane emissions from acidified dairy slurry is related to inhibition of methanosarcina species." *Frontiers in microbiology* (2018): 2806.

[49] Sommer S. G., Clough T. J., Balaine N., Hafner S. D., Cameron K. C. (2017). Transformation of organic matter and the emissions of methane and ammonia during storage of liquid manure as affected by acidification. J. Environ. Qual. 46 514–521. 10.2134/jeq2016.10.0409; this paper was published in 2017 so cost estimates will now require some adjustment.

[50] Petersen S. O., Hojberg O., Poulsen M., Schwab C., Eriksen J. (2014). Methanogenic community changes, and emissions of methane and other gases, during storage of acidified and untreated pig slurry. J. Appl. Microbiol.

[51] Eriksen J., Sørensen P., Elsgaard L. (2008). The fate of sulfate in acidified pig slurry during storage and following application to cropped soil. J. Environ. Qual.

[52] Kai, Peter, et al. "A whole-farm assessment of the efficacy of slurry acidification in reducing ammonia emissions." *European Journal of Agronomy* 28.2 (2008): 148-154.

fertiliser costs. Biomethane could eventually be incorporated within the national gas grid as is done in Germany, France, Italy and Denmark (see Briefing Paper NIAR 82-21[53]). As part of the US Methane Emissions Reduction Action Plan, it is planned that a public-private partnership will be formed to support biogas policies, programmes, and research[54].

The UK Government has launched a Green Gas Support Scheme for incorporating biomethane into the gas grid. However, this is limited to Great Britain[55]. Currently, NI has three and half times as many AD based generating stations than in GB (by around three and half times). This is due to NI's high availability of feedstocks and the nature of previous support schemes[56] (for further details, see Briefing Paper NIAR 82-21).

3.2 The future of farming and alternative proteins

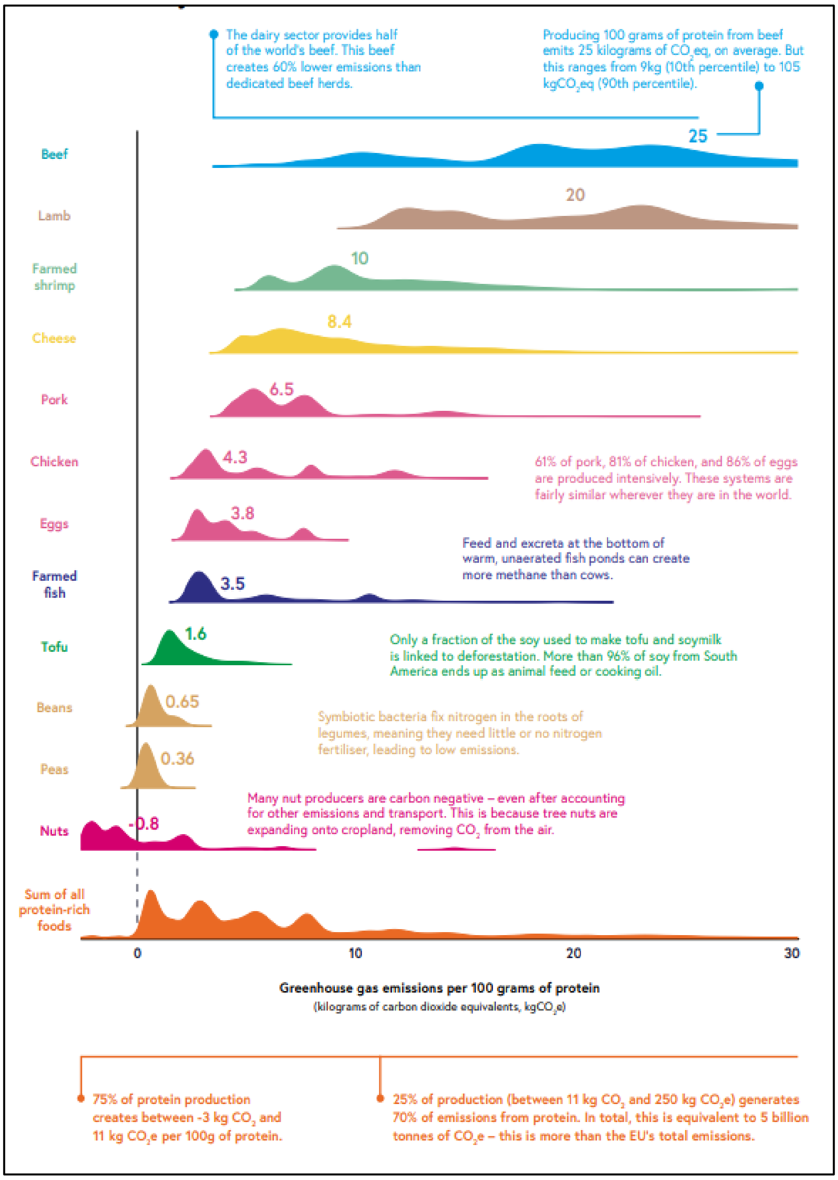
The amount of carbon equivalent produced by kilogram (kg) of meat varies across the world depending on a range of factors, including the nature of farming practices. For example, each kg of meat produced in Paraguay is equal to over 200kg of carbon, whereas in Denmark, emissions are under 15kg[57]. The UK is among the largest emitters within the OECD countries, whereas countries such as the United States that practice intensive livestock rearing reduce the animal life span. Nevertheless, the think tank RethinkX has estimated that by 2030, cattle demand within the US will be reduced by 70%. They propose this will be a direct result of alternative protein innovation[58].

[53] Research and Information Service Briefing Paper. Anaerobic Digestion in Northern Ireland, NIAR 82-21, 2021.
[54] The White House Office of Domestic Climate Policy. U.S. Methane Emissions Reduction Action Plan.
[55] Green Gas Support Scheme Guidance, 2022
[56] Research and Information Service Briefing Paper. Anaerobic Digestion in Northern Ireland, NIAR 82-21, 2021.
[57] National Food Strategy, a Government-commissioned independent review into the food system
[58] Food and Agriculture RethinkX Report

3.2.1 Protein replacement technologies

The Royal Society has published a prediction that the global alternative meat industry has the potential to grow by 10% within the decade, which is equivalent to over $140 billion[59]. A UK Government-commissioned independent review of the National Food Strategy has suggested that vegetable proteins have the lowest carbon footprints (Table 2). The report urges the UK to invest £50 million in alternative protein start-ups and scientists.

Table 3. Different types of protein carbon footprints. *Source: National Food Strategy, a Government-commissioned independent review into the food system*



[59] The Royal Society Future food: health and sustainability

The Green Alliance has suggested that by replacing processed meat with alternative proteins the methane emissions from agriculture can be reduced by 8%.

According to the global McKinsey market survey published in 2019, plant-based protein sales increased by 17% in 2018, and the alternative protein market is worth $2.2 billion[60].

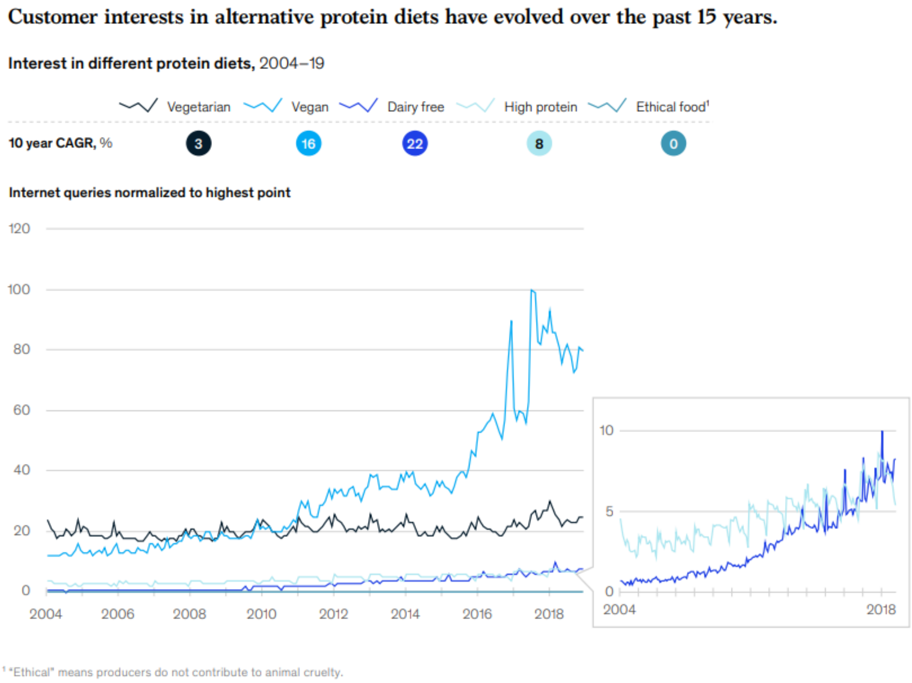


Figure 3. Customer interest in alternative protein. Source:[Alternative proteins: The race for market share is on (mckinsey.com)](mckinsey.com)

In 2020, the Good Food Institute reported that the plant-based food market in the US increased five times faster than entire food sales growth within a year and achieved sales of $5 billion which is an 11% increase from the previous year[61]. They reported that plant-based milk holds the largest plant-based food market share, with a prospect for plant-based meat to reach market share equivalence worth $12 billion in the US. Moreover, they reported that the main driver for growth in plant-based food is the manufacture of products that are most similar in taste, appearance and packaging to traditional goods. Therefore,

60 Alternative proteins: The race for market share is on (mckinsey.com)
61 Plant-Based Food Retail Market Overview-Good Food Institute.

the market innovation in premium products that resemble animal products has some way to go to reach its full potential.

In November 2022, the FDA officially approved the safety of lab-grown meat for human consumption in Berkeley, California by food technology company Upside Foods[62]. The Scottish-based food tech company Roslin Technologies chief executive Ernst van Orsouw commented on this to the BBC[63]:

> *[The FDA approval is a] "major milestone…It is very exciting to see a globally leading regulator now come to the same conclusion that cultivated meat is safe to eat…The FDA has been taking a risk-based, science-based and practical approach to regulating this novel food, which can be an excellent guide for other jurisdictions as well…[this step] will spur further investment and innovation."*

According to the Global Cleantech Innovation Index of 2022, there are five alternative protein companies which have made a significant impact on the market from the Netherlands, United States, Germany, Israel and Hong Kong[64].

Alternative proteins are not just meat substitutes, they can also substitute milk and egg products. These products may not be compelling for all individual consumers. However, they can be used in large, processed food industries. According to the Dairy Council for Northern Ireland, the yearly income from dairy export sales is £573 million to over 80 countries[65]. If alternative milk protein manufacturing becomes cheaper and closer to the real product, with less environmental impact, it is proposed that this could significantly harm the local dairy industry[65].

[62] FDA Completes First Pre-Market Consultation for Human Food Made Using Animal Cell Culture Technology, 2022
[63] Lab-grown chicken safe to eat, say US regulators, BBC news, Novemeber 2022.
[64] 2022 Global Cleantech 100 List
[65] Dairycouncil.org

However, within the last year, the share of the two major alternative protein companies, Beyond Meat (USA) and Oatly (Sweden), has dropped by over 70%[66]. The sector is challenged by the shift in investment to cellular agriculture (the production of agricultural goods such as protein, tissues, and fat from cell culture with different new biotechnologies) in addition to the continued subsidies

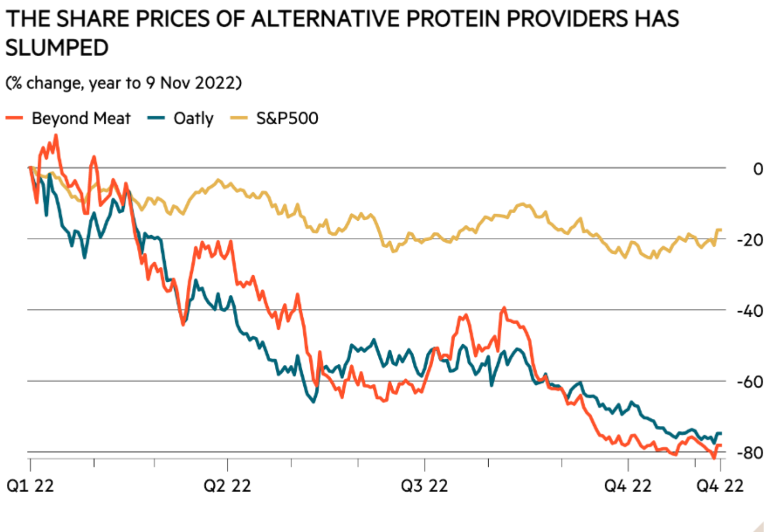


Figure 4. Share prices of Beyond Meat and Oatly have dropped over the last year. Source: Alternative proteins leaving investors queasy, Investor Schronicle, 2022

given to traditional agriculture[66].

3.2.2 Alternative Protein in Northern Ireland

Currently, the alternative protein market within Northern Ireland is limited. The company Finnebrogue Artisan, located in Downpatrick already has on the market a variety of vegan and vegetarian alternatives including vegan sausages and plant-based chicken, ham and red meat[67]. The Born Maverick company, Púr – Nature's Wonder Blend, located in Belfast, has developed a prawns and scallops prototype made from seaweed[68].

Another potential concern with the alternative protein market is the health aspects of such a diet. Although there is a general view that a plant-based diet

[66] Alternative proteins leaving investors queasy, Investor Schronicle, 2022
[67] Finnebrogue Artisan
[68] Born Maverick develops foods of the future, Innovation factoryni, 2021

has health benefits, there is some research that opposes this opinion. There is some evidence to suggest that 'ultra-processed' food as a whole can lead to non-communicable diseases[69-70]. Plant-based protein is a processed food product that contains higher amounts of salt[71]. The processing of alternative protein may have its downside to health, especially as they target the fast-food market. It has been suggested that more long-term research on alternative proteins and their health effects should be conducted[72]. Nevertheless, research conducted by Alessandrini et al. (2021) assessed the nutrient profile of 207 plant-based meat against 226 meat products from 14 different stores in the UK[73]. They concluded that only 14% of the plant-based meat was less healthy in comparison to 40% of meat products. Moreover, only 20% of plant-based meat is high in total fats, versus 46% of meat products.

4 Peatland and carbon sequestration

4.1 Peatlands as sequesters versus emitters

Natural peatlands are a sink of CO_2 through accumulating soil carbon in the form of dissolved organic carbon in their soils. However, they can also be a source of methane, nitrous oxide (N_2O) and CH_2 carbon dioxide, depending on their condition.

Peatlands form in environments of heavy rainfall and poor drainage, resulting in waterlogging that restricts vegetation decomposition and contact with oxygen[74]. Additional, nitrogen (N) and other nutrients from the undecomposed vegetation

---

[69] Monteiro, C.A.; Cannon, G.; Levy, R.B.; Moubarac, J.-C.; Louzada, M.L.; Rauber, F.; Khandpur, N.; Cediel, G.; Neri, D.; Martinez-Steele, E.; et al. Ultra-Processed Foods: What They Are and How to Identify Them. *Public Health Nutr.* **2019**, *22*, 936–941

[70] Rauber, F.; Steele, E.M.; Louzada, M.L.D.C.; Millett, C.; Monteiro, C.A.; Levy, R.B. Ultra-processed food consumption and indicators of obesity in the United Kingdom population (2008–2016). *PLoS ONE* **2020**, *15*, e0232676.

[71] Alessandrini, R., Brown, M. K., Pombo-Rodrigues, S., Bhageerutty, S., He, F. J., & MacGregor, G. A. (2021). Nutritional quality of plant-based meat products available in the UK: a cross-sectional survey. *Nutrients*, *13*(12), 4225.

[72] Payne, C., Scarborough, P., & Cobiac, L. (2016). Do low-carbon-emission diets lead to higher nutritional quality and positive health outcomes? A systematic review of the literature. Public Health Nutrition, 19(14), 2654-2661

[73] Alessandrini, R., Brown, M. K., Pombo-Rodrigues, S., Bhageerutty, S., He, F. J., & MacGregor, G. A. (2021). Nutritional quality of plant-based meat products available in the UK: a cross-sectional survey. *Nutrients*, *13*(12), 4225.

[74] Clymo, R. S. "The limits to peat bog growth." *Philosophical Transactions of the Royal Society of London. B, Biological Sciences* 303.1117 (1984): 605-654.

accumulates within peatlands. This anaerobic environment is ideal for methanogenesis (microbial respiration that generates methane) and supports atmospheric methane (CH_4) release. Northern peatlands alone contribute 12.2 % of methane emissions[75] at an annual release of 46 Tg CH_4-C[76].

Under natural conditions, northern peatlands accumulate soil carbon over thousands of years at a rate of 76 Tg C year−1 (Gorham, 1991), with a total carbon stock of 473–621 Pg C [77] which is 40% of soil carbon globally, even though they cover only 3% of the surface of the Earth[78]. Over the centuries, humans have drained and exploited large peatland areas for agriculture, grassland, forestry and as a source of energy. Although peatland drainage has a large economic contribution worldwide, it can lead to land subsidence, floods and fires, and an increase in long-term CO_2 emission. As peatlands are drained, they come into contact with the oxygen in the atmosphere and suppress microbial methane formation. However, oxidation transfers peatlands to a source of CO_2 by oxidising the soil carbon, removing vegetation photosynthesis, inhibiting soil carbon accumulation and the combustion of peat fuel[79]. On the other side, oxidation can reduce CH_4 emissions[80].

Scientists and global leaders have been looking at peatland recovery by re-wetting to promote their return to being a natural GHG sink. However, as the effect of CO_2 on the atmosphere is long-term, compared to methane which is short-term but more potent[81], and the peatland soil accumulation is a long natural process, the total re-wetting benefit for climate goals needs to be

---

[75] Wuebbles, Donald J., and Katharine Hayhoe. "Atmospheric methane and global change." *Earth-Science Reviews* 57.3-4 (2002): 177-210.

[76] Gorham, Eville. "Northern peatlands: role in the carbon cycle and probable responses to climatic warming." *Ecological applications* 1.2 (1991): 182-195.

[77] Yu, Zicheng, et al. "Global peatland dynamics since the Last Glacial Maximum." *Geophysical research letters* 37.13 (2010).

[78] Cooper, Mark, et al. "Infilled ditches are hotspots of landscape methane flux following peatland re-wetting." Ecosystems 17.7 (2014): 1227-1241.

[79] Waddington, J. M., K. D. Warner, and G. W. Kennedy. "Cutover peatlands: a persistent source of atmospheric CO2." *Global biogeochemical cycles* 16.1 (2002): 1-7.

[80] Klemedtsson, Å. K., P. Weslien, and L. Klemedtsson. 2009. Methane and nitrous oxide fluxes from a farmed Swedish Histosol. European Journal of Soil Science 60:321-331.

[81] Jackson, R. B., et al. "Methane removal and atmospheric restoration." *Nature Sustainability* 2.6 (2019): 436-438.

addressed carefully as re-wetting can potentially cause an increase in methane emissions, offsetting the benefits of increased CO_2 sequestration.

4.2 Challenges in re-wetting

Studies focusing on the potential of GHG mitigation by re-wetted peatlands have shown conflicting results. While some are optimistic, suggesting that the total CO_2 sink can be restored in a mannerly timescale,[82] others indicate that any human intervention may increase the damage[83]. In 2015 Vanselow-Algan et al. investigated three sites in Germany 30 years after they were re-wetted[84]. They found that not only did CH_4 formation and transportation into the atmosphere increase, but the annual GHG emissions rate was, at minimum, twice the amount emitted by industrial extraction sites. Moreover, they found that the rewetting and water table fluctuation were not the only contributors. Specific vegetation structures (aerenchymatous) that transport CH_4 through the plant stems were also contributing to methane emission. This study site shows that even after 30 years, just by re-wetting the land it may not return to natural conditions. It is important to note that the sample size in this study is small. Nevertheless, this points out that rehabilitation of peatland is a complex issue.

4.3 Peatlands Restoration

In a study conducted in 2014, researchers found that CH_4 'hot spots' in infilled ditches were associated with vegetation with aerenchymatous, and suggested the promotion of peat moss colonisation (*Sphagnum)* to displace the aerenchymatous vegetation[85]. In general, re-introduction of natural peatland

[82] Tuittila, E.-S., V.-M. Komulainen, H. Vasander, and J. Laine. 1999. Restored cut-away peatland as a sink for atmospheric CO2. Oecologia 120:563 - 574

[83] Wilson, D., E.-S. Tuittila, J. Alm, J. Laine, E. P. Farrell, and K. A. Byrne. 2007b. Carbon dioxide dynamics of a restored maritime peatland. Ecoscience 14:71-80.

[84] Vanselow-Algan, M., et al. "High methane emissions dominated annual greenhouse gas balances 30 years after bog rewetting." *Biogeosciences* 12.14 (2015): 4361-4371.

[85] Cooper, M., et al. "Infilled ditches are hotspots of landscape methane flux following peatland re-wetting." *Ecosystems* 17.7 (2014): 1227-1241.

vegetation restores CO_2 fixation by photosynthesis[86]. *Sphagnum* has been found to support bacterial consumption of CH_4 and reduce CH_4 transport to the atmosphere[87].

Wilson et al. noticed that all vegetated peatlands had a net cooling effect. However, peatlands covered by *Eriophorum* (colloquially known as bog-cotton, which has an aerenchymatous stem structure) have a net cooling effect over a 100-year horizon, whereas peat moss has a near-neutral effect[88]. They noted that if peatlands endure further drought, reducing the water table will lead to unfavourable conditions for peat-forming. This will lead to dry heathland with tree colonisation, leading to further drying and increased CO_2 emissions.

However, in the UK, around 64,000 ha of deep peat is used for cropland, 148,000 ha is used for intensive grassland,[89] and some are cut for turf. Although there is an urgent need to combat emissions by restoring natural peatland, with an increased demand for food and energy, there is potentially a conflict between the two needs.

A study conducted by Evans et al. emphasised this issue and looked for a win-win solution by collecting CH_4 and CO_2 measurements from a variety of peatlands across the UK and ROI [90]. The study found a linear relationship between CO_2 and the water table depth (WTDe), with each 10cm decrease in the WTDe, there is an annual increase of 3t CO_2 emissions.

On the other hand, when the WTDe is between 0 and 30cm, methane is produced and counteracts the reduction in CO_2 emissions (Figure 5). By combining both CH_4 and CO_2 measurements, they found that the reduction in drainage depths of >8cm will have a net climate benefit where GHG emissions

86 Waddington, J.M. & Price, J.S. (2000) Effect of peatland drainage, harvesting and restoration on atmospheric water and carbon exchange. Physical Geography, 21(5), 433–451

87 Raghoebarsing AA., et al., (2005). Methanotrophic symbionts provide carbon for photosynthesis in peat bogs. Nature 436:1153–6.

88 Wilson, D., et al. "Rewetted industrial cutaway peatlands in western Ireland: a prime location for climate change mitigation?." *Mires & Peat* 11 (2013).

89 Evans, C. et al. Implementation of an Emission Inventory for UK Peatlands. (Centre for Ecology and Hydrology, Bangor, 2017).

90 Evans, C.D., Peacock, M., Baird, A.J. *et al.* Overriding water table control on managed peatland greenhouse gas emissions. *Nature* **593**, 548–552 (2021).

are negative. The CO_2 sink cooling will exceed CH_4 emissions in water table depth (WTDe) of 5cm and 13cm on a 100-year time horizon (Figure 5).

Furthermore, as cropland has a typical WTD_e of 90cm and grassland 60 cm, they evaluated that CO_2 emissions can be reduced by 3.3 Mt CO_2 a year (± 2.7-4.0 Mt CO_2 yr^{-1}) just by halving the drainage depths. This way, the peatland would not be completely restored but would reduce emissions and be available for land use. The researchers urged for the development of water-tolerant, economically feasible crops so that these lands could continue to be harvested[82].

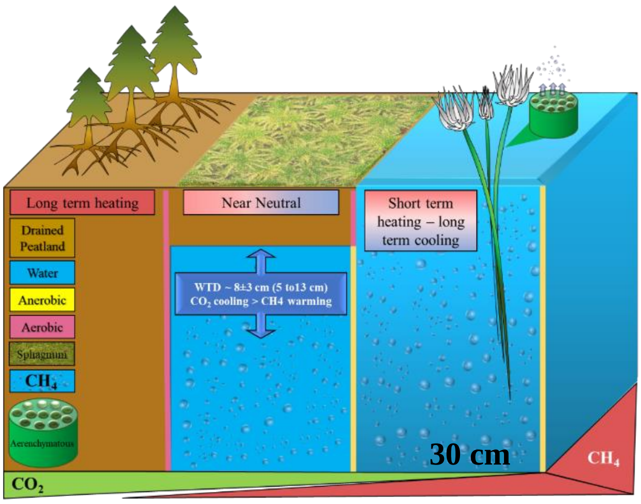


Figure 5. Illustration of the different scenarios of peatland emissions according to the research conducted by Evans et al.,[83] and Cooper, Mark, et al.[78]. As the WTDe is between 0 and 30 cm methane is produced and counteracts the reduction in CO_2 emissions (section on the right of the illustration). In drainage depths of > 8 cm and WTDe are between of 5 cm and 13 cm (middle section of the illustration) the GHG emissions are negative as the CO_2 sink cooling will exceed CH_4 emissions on a 100-year time horizon. Illustrated by Bea Baharier based on Evans et al., 2017; Wilson et al., 2013; Cooper et al., 2014; Waddington & Price 2000 and Raghoebarsing et al., 2005.

4.4 Other Challenges in peatland restoration

Another practice that harms peatlands' capability to store CO_2 is turf cutting. Turf harvesting in Ireland and Northern Ireland is a practice that goes back to medieval times and is deeply rooted in cultural heritage[91]. However, the

[91] Feehan, J. (1997). Bogs. In F. H. A. Aalen, K. Whelan, & M. Stout (Eds.), Atlas of the Irish rural landscape (pp. 106–108). Cork, Ireland: Cork University Press.

cultivation of turf may harm the environment and public health[92]. Nevertheless, as new regulations have been presented in Ireland[93] limiting turf marketing, the local rural communities have resisted this ban[94]. Although the Irish government has implemented a compensation scheme, many turf cutters have refused to cease cutting[95]. The refusal is due to a cultural and heritage connection to the practice[96]. Moreover, with energy prices rising due to the geopolitical arena the reliance on locally sourced energy is essential and gives a sense of security to different local communities[97].

Another issue arising from peatland rehabilitation is the complex ownership of land title history with many missing records and thus, it is amongst the most difficult types of land to prove ownership[98].

The re-wetting of peatlands and the monitoring of their WTDe and emissions are essential to reaching a total climate benefit in the long term. Nevertheless, whether peatlands are restored or not and by what mechanism, the research discussed in this section suggests they are methane emitters, even if they are restored to natural conditions. Therefore, the emissions would need to be accounted for when attempting to reach the climate goals, such as finding ways to utilise methane or other large-scale global methane mitigation.

5 Climate engineering methods

Some climate engineering methods may mitigate natural peatland and other methane emissions. These are mostly large-scale climate-altering mechanisms and their suitability for NI may need further consideration. Additionally, it is important to note that climate engineering has many concerns involving the risk

[92] Colm Byrne, Kathleen Bennett, Anne Hickey, Paul Kavanagh, Brian Broderick, Margaret O'Mahony, David Williams, 207 Acute Incidence of Disease at Elevated Levels of Fine Particulate Matter (PM2.5) in Dublin, Ireland, Age and Ageing, Volume 48, Issue Supplement_3, September 2019, Pages iii17– iii65

[93] gov.ie - Government agrees new regulations on solid fuels (www.gov.ie)

[94] We're being left with nothing': Ireland's turf wars expose rural grievances, The Guardian, 2022

[95] Turf cutters group rejects bog deal, (2004) The Irish Times

[96] McGrath, Margaret, and Helen McGonagle. "Exploring 'wicked problems' from an occupational perspective: The case of turf cutting in rural Ireland." *Journal of Occupational Science* 23.3 (2016): 308-320.

[97] IFA Critical of Failure to Implement Turf Cutting Package, (2011) The Connacht Irish Farmers Association (IFA)

[98] I own acres of bog but how can I prove it?, The Irish Times, 2020

associated with altering a planet's climate without sufficient long-term studies (over a human timescale) to predict all outcomes, in addition to ethical concerns linked to them. Therefore, this step is commonly unfavourable amongst national policymakers[99]. Essentially, climate engineering mimics a natural reaction in nature and is manipulated or enhanced by human intervention.

In COP26, Climate Restoration with Iron Salt Aerosol (ISA) has been proposed as a way to remove methane from the atmosphere. Aerosols are a naturally occurring phenomenon. However, by increasing their occurrence and controlling their content, Oeste et al. 2017 proposed that ISA has the potential to prevent or even reverse global warming[100]. Aerosol forming in a natural event such as a volcanic eruption can prevent sunlight radiation back to space, creating a short-term cooling effect. Oeste et al. suggest that by creating ISA, they can create an oxidising reaction that conceptually can remove tropospheric methane 250 times faster. Moreover, they propose that this can be used as a cooling stage for peatlands and wetlands. As iron is used by microbes, it can compete with methanogenesis and inhibit various microbial CH_4 production. Hence, this can be an additional option to mitigate localised methane emissions. According to different studies this solution has low cost and easy implementation[101]. Different studies use different ratios of iron within their compounds and cost estimation ranges between \$0.10/t CO_2 and \$42/t CO_2[86].

6 Energy associated emission

According to The International Energy Agency (IEA), 11% of UK methane emissions are from the energy sector. However, methane emissions from oil and the gas industry include pipe leakage which is notoriously under-reported[102]. In February 2022, a press release by the IEA reported that the

---

[99] Scott, D. (2012) Geoengineering and Environmental Ethics. Nature Education Knowledge 3(10): p10

[100] Oeste, Franz Dietrich, et al. "Climate engineering by mimicking natural dust climate control: the iron salt aerosol method." *Earth System Dynamics* 8.1 (2017): 1-54.

[101] Ming, Tingzhen, et al. "A nature-based negative emissions technology able to remove atmospheric methane and other greenhouse gases." *Atmospheric Pollution Research* 12.5 (2021): 101035.

[102] IEA (2022), Global Methane Tracker 2022, IEA, Paris., Global Methane Tracker 2022, IEA for the United Kingdom. License: CC BY 4.0

global energy sector methane emissions are around 70% higher than officially reported by national governments[103]. The IEA estimated that around 20% of methane emissions from the energy sector in the UK are fugitive emissions (due to unintended leakages). The IEA Executive Director Fatih Birol said:

> *"At today's elevated natural gas prices, nearly all of the methane emissions from oil and gas operations worldwide could be avoided at no net cost."*

Moreover, they estimate that an additional 180 billion cubic metres of natural gas could have been available in 2021 if all fossil fuel methane leakages would have been captured[104]. To emphasise, they stated that this amount is equivalent to Europe's gas power sector. They encourage the application of known technologies and established policies to improve this situation. They have a stabilised database for worldwide technologies and policies[105-106]. Therefore, the initial investment in methane recovery costs would be covered by the saved gas with additional profit, even if the gas prices drop. The Green Alliance has predicted a total 9% reduction in UK methane emissions by mediations made in the energy industry[107].

The Green Alliance has suggested a list of methane emission reduction acts that can cut emissions from the energy sector[101]. The full list can be seen in Table 3 below.

---

[103] IEA Press Release - Methane emissions from the energy sector are 70% higher than official figures

[104] IEA (2022), *Global Methane Tracker 2022*, IEA, Paris https://www.iea.org/reports/global-methane-tracker-2022, License: CC BY 4.0

[105] IEA database- Fuels-and-technologies

[106] IEA database – worldwide policies

[107] The Global Methane Pledge - How the UK can meet its commitment" repost

Table 4 Ways in which methane emissions could be cut from the energy sector. Source: [The Global Methane Pledge - How the UK can meet its commitment" repost]

Interventions to cut methane leakage in the energy industry

Intervention	Methane abatement (thousand tonnes)	Savings (£/mmbtu[17])
Replace gas pumps and controllers with pressurised air pump systems (offshore)	5.78	18.54
Vapour recovery units (recovery of gas built up in equipment, eg oil tanks)	6.41	17.39
Annual upstream leak detection and repair (LDAR)	9.07	16.47
Vapour recovery units (offshore gas)	3.87	16.39
Vapour recovery units (offshore oil)	8.56	16.28
Replace with pressurised air pump systems (onshore oil)	0.34	16.24
Replace gas pumps with electric motors (downstream gas)	4.56	14.35
Biannual upstream LDAR	4.53	14.28
Annual downstream LDAR	17.36	13.48
Quarterly upstream LDAR	3.40	12.81
Monthly upstream LDAR	2.26	9.89
Replace gas pumps with electric motors (onshore oil)	0.81	9.31
Biannual downstream LDAR	8.68	8.83
Quarterly downstream LDAR	6.51	5.72
Other	7.27	2.21
Install flares (downstream gas)	1.10	-0.19
Monthly downstream LDAR	4.34	-0.48
Install flares (offshore)	58.60	-1.50

The need for domestic gas versus imported gas is rising with the restrictions on gas supply from Russia. The OECD published an economic growth outcome in November 2022 showing that the UK has the worst economic growth (GDP at market prices of -0.4) out of the G7 countries, and amongst other large economies as well[108]. Countries insulated from the gas crises predominantly rely on domestic gas. Although the UK economy is not directly reliant on Russia and Ukraine trade, it is affected by the global market, notably in case of higher gas and electricity demand resulting in supply disruptions from the continent during a cold winter[109]. Improving methane leakage has the potential not only to combat climate change but also to improve self-reliance on localised energy sources. The OECD Economics Department report, ‘Emergency plans and solidarity: Protecting Europe against a natural gas shortage’, looked at different scenarios for the EU and UK gas storage level developments based on gas consumption, supply risk, and the case of a cold winter (Figure 5).

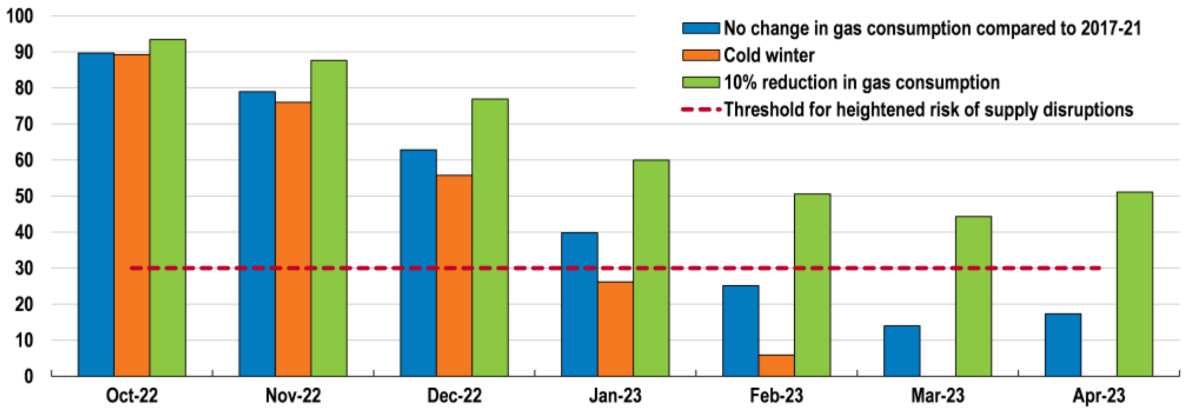


Figure 6. Different scenarios for the EU and UK gas storage level developments, %. Source: OECD Economics Department, Emergency plans and solidarity: Protecting Europe against a natural gas shortage.

108 OECD Economic Outlook, Volume 2022 Issue 2, OECD -iLibrary

109 Jörg Haas, Tomasz Kozluk, Giuliana Sarcina, OECD Economics Department, Emergency plans and solidarity: Protecting Europe against a natural gas shortage, 2022

8 Offsetting emissions

It is important to note that the UK is already a global leader amongst the most advanced countries in CH_4 emissions reduction. Some of the major CH_4-emitting countries have not signed the Methane Pledge (such as China, India and Russia), which are emitting substantially more methane than the UK in total. However, although these countries have not signed the international pledge, they have taken actions on a national level with recent legislation to mitigate the emissions[110].

The Global Cleantech Innovation Index of 2022 has reported on six UK-based companies in their top 100. However, none of them address methane emissions directly, nor are they based in NI[111]. According to the Irish Tech News, the best climate tech companies from Northern Ireland in 2022 are Artemis Technologies and CATAGEN (both are located in Belfast)[112]. Artemis Technologies (Belfast)[113] is a leading green maritime innovation company. To create zero-emission vessels, they aim to decarbonise the maritime industry through innovation, digitalisation and autonomy. CATAGEN (Belfast)[114] is a company grown from Queen's University devoted to cleaning and decarbonising the air. CATAGEN are Catalyst Ageing Emissions experts providing emissions data and testing for major automotive labels. Moreover, they develop technologies in Green Hydrogen and E-fuels. Both companies are small and midsize businesses (SMBs) and may have the potential to keep growing.

Other industries in Northern Ireland may be further explored for their decarbonisation and offsetting emissions for NI and beyond. Companies such as Aethergy Energy Audits can give individual businesses a complete energy usage analysis to reduce energy waste and, by doing so save business costs[115].

110 IEA database – worldwide policies
111 2022 Global Cleantech 100 List
112 The best climate tech companies from Northern Ireland, Irish Tech News 2022
113 Artemis Technologies
114 Catagen
115 Aethergy Energy Audits

Other legacy industries in NI, such as film and textile, are carbon-heavy due to transport and production. However, new approaches located in NI, such as the virtual production in Ulster studios[116], and reviving local traditional textile production could potentially substantially cut carbon emissions.

[116] Sustainable Film - Virtual Production is reducing costs – and it's reducing carbon footprints too