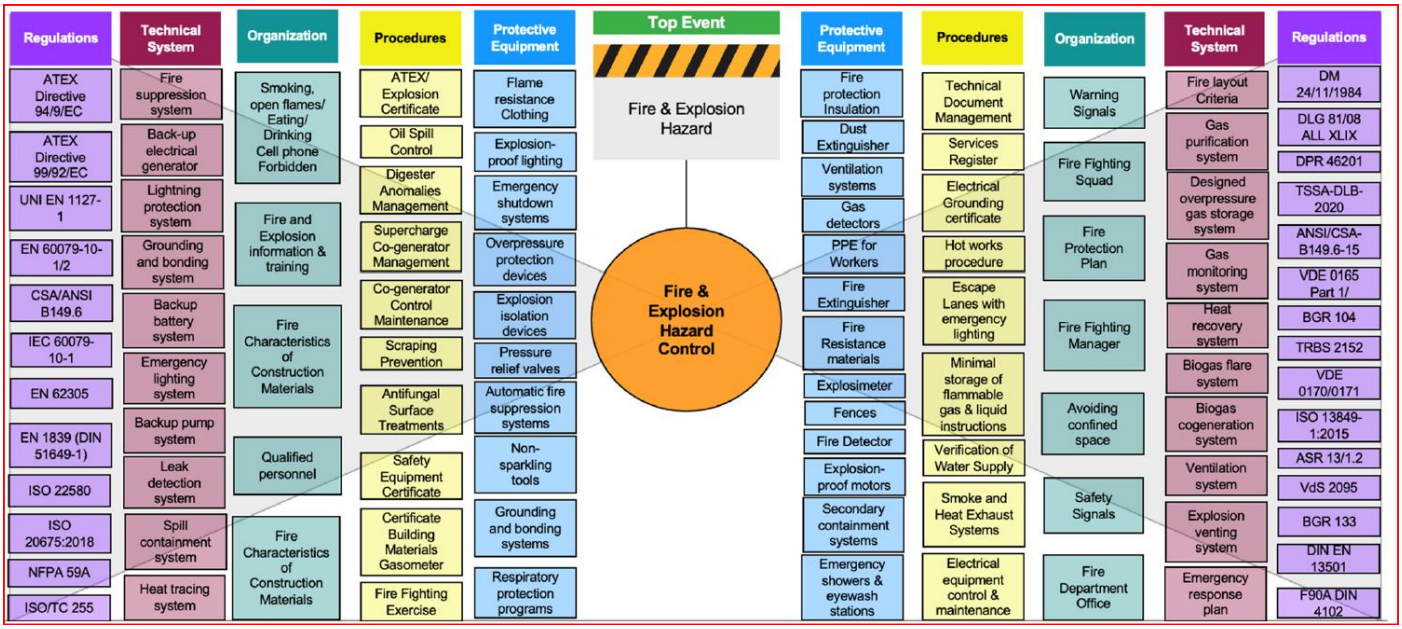
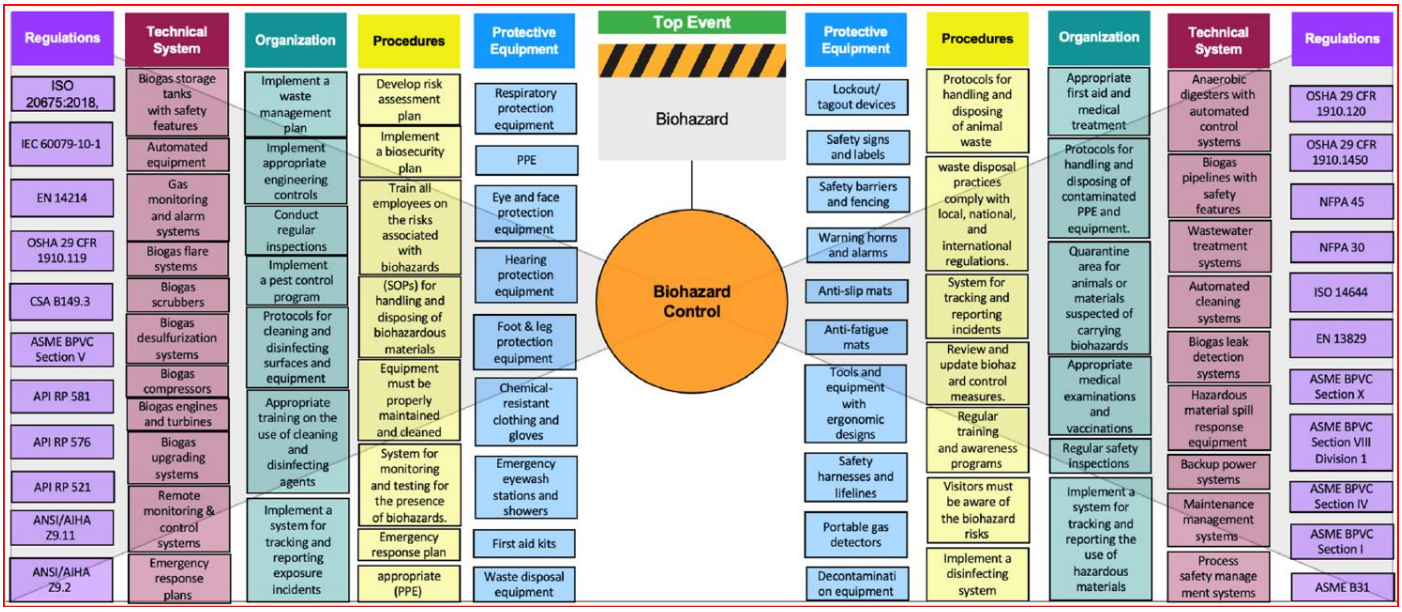
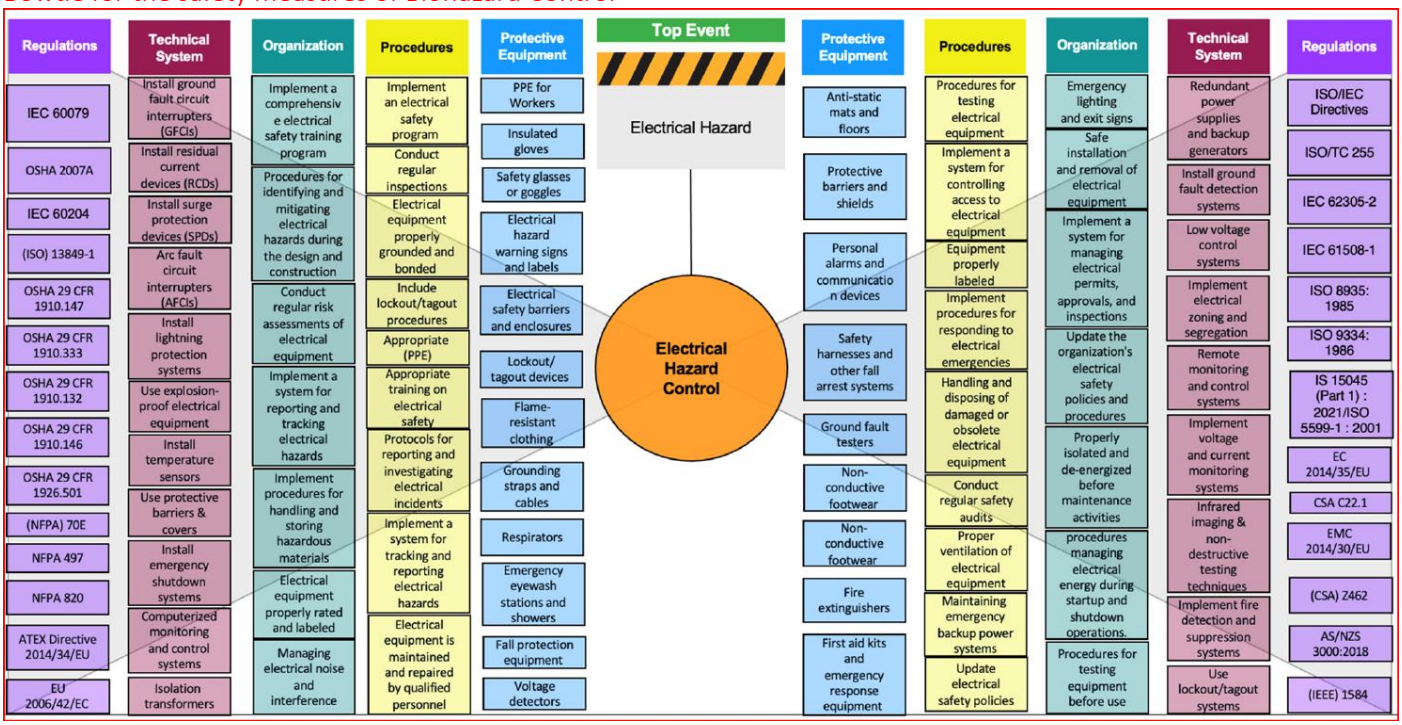


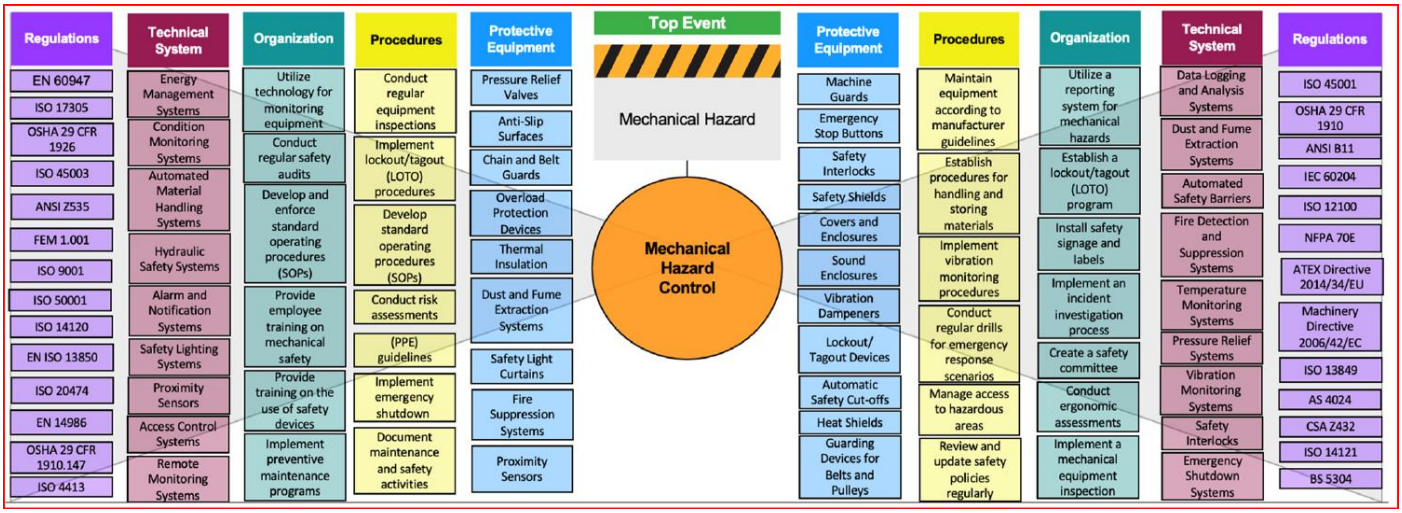
Bowtie for the safety measures of Fire & Explosion Control



Bowtie for the safety measures of Biohazard Control



Bowtie for the safety measures of Electrical Hazard Control



Bowtie for the safety measures of Mechanical Hazard Control

Reference Number 43: Explosion safety in anaerobic digestion sites; where it can go wrong and guidance to avoid that happening Sarah Bergin, Graham Atkinson, Alan Beswick, Brian Crook, Tim Small, Lee Schilling, SYMPOSIUM SERIES No.170 HAZARDS 33 © 2023 Crown copyright

Anaerobic digestion (AD) is a series of biological processes in which micro-organisms digest plant and/or animal material in sealed containers, producing biogas, which is a mixture of methane, carbon dioxide and other gases.
AD is a complex, living, biological process that is affected by numerous interdependent factors such as temperature, retention time and agitation.
Methane, the main gas of interest in biogas, has an explosive range of between 5 % and 15 % vol. in air. Within biogas, methane accounts for between 50 % and 70 % of the overall gas mixture. Thus, the generated methane has the potential to be within its explosive range at various times during the process, not only during intentional gas generation activities such as the digestion process but also at times when presence of methane is not essential e.g., in the feedstock reception area/holding tanks, or when storage tanks are being accessed for maintenance purposes.
Over the time period from 2010-2020, using search criteria that included biogas/anaerobic digestion as keywords, 68 incidents were recorded. In terms of incident occurrence by industry, 40 of these incidents occurred on industrial sites, 9 were logged as agricultural sites and 19 incidents did not specify industry. It is thought that this seemingly larger incident occurrence in industrial sites is more likely as a result of underreporting in the agricultural sector, rather than the industrial sector being inherently more incident prone. This supposition appears to be corroborated by anecdotal observation and material breaches identified as part of the inspection scheme, which is discussed further in the "Findings from HSE programme of inspections" section below.
Figure 2 shows the breakdown of incident type over the ten-year period; categorised as fire and explosion risk, asphyxiation/toxic gas release, physical injury, and environmental pollution due to biogas release to atmosphere or slurry (solids) release. From these reports, environmental pollution accounted for the most frequent occurrences. This is again possibly down to level of reporting (or underreporting) of human safety issues. Environmental permitting of most AD sites tends to be routinely inspected against the environmental criteria of the license rather than health and safety regulations. Where physical injuries resulted (7 incidents), reasons included equipment failure due to corrosion, use of incorrect tools/PPE or operative not anticipating the hazard and thus not implementing a safe system of work.
In the case of asphyxiation/toxic gas releases (7 incidents), where operatives were in close proximity, this tended to be during maintenance activities, for example breaking of a crust in the digester. Where toxic gas releases occurred (not necessarily causing an asphyxiation risk), this tended to be due to failure/absence of an odour abatement system, such as an H_2S scrubbing. In terms of fire and explosion risks (15 incidents), these tended to occur as a result of a deviation from normal operating conditions, including foaming causing blockage of PRVs leading to over pressurisation, or power cuts causing safety critical equipment such as flares to stop. The most serious incidents involved hot works on storage tanks that contained accumulations of flammable gas that had not been properly identified during Hazardous Area Classification (HAC).

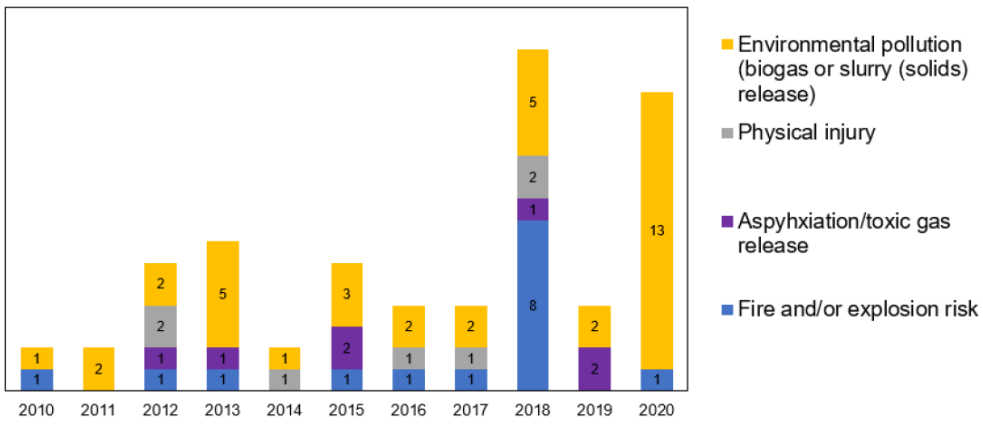


Figure 2: Breakdown of incident from 2010-2020 by nature of risk that occurred i.e. environmental pollution, physical injury, asphyxiation/toxic gas release and fire/explosion risk. The number of incidents for each incident type is overlayed on the relevant section of the bar.

Twenty-two inspections at AD sites were carried out by HSE's Field Operations Division in 2021/22. These were large sites dealing with sewage, food, and industrial wastes. In 2022/23, forty-nine inspections were carried out at agricultural sites. Note: these were routine inspections and not in response to an unsafe occurrence or concern being reported. The outcome of this campaign was that material breaches were found in 50% of cases for industrial sites and 40% of cases in agricultural sites.

Reference Number 44: **Process safety at anaerobic digestion sites and its workplace impact: A rapid review. Alan Beswick, Gareth Evans, Brian Crook, Becky Gosling, Claire Bailey, Iwona Rosa, Helena Senior, Jodi Brookes, Owen Butler, Paul Johnson, Penny Barker, Sarah Bergin, Lee Schilling, Tim Small. Process Saf Prog. 2025;44:359–367. wileyonlinelibrary.com/journal/prs. Crown Copyright.**

For this review, the potential for worker exposure to hazards at AD sites is the focus, including exposures to toxic substances, injuries, and fatalities from failures in mechanical and process control.

AD hazards can be broadly categorized as follows:

1. Explosive Atmospheres: These can occur with the uncontrolled release, inappropriate storage, or improper handling of flammable biogas, which poses serious fire, explosion, toxic, and asphyxiant risks. The release of large quantities of fugitive biogas from the AD plant has been widely described, and for methane (CH_4) this is often in relation to the environmental impact or economic loss of biogas. However, if not monitored, biogas leaks also present a risk of explosion or flash fire.

2. Harmful Chemicals: Exposure to toxic compounds from the feedstock or AD processes may cause ill health, asphyxiation, and death. For example, hydrogen sulfide gas (H_2S) is a potent respiratory and neurological toxicant acting as a pulmonary irritant and asphyxiant. Volatile organic compounds (VOCs) can also cause irritation in the respiratory tract, throat, nose, and eyes, as well as headaches, dizziness, and nausea.
Long-term exposure to VOCs can disrupt the functions of the central nervous system, cause organ damage, and some VOCs may cause cancer. Most of the studies on AD units have focused on the role of H_2S as an inhibitor of the methanogenic process or its corrosive effects on metal pipework and CHP engines. Microbial VOCs are often linked to odour concerns rather than respiratory ill health impact.

3. Pressure Accumulation: Biogas components, including CH_4, H_2, carbon dioxide (CO_2), H_2S, or a mixture of these, can accumulate and over-pressurize digester vessels, pipework, and other gas containment structures. This may result in containment failure with leakage, fire, and explosion. Pressure build-up may be exacerbated by precursor events or engineering failures, such as pressure release valve or pipework blockage. Poor control of the AD process causing foaming events contributes to these risks.

4. Other Engineering Failures: Mechanical breakdown or deterioration in pumps, valves, mixing mechanisms, and other critical components requires frequent maintenance interventions. Examples of such failures include corrosion of metal equipment caused by H_2S, malfunctions of equipment caused by foaming residues, or siloxane combustion products deposited inside CHP machinery, increasing wear and tear. When these failures occur, maintenance tasks may expose employees to chemical or microbiological hazards. Such failures are also linked to poor levels of process reliability and control.

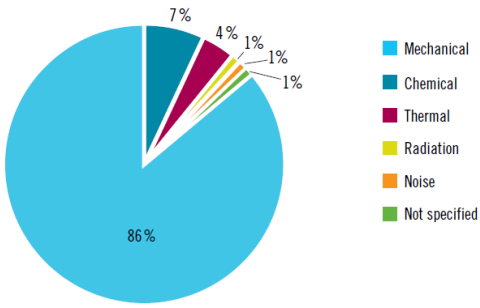
5. Harmful Microorganisms: Exposure to various microorganisms within feedstocks prior to processing (storage and handling), or during the AD process itself, can be hazardous to human health.
Some of these microorganisms are pathogenic, causing infections, inflammation, or toxicity. Exposure may be due to direct contact or inhalation. Some microorganisms cause allergic disease, particularly airborne fungal or bacterial spores. These are often present in large numbers when decomposing organic feedstocks are handled.
In recent years, serious incidents have occurred at AD facilities in parts of the United Kingdom and elsewhere, some causing injury or fatality. These have arisen at different types of AD facilities and include established sites where robust systems and process understanding might reasonably be assumed. These events may reflect the complexity of the microbiological and engineering processes being managed and, among employees, a potential lack of knowledge about the correct preventive and mitigating actions to take. AD plant designs vary, but the associated hazards remain largely consistent and must be controlled.
Multiple reported hazards associated with AD site incidents
A range of hazards and defects has been described across multiple peer-reviewed papers, where common events act as precursors to dangerous occurrences that have the potential to injure or kill AD site personnel, or can affect those attending the site to assist in an emergency response. Examples of these are summarized in Table 1.

TABLE 1 AD-related hazards and outcomes from major incident studies.

Main hazard(s) identified/exposure risks	Study outcomes/conclusions
Between 2003 and 2010, most deaths or injuries involved biogas explosions, or toxic inhalation of H_2S, particularly in confined spaces	Five plants exploded during commissioning or during maintenance work. Thirteen deaths: four following gas explosions; four from H_2S exposures after safety devices were disabled. Eleven serious injuries were due to burns, explosions, or H_2S exposure. Firefighters' injuries from H_2S exposures. Conclusion: AD industry lacked formal safety culture; rigorous procedures needed for hazardous materials
In 10 years, 800 incidents in 13,171 European biogas sites. Included: biogas leakage from storage tanks, distribution networks; release of H_2S; valves freezing; high pressure inside digester; overflowing sewage systems; dangerous raw feedstock	Three fatal incidents. Risk analysis concluded risk not as high as in chemical plants but still have serious localized consequences. Risk assessments are critical to reduce the frequency of incidents.
Of 169 reported incidents in the biogas supply chain, 66% involved release of biogas; fires for 23%; explosions for 19%. Also, incidents due to exposures to gases such as H_2S.	Causes of biogas release: equipment failure, operational error, and explosions, from maintenance errors and system design errors. Learning from previous accidents and developing risk-awareness skills are needed but are limited by insufficient recording and/or in the published literature. Safety procedures of other industries should be adopted; specific safety standards for biogas production facilities could avoid future design and operational errors.
Fires occurred in 52 of 132 incidents where energy generation units (ICE-CHP) were located. Flash fires in 22 of 45 incidents in digester vessels or in gas storage vessels. Biogas leaks occurred from damaged piping, defective gas burners, and damaged gas storage vessels	In 28 of the 52 fires: a technical defect; for example, electrical problems, leakage of operational fluids and ignition, or ignition of other flammable materials from hot surfaces. Flash fires caused by maintenance errors; for example, welding inside poorly ventilated areas; also from lightning (2 incidents). Technical defects included defective shut-off valves due to low temperatures. Biogas leaks from compressors were often linked to defective seals or failure of materials.

Reference Number 45: BIOGAS Safety first- Guidelines for the safe use of biogas technology. Fachverband Biogas e. V. Dr. Claudius da Costa Gomez (V.i.S.d.P.), ISSN 2510-487X www.biogas-safety.org. Angerbrunnenstraße 12 · 85356 Freising · Germany Phone +49 (0) 81 61- 98 46 60 Fax +49 (0) 81 61- 98 46 70 info@biogas.org, www.biogas.org

Figure 1: Types of hazard relating to accidents resulting in personal injury (SVLFG, 2012).



Environmental hazards

Essentially the environment is only exposed to danger if biogas escapes into the atmosphere or working materials in the plant (e.g. digestion substrate, silage effluent, oils or fuels) enter nearby bodies of water. An accident of this type may be caused by structural faults or operating errors.

Environmental hazards from biogas plants can be divided into emissions into air and emissions into soil and water. Analyses of biogas plants show that the digestate storage tank is one of the main sources of methane emissions, especially if it does not have a gas-tight cover. The CHP unit also presents some hazard, however in a lower degree. Other plant components are normally relatively gas-tight, but gas leakages at connection parts between the gas storage and the digester and pre-digester pits could happen.

Emissions of ammonia from biogas plants should also be minimised. Ammonia causes acidification in soils, promotes eutrophication, can damage vegetation and can have detrimental impacts on health (in higher concentrations it is toxic; in groundwater, converted to nitrite, it adversely affects metabolism).

Measures to reduce ammonia are similar to those for methane. This means that gas emissions to the atmosphere should be avoided (especially from the digestate storage tank). The techniques used for field spreading of digestion products have a crucial influence on ammonia emissions. Where possible, digestion products should be worked into the soil quickly, and if at all feasible application should not take place when ambient temperatures are high (i.e. preferably on cool days and not around the middle of the day).

Various combustion products such as nitrogen oxides, sulphur dioxide, carbon monoxide and particulates, among others, are produced during the combustion of biogas. Emissions of these products should be regulated in the respective national regulations.

Emissions to soil and water

The quantities of liquids processed and stored in biogas plants range from around a hundred to several thousand cubic metres, individual tanks often hold several thousand cubic metres. The contents of the tanks should not escape into the environment, whether in normal operation or in the event of an accident. Environmental impacts are most likely to arise from the organic load and nutrients. If a tank leaks, for example, large quantities of organically polluted liquids enter the environment. The high organic load (high chemical oxygen load) is broken down by microorganisms, thereby consuming oxygen.

The greatly reduced oxygen content can lead to death of fish populations. If large quantities of substrate enter the environment there is a considerable risk of eutrophication of water bodies.

The use of processing aids (refer to section on hazardous substances) also brings with it the risk of environmental hazards. Mixtures of trace elements, for example, if spilled into bodies of water, can be highly toxic for water organisms and have a longterm impact.

Health hazards

In light of the potential sources of danger outlined above it is impossible to completely rule out health hazards for operators, employees and third parties. These health hazards can be divided into four categories: hazardous substances, electrical hazards, mechanical hazards, and explosion and fire hazards.

Hazardous substances that are particularly likely to be present at biogas plants are biogas, processing aids, oils, activated carbon, silage effluent, slurry, wastes and biological agents.

Typical hazards include:

- Risk of asphyxiation and/or poisoning by fermentation gases / biogas in feedstock receiving areas. Release of highly toxic gases such as hydrogen sulphide in the receiving area, especially during mixing, as a result of reactions between feedstock materials

- Hazards associated with the use of additives and auxiliary materials with hazardous properties (e.g. carcinogenic and reprotoxic mixtures of trace elements.

Biological agents

The intake of biological agents through the respiratory tract, hand-to-mouth contact, skin/mucous membrane contact, cuts and stab injuries is relevant to the assessment of potential hazards.

The following are examples of hazards that may arise from biological agents during the production of biogas:

- Inhalation of dusts or aerosols containing moulds, bacteria or endotoxins, for instance from silage or dry poultry excrement that has become damp (SVLFG, 2016).
- If activities are conducted with visibly mouldy wastes, it is impossible to rule out acute toxic effects from the inhalation of mycotoxins or other microbiological metabolic products (TRBA 214, 2013).

Additional hazards that may arise in plants where other substrates are used beside energy crops, liquid manure and solid manure: biological agents in cosubstrates (e.g. pathogens); manual contact during sorting.

Various risky agents and materials are also liable to arise in the course of waste treatment. These may include impurities (interfering substances), animal carcasses, or wastes from hospitals, doctor's practices or households with people who are sick or in need of care (e.g. used syringes and cannulas).

Biological agents can also be introduced by rodents, birds or other animals and their excrement.

Hazards from electrical equipment

A variety of electrical equipment is used in biogas plants (control equipment, CHP unit, pumps, agitators, measuring instrumentation, etc.). Under certain circumstances this equipment may have adverse effects on health as a result of electrical hazards from the presence of electrical energy.

- Danger of electric shock or arc caused by an electric shock through an individual's body or by an arc flash.

Example: damaged power cables on agitators

- Danger from electric or magnetic fields from irritant effects in the human body created by the circulation of induction currents caused by electric fields, induced currents or magnetic fields. These effects occur in a frequency range up to 30 kHz (low-frequency range).

Example: electromagnetic, electrical and magnetic radiation from the generator of the CHP unit (danger for people with pacemakers).

- Danger from static electricity caused by an electric shock from the discharge of static electricity

Mechanical hazards

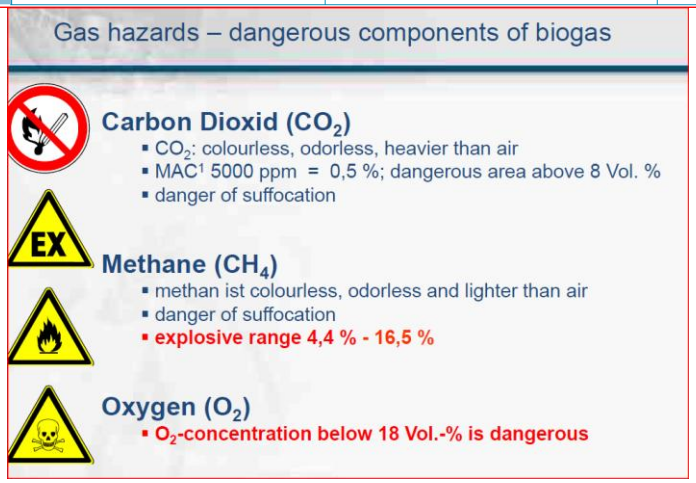
Accident blackspots in this connection include work on the silo or other workplaces at a height, work in the vicinity of rotating parts (e.g. feeding systems) or work in the vicinity of moving vehicles (risk of being run over). Accidents are particularly likely to occur during maintenance and repair work if inadequate protective measures have been taken.

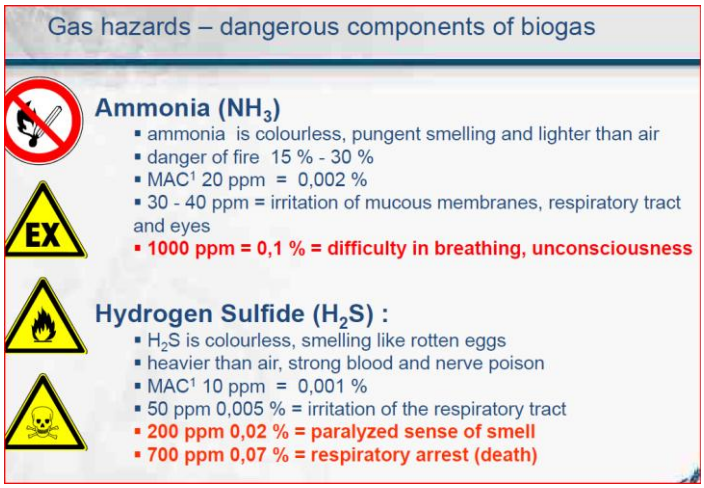
Gas hazards

The workplace exposure limit (TRGS 900, 2016) or occupational exposure limit (OEL) is the timeweighted average concentration of a substance in air at the workplace over a specified reference period at which no acute or chronic harm to the health of employees is expected to be caused. As a rule, the limit is set on the assumption that the exposure is for eight hours a day, five days a week over a working lifetime.

Table 2: Properties of the gaseous constituents of biogas. Sources: (TRGS 900, 2016) and (SVLFG, 2016)

	Properties	Hazardous atmosphere	Workplace exposure limit
CO_2	Colourless and odourless gas. Heavier than air.	8 % v/v, danger of asphyxiation.	5500 ppm
NH_3	Colourless and pungent-smelling gas. Lighter than air.	Above 30–40 ppm mucous membranes, respiratory tract and eyes become irritated. Above 1000 ppm breathing difficulties, potentially inducing loss of consciousness.	20 ppm
CH_4	Colourless, odourless gas. Lighter than air.	4.4–16.5 %	-
H_2S	Highly toxic, colourless gas. Heavier than air. Smells of rotten eggs	Above a concentration of 200 ppm the sense of smell becomes deadened and the gas is no longer perceived. Above 700 ppm, inhaling hydrogen sulphide can lead to respiratory arrest.	5 ppm





Explosion and fire hazards

Flammable substances may be present in the form of gases, vapours, mists or dusts. An explosion can only occur if three factors apply simultaneously:

- flammable substance (in distribution and concentration conducive to explosion)
- oxygen (from air)
- source of ignition

Depending on the circumstances, two types of explosion can take place in biogas plants: detonation and deflagration. A detonation is rapid combustion occurring at the explosive limit. The pressure generated is lower than in the case of a deflagration, but is sufficient to destroy window panes, for example. Personal injuries are usually limited to bruising, burns and cuts.

A deflagration is a form of explosion in which the propagation velocity of the reaction front is below the speed of sound in the respective medium and the combustion gas plumes flow in the opposite direction of propagation. The resultant pressure is enough to damage or entirely destroy buildings. People may suffer serious injuries, which may even be fatal. If the concentration of biogas in the atmosphere is between 6 and 22 % v / v, there is a risk of explosion in the presence of an ignition source (explosive range, explosive atmosphere). In the case of pure methane gas, the explosive range is between 4.4 and 16.5 % v / v. The ignition temperature of biogas is 700°C (methane 595°C). The composition of biogas may vary with regard to the proportions of methane and carbon dioxide, with the result that the explosive range of the gas mixture in the presence of air also varies.

In addition to the specific hazards outlined above, weather-related or other environmental sources of danger may also arise, **for example from flooding, earthquakes, storms, ice and/or snow, power outage, heavy rainfall or frost**. Site-related sources of danger such as the effect of neighbouring businesses or the traffic situation must also be taken into account. Environmental sources of danger such as these may result in interactions with other specific hazards.

Reference Number 46: BIOGAS: OPPORTUNITIES TO IMPROVE SAFETY AND SAFETY REGULATION. Olivier SALVI, Christine CHAUBET, Sébastien EVANNO. Transactions of the VŠB- Technical university of Ostrava. Vol. VII, No. 2, 2012. Safety Engineering Series, ISSN 1805-3238. p. 36- 43, DOI 10.2478/v10281-012-0010-0

Biogas safety issues

• *Main risks for biogas production* Biogas production plants present three main risks:

- The risk of explosion is the most studied because it is related to the production and use of a flammable gas which is composed mainly with methane (cf. Tab. 1).
- The second major risk is toxicity due to the presence of H2S. It is a very toxic gas that is produced in anaerobic digestion.
- The microbial risk is also to be considered, however chronic risk of inhaling pathogens and minor elements when using biogas is overshadowed by the two previous risks.

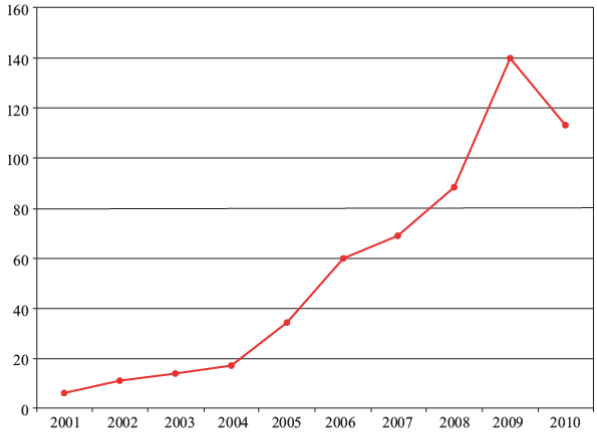


Fig. 1 Number of accidents on installations producing Biogas in Germany

Typical incidents in biogas plants are listed below:

- leakage in the storage tank and/or on the distribution network of the biogas,
- leakage following the completion of work on site storage and distribution of biogas,
- accidental release of H_2 S especially in mixtures of septic waste,
- water pollution caused by effluent discharge,
- overflowing sewage systems or storm-water control due to exceptional downpours, to equipment failures in the event of massive influx of water fire suppression,
- presence of dangerous products in the raw material used to produce biogas,
- overflow, freezing of valves, high pressure inside the digester.

Dangerous component of biogas

Fachverband BIOGAS

Carbon dioxide (CO_2)

- CO_2: colorless, odorless, heavier than air
- MAC[1] 5000 ppm = 0,5 %; dangerous area above 8 Vol. %
- danger of suffocation

Methane (CH_4)

- methane is colorless, odorless and lighter than air
- danger of suffocation
- **explosive range 4,4 % - 16,5 %**

Oxygen (O_2)

- **O_2-concentration below 18 Vol.-% is dangerous**

Ammonia (NH_3)

- ammonia is colorless, pungent smelling and lighter than air
- danger of fire 15 % - 30 %
- MAC[1] 20 ppm = 0,002 %
- 30 - 40 ppm = irritation of mucous membranes, respiratory tract and eyes
- **1000 ppm = 0,1 % = difficulty in breathing, unconsciousness**

Hydrogen Sulfide (H_2S) :

- H_2S is colorless, smelling like rotten eggs
- heavier than air, strong blood and nerve poison
- MAC[1] 10 ppm = 0,001 %
- 50 ppm 0,005 % = irritation of the respiratory tract
- **200 ppm 0,02 % = paralyzed sense of smell**
- **700 ppm 0,07 % = respiratory arrest (death)**

[1] maximum allowable concentration

Table 4: Risk analysis

			Potential Consequences				
			Minor injuries or discomfort. No medical treatment or measurable physical effects	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality
			Not Significant	Minor	Moderate	Major	Severe
Likelihood	Expected to occur regularly under normal circumstances	Almost Certain	Medium	High	Very High	Very High	Very High
	Expected to occur at some point	Likely	Medium	High	High	Very High	Very High
	May occur at some point	Possible	Low	Medium	High	High	Very High
	Not likely to occur in normal circumstances	Unlikely	Low	Low	Medium	Medium	High
	Could happen, but probably never will	Rare	Low	Low	Low	Low	Medium

Cases, Causes, and Impacts of Safety Incidents at AD Systems

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Bio Town Ag. Reynolds, IN 47980, USA
March 10, 2023

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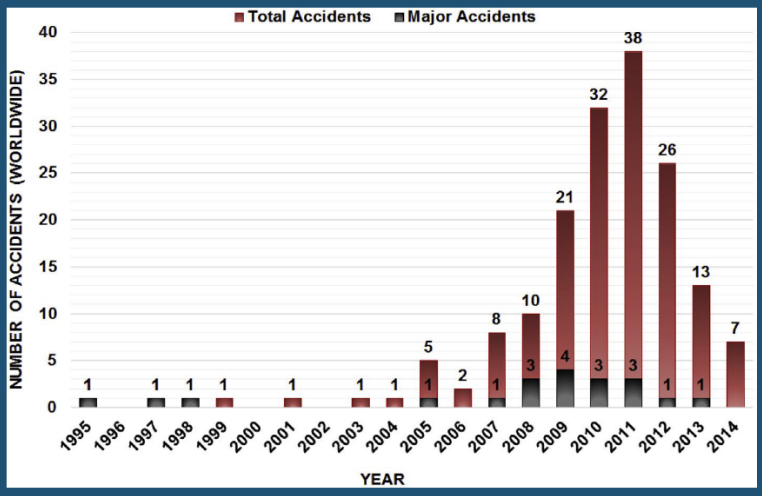
169 Cases in Europe (1995–2014)

12% (20 cases) of the 169 were major accidents (*major emission, fire, or explosion leading to serious danger to human health or the environment*).



Casson Moreno et al. 2016. Renewable Energy. 96, 1127-1134.

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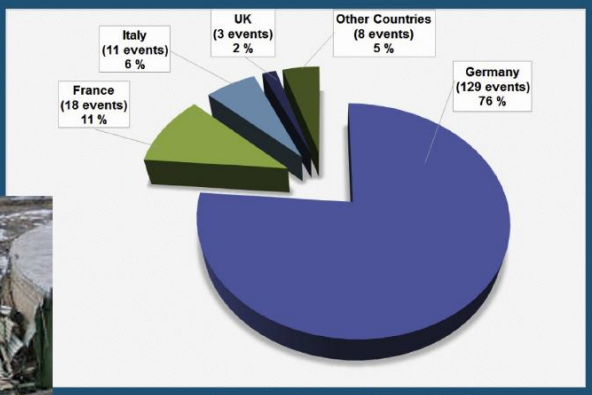
169 Cases in Different Countries



Countries of the 169 cases

Casson Moreno et al. 2016. Renewable Energy. 96, 1127-1134.

Damage in an AD incident

Jenkins et al., 2013. Loss Prevention Bulletin (229), 19-24.

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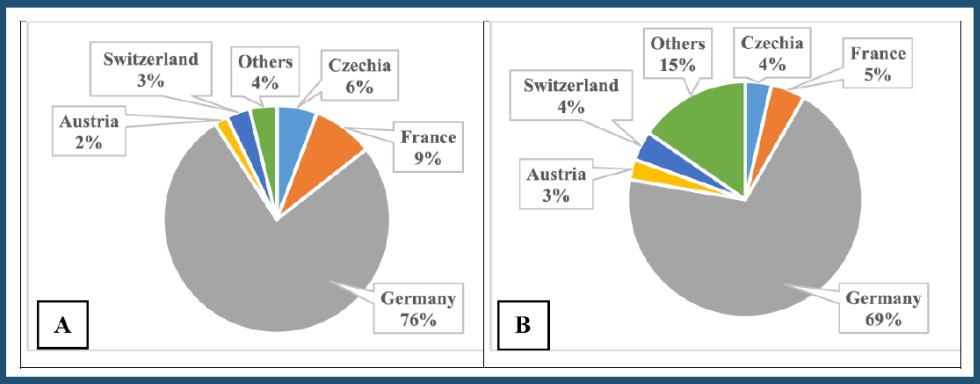
208 Cases in Europe (2006–2016)



Share of accidents in individual countries of 208 events (A). Share of individual countries in the total number of biogas stations in 2015 (B).

Travnicek et al. 2018. Renewable Energy. 122, 89-97

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2 Cases in England and Hungary

Dec. 3, 2020, Avonmouth, Bristol, England. Wesset Water's anaerobic digester explosion killed four people.

https://www.industrytap.com/what-may-have-caused-the-avonmouth-anaerobic-digester-explosion/55634

2021, Hungary: Explosion in the Nyírbátor Biogas Plant - three people died.

Daily News Hungary · Bátor Média · Oct 14, 2021

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4 Cases in USA (2011–2016)

1. April 17, 2011, Linwood, New York. Noblehurst Farms lost its digester, in an early morning fire.
   https://www.manuremanager.com/noblehurst-farms-loses-digester-in-fire-3731/

2. July 2012, Oakley Farm in Aumsville, Oregon. An explosion at the anaerobic manure digester.
   https://www.oregonlive.com/pacific-northwest-news/2012/07/methane_fueled_explosion_at_au.html

3. Aug. 6, 2014, Town of Vienna, Wisconsin. An explosion destroyed the roof of a 1.25-million-gallon manure digester.
   https://www.manuremanager.com/manure-digester-explosion-in-wisconsin-sparks-fire-15850/

4. Nov. 2016, Lowell, Michigan. Lowell Energy AD digester exploded due to a buildup of methane gas, resulted in a ruptured tank cover, a lingering odor and spilled waste.
   https://www.waste360.com/safety/michigan-biodigester-explodes-methane-gas-buildup

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3 Cases in USA in 2017 & 2018

5. Jan. 22, 2017, International Paper in Cantonment, Florida. An explosion caused significant structural damage to the largest pulp digester as well as the power house at the mill.
   http://www.northescambia.com/2017/01/my-heart-sank-mill-manager-speaks-out-about-explosion-future-of-ip

6. Jan. 2018, Missouri. Gas build-up leads to explosion at Blue River Wastewater Treatment Plant, Part of the building collapsed.
   https://www.kshb.com/news/local-news/gas-build-up-leads-to-explosion-at-blue-river-wastewater-treatment-plant

7. Aug. 30, 2018, Chicago. An explosion at a water reclamation plant in appears to have been caused by methane gas ignited by a worker's welding torch.
   https://www.wateronline.com/doc/explosion-at-chicago-water-reclamation-plant-injures-0001

PURDUE UNIVERSITY

2 Cases in USA in 2020 & 2021

- April 2020. Jay, Maine.
  A paper mill disabled by a dramatic explosion.
  No one was injured but 230 workers were left without jobs.
  The mill will close in the first quarter of 2023.
  https://apnews.com/article/explosions-maine-susan-collins-angus-king-4dfd183575a0f364a4545bec0e1132e6

Photo from AP News.
https://apnews.com/article/391dfff9b3768186d3ad318fa30f11fb/gallery/8139f20f69904163b8ebe9756ecea959

- June 8, 2021, Stockton, Iowa. Bob Baenziger Jr., 54, died while performing a dive to repair a broken cable at the bottom of a million-gallon anaerobic digester tank at Sievers Family. *(From multiple source, including https://www.desmoinesregister.com/story/news/2021/07/30/diver-robert-baenziger-jr-drowns-iowa-farm-accident/5427513001/)*

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143 Cases in Asia (1958–2022)

Cases and losses
- Total cases: 143 (all “major accidents”)
- Fatalities: 266
- Injuries: 219
- Total property damages: unknown, but huge

Victims
- Male : female = 5.5 : 1
- Minimum age: 3-year-old
- Maximum age: 75-year-old

Cases in two digester types:
- ~73.2% at household digesters
- ~26.8% at industrial digesters

Household digester
https://www.sohu.com/a/323140642_120034261

Industrial digesters

Ni, Unpublished data. Do not cite.

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Acute Poisoning and Explosion

- Poisoning by inhaling hydrogen sulfide (H_2S), 80.6% of all cases.
- Explosions by welding or other work at digesters, and fires by inappropriate use of biogas for cooking, and a lightning strike, 19.4% of all cases.

Poisoning in 2018, China.
https://www.sohu.com/a/233521492_420076

Incidents occurred while:

- Maintaining and repairing digester systems.
- Rescuing other victims in digesters.
- Rescuing animals fallen into digesters.
- Recovering lost items (such as cell phones) from digesters.

Explosion in 2013, India.
https://www.indiatvnews.com/news/india/

Ni, Unpublished data.

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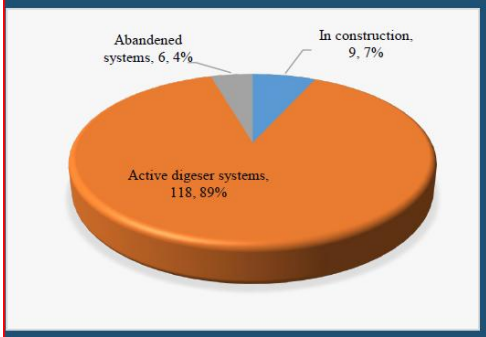
Status of Digesters at Incidents



Ni, Unpublished data.

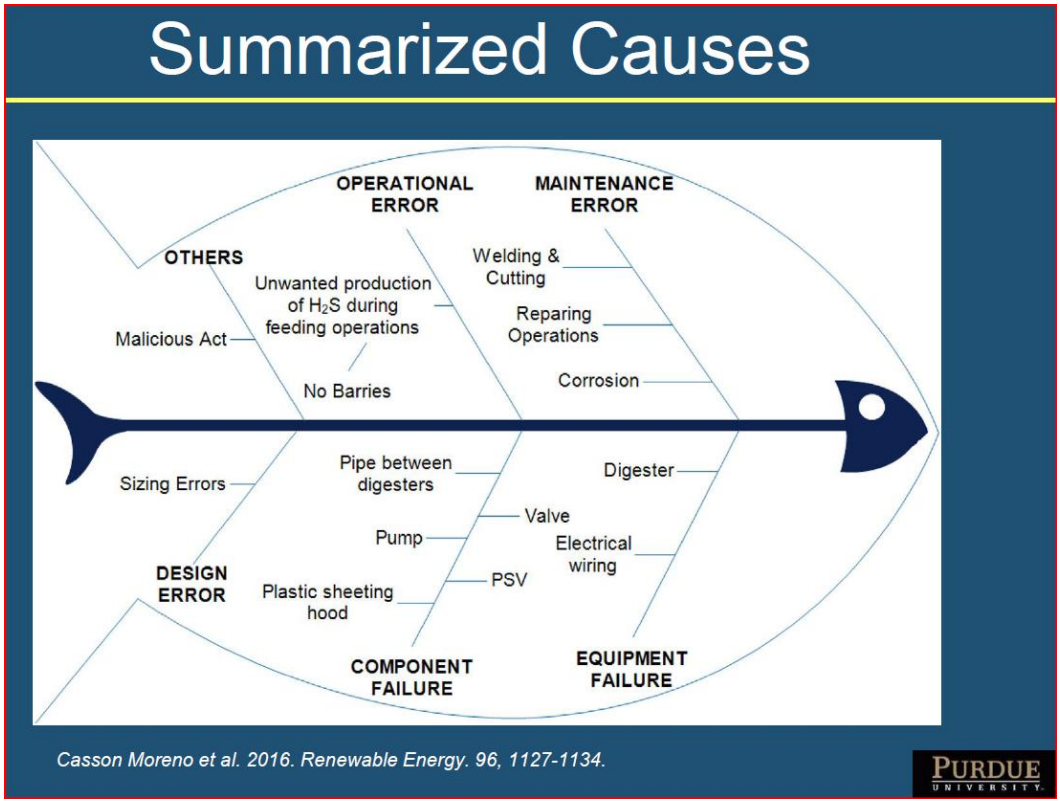
Incidents occurred:

- 89% at active digester systems.
- 7% at digesters in construction.
- 4% at abandoned digesters.

An abandoned household digester in China that claimed 3 lives

Chen, 2015. Deyang Evening News.

PURDUE UNIVERSITY



Reference Number 47: BIOEXELL-European Biogas Centre of Excellence

MANAGEMENT OF BIOLOGICAL CONTAMINATION

The main biologic contaminants in AD substrates are various types of bacteria, viruses, intestinal parasites, prions and other contaminants. The modern technologies of manure and biogenic waste treatment should not result in new routes of pathogens and diseases transmission between animals, humans and the environment. Some main measures would contribute to ensuring a veterinary safe recycling of digestate:

- Livestock health control. No animal manure and slurries will be supplied from any livestock with health problems.
- Feedstock selection and control. Hazardous biomass types are excluded from anaerobic digestion and canalised towards suitable, safe disposal methods (table 3).
- Pre-treatment/sanitation of feedstock
- Pressure sterilisation: 1330C, 3 bar, for 20 minutes.
- Pasteurisation: 700C, for 1 hour.
- Regularly control of the efficiency of pathogen reduction measures in digestate.

Table 3: Health rules concerning animal by-products not intended for human consumption

Category and description	Rules for utilisation
1. Animals suspected to be infected with TSE, specific risk material. - Animals, other than farm and wild animals, spec. pets, zoo and circus animals. - Catering waste from means of transport operating internationally	Always destruction incineration
2. Manure from all species and digestive tract content from mammalians. - All animal materials collected when treating wastewater from slaughterhouses or from category 2 processing plants, except from cat.1 slaughterhouse wastewater treatment plants. - Products of animal origin, containing residues of veterinary drugs. Dead animals, others than ruminants.	For AD must be pressure sterilised, for 20 minutes at 133^{0}C and 3 bars. NB: Manure and digestive tract content can be used for AD without pre-treatment.
3. All parts of slaughtered animals, declared fit for human consumption, or not affected by any signs of diseases. - Hides, skins,	For AD must be sanitised in separate tanks for 1hour at 70 ^{0}C.

THE PLANNING TASK

Feasibility studies

The potentials of a biogas plant can be established in a geographically defined area. The biogas plan may typically consist of the following items:

· mapping of manure resources
· mapping of waste products
· energy production and application/sales of energy
· supply scenarios (alternatives)
· estimate of consequences for the plant
· utilization of the digested product as manure

As an alternative the potentials can be studied based on a specific project. The contents will more or less be identical but be adapted to specific conditions at the site and the required plant concept. Table 1 shows the average biogas potential of the most common AD substrates in Denmark.

Location of the plant

The projects can be established in connection with a biogas plan or based on knowledge about local conditions. The following conditions must be observed:

- Accessibility to biomass – manure and/or various type of waste
- Possibilities of selling power and possibly heat (either directly or as cooling through absorption coolers)
- Political readiness to establish the project
- Possibilities of financing.

High-rate conversion requires available resources of a minimum of 40 t of biomass/day and a part of the biomass must be procured as high-grade waste products, etc. Transport of biomass is one of the important operation costs for the biogas plant. Aiming to have a sustainable economy for the plant, a thumb rule must be considered: the nutrient value of the digested biomass unit must be at least the same or bigger that the total costs of treatment, storage and transport of the same digested biomass unit. This aspect must be considered when planning the emplacement of the plant in the area as well as the location of the post storage tanks for digested biomass.

NB: When deciding upon the location of a biogas plant, a suitable distance between the plant and the residential areas must be considered as well as the direction of the main winds, in order to minimise traffic and odour nuisances.

Mapping of resources and energy sale

The resources are mapped either directly or indirectly. By direct mapping the specific qualities and quantities are examined. It is often possible in industries or other enterprises, which have already established a more or less organized handling of the biomass. Indirect mapping indicates that quantity etc. is estimated from standard figures such as e.g. manure production per cow, waste production per inhabitant, waste quantity per slaughtered animal. The method is particularly suited for mapping of manure and organic household waste. In practice the methods are combined.

The following information about the biomass is obligatory:

- Quantity
- quality (content of dry matter and a rough identification of type)
- possible seasonal variations
- present use/disposal (possibly including price of disposal).

Organisation

Besides the technical assessments the feasibility study should also contain an assessment of the organisation of the project under establishment and under operating conditions. As biogas projects aim at meeting requirements and solving problems for individuals, companies, groups, etc. it is essential that all interested parties are involved from the first steps of the planning phase.

Reference Number 48: A Human Health Toxicity Assessment of Biogas Engines Regulated and Unregulated Emissions. Alarico Macor and Alberto Benato. Appl. Sci. 2020, 10, 7048; doi:10.3390/app10207048

The aim of the present work is to evaluate the damage to human health arising from both regulated and unregulated emissions from biogas and natural gas internal combustion engines.

A more complete picture of the toxicity of both fuels is provided by the analysis of damage to human health assessed in the "Health Impact Assessment". The main outcomes are:

• The damage per unit of electricity caused by biogas is about three times the damage caused by natural gas.

• Among the four impact categories, "respiratory inorganics" is the most important because it contains NOx and SOx; the two substances with the highest impact. For this reason, "respiratory inorganics" accounts for approximately 97% of the total damage caused by the entire set of emissions. Among other categories, only the "respiratory organics" contributes in a non-negligible way.

• The classification of the most harmful substances shows NOx in the first place. It produces, on average, over 90% of the damage to human health for both biogas and natural gas. However, the damage generated by NOx from biogas is about three times higher than from natural gas. SO2 is present in all investigated biogas exhausts and it accounts for about 6% of the total damage while it is practically absent in natural gas. The VOCs produce quantitatively similar damage for both fuels. Hence, the investigation highlights the role of NOx and SOx. However, SOx is not classified as "regulated emissions" for biogas ICEs. So, being the SOx contribution to the total damage non-negligible, this compound needs to be included among the biogas "regulated emissions". There is also the need to fix a proper limits in order to reduce the harmfulness to humans of biogas fuel.

Based on actual scientific knowledge and performed computations, it is possible to conclude that:

• Among unregulated emissions, formaldehyde is 5 time higher in biogas exhausts than in natural gas ones.

• NOx in the biogas engines exhausts is three times higher than those of natural gas.

• HIA and RA analyses complement each other and provide a picture of the damage to human health.

• Carcinogenic risk evaluation reveals that B(a)Peq of biogas and natural gas are comparable.

• Biogas toxic equivalency of dioxins and furans in the biogas exhausts is 10 times higher than in the natural gas exhausts.

• The contribution to human health damage of unregulated emissions is limited due to their very small quantities.

• For biogas and natural gas ICEs, considering NOx and SOx is enough to obtain a good estimation of the damage to human health.

• The damage per unit of electricity computed from biogas engines exhausts is about three times higher than from natural gas.

Reference Number 49: Understanding risks and optimising anaerobic digestion to minimise pathogen and antimicrobial resistance genes entering the environment. Devendra Saroj, Lisa M Avery, Rupert L Hough,

Material that originates from the human or animal gut can contain pathogens and other organisms, any of which may be carrying genes that make them resistant to antibiotics. If we apply those to land, and allow them to enter the environment, they can remain in the soil or be washed into water bodies which may be used for irrigation of food crops, water supplies, recreation or shellfish production. From here, humans and animals can potentially consume pathogens/resistant organisms or come into direct contact with them in the environment. Given that earlier this year, the UK's outgoing chief medical officer said that "we are in an arms race against microbes" and that if no action is taken on antimicrobial resistance, 10 million people worldwide could die each year by 2050; we ought to understand exactly what is in the organic amendments we apply to land.

Anaerobic digestion (AD) utilises organic materials to produce energy *via* biogas while also producing nutrient-rich digestate ideal for application to land as a fertiliser. However, there may be a risk to human (and livestock) health if pathogens originating in the feedstock are transferred to land and potentially taken up into the food chain This is compounded by concerns over antibiotic-resistant bacteria (ARBs) entering the environment. Resistance genes (ARGs) can be transferred widely within the soil microbiome, including to and from pathogens, and we do not know their fate during and post-anaerobic digestion. Organisms of particular concern include Clostridia, which, being anaerobes, can proliferate under the digester conditions and isn't always removed by pasteurisation. With little data on pathogen and ARB/ARG prevalence in feedstocks, persistence/proliferation through the AD process, we cannot determine risks associated with application of AD to land or how it compares to traditional organic amendments.
Response MLavelle: These results indicate that land spreading of digestate requires compliance with the Precautionary Principle in relation to human health & that this Application be refused.

Reference Number 50: Microplastics, Antibiotics, and Heavy Metals in Anaerobic Digestion Systems: A Critical Review of Sources, Impacts, and Mitigation Strategies. Liu, H.; Yuan, X.; Yao, Y.; Yao, L.; Zhang, J.; Maurer, C. Recycling 2025, 10, 116. https://doi.org/10.3390/recycling10030116
The widespread implementation of anaerobic digestion (AD) systems for organic waste treatment is increasingly challenged by emerging contaminants, including microplastics (MPs), antibiotics, and heavy metals (HMs), which exhibit environmental persistence and pose risks to ecological and human health. This review critically examines the sources, transformation pathways, and advanced mitigation strategies for these contaminants within AD systems. MPs, primarily derived from fragmented plastics and personal care products, accumulate in digestates and act as vectors for adsorbing toxic additives and pathogens. Antibiotics, introduced via livestock manure and wastewater, exert selective pressures that propagate antibiotic resistance genes (ARGs) while disrupting methanogenic consortia. HMs, originating from industrial and agricultural activities, impair microbial activity through bioaccumulation and enzymatic interference, with their bioavailability modulated by speciation shifts during digestion. To combat these challenges, promising mitigation approaches include the following:

- bioaugmentation with specialized microbial consortia to enhance contaminant degradation and stabilize HMs;
- thermal hydrolysis pretreatment to break down MPs and antibiotic residues;
- chemical passivation using biochar or sulfides to immobilize HMs.

Co-digestion practices inadvertently concentrate these contaminants, with MPs and HMs predominantly partitioning into solid phases, while antibiotics persist in both liquid and solid fractions. These findings highlight the urgency of optimizing mitigation strategies to minimize contaminant mobility and toxicity. However, critical knowledge gaps persist regarding the long-term impacts of biodegradable MPs, antibiotic transformation byproducts, and standardized regulatory thresholds for contaminant residues in digestate. This synthesis underscores the necessity for integrated engineering solutions and policy frameworks to ensure the safe resource recovery from AD systems, balancing energy production with environmental sustainability.

Microplastics is the subject of the contamination studies of the 14 papers we consider for this critical review. The pervasive use of plastics—global production reached 360 million metric tons in 2018—has led to irreversible environmental fragmentation, with an estimated 12 billion tons of plastic waste projected to accumulate in landfills and ecosystems by 2050. Secondary microplastics (MPs, 1 µm–5 mm) predominantly originate from the degradation of microplastics through mechanical abrasion, UV weathering, and microbial action, while primary MPs are intentionally manufactured for industrial applications (e.g., electronics coatings, personal care products). China alone discharges approximately 306.9 million tons of plastic microbeads annually into aquatic environments, exemplifying the scale of anthropogenic MP emissions.
Wastewater treatment plants (WWTPs) act as critical interception points, retaining >90% of influent microplastics (MPs) in sewage sludge through sedimentation and filtration processes. However, this retention inadvertently transforms sludge into a concentrated MP reservoir, with digestates containing 5-fold higher MP concentrations than raw waste-activated sludge (WAS) [24]. Globally, PS, PVC, PP, PET, and PE dominate sludge-associated MPs, exhibiting morphological diversity (spheres, fibers, fragments) and size heterogeneity (0.1–5 mm). Regional studies reveal substantial variations: Italian WWTPs report PA and PET concentrations of 29.3–1470 µg/g in sludge, while Canadian facilities detect 50–150 µg/L polystyrene nanoplastics (PsNPs) in anaerobically digested sludge.
Notably, MPs' high surface-area-to-volume ratio and hydrophobicity enable them to act as vectors for heavy metals, antibiotics, and pathogens through adsorption–desorption dynamics, amplifying contaminant mobility in AD systems. Land application of MP-laden digestates introduces these composites into agricultural soils, posing long-term risks to food security—a critical nexus requiring regulatory intervention.

Antibiotics is the subject of the contamination studies of 18 papers we consider for this critical review. Antibiotics, widely used as growth promoters in livestock and additives in personal care products, have experienced escalating environmental release due to surging global consumption. Between 2000 and 2015, global antibiotic usage increased by 65%, with 30% allocated to livestock farming, while medical and aquaculture sectors accounted for 55% and 15%, respectively. Approximately 17–90% of veterinary antibiotics are excreted as parent compounds or active metabolites, resulting in concentrations ranging from 100 µg/L to 500 mg/L in livestock manure. To the best of our knowledge, there are four types of antibiotics including tetracyclines, sulfonamides, quinolones, and macrolides that were reportedly detected in the FW and related AD systems, as shown in Table 1. In China's intensive farming systems, tetracyclines (TCs), sulfonamides (SAs), and fluoroquinolones (QNs) constitute >75% of the antibiotic load in swine manure, while enrofloxacin concentrations in poultry manure exceed those in swine/cattle manure by three orders of magnitude.

Table 1. Antibiotic contents found in manure and digestates.

Country	Matrix	CTC	DC	OTC	TC	SDZ	SMZ
China	Dairy cow feces	1	-	5.1	1.1	-	0.46
China	Cattle manure	-	-	21.4	12	4.6	9.4
China	Cow dung	2.2	0.68	1.2	-	-	-
China	Cow feces	1.5	-	-	0.02	-	-
The Netherlands	Swine feces	-	1.9	0.16	-	0.13	-
Belgium	Swine manure	-	22.8	2	-	3	-
Germany	Swine manure	6.2	-	21.5	9.7	4.9	-
Austria	Pig manure	46	-	29	23	-	-
Germany	Pig manure	37.4	27.4	13.6	152	7.3	-

Antibiotics enter anaerobic digestion systems via two primary pathways:

- codigestion of livestock manure (e.g., TCs (tetracyclines): 21.4–152.0 µg/g dry weight) with municipal waste-activated sludge (WAS), directly suppressing methanogen metabolic activity;
- WAS-retained antibiotics (e.g., sulfamethoxazole: 3–9.4 µg/g) influencing microbial community function through extracellular polymeric substance-mediated adsorption–desorption dynamics [46]. Antibiotics with low MIC50 values (e.g., enrofloxacin MIC50 <0.06 µg/mL) inhibit key enzymatic activities via ribosomal targeting, reducing CH_4 yield by 30–50%. Concurrently, antibiotic-induced selective pressure drives horizontal transfer of antibiotic resistance genes (ARGs, e.g., sulfonamide resistance genes sul1 and sul2), increasing multidrug-resistant bacteria abundance by 2–3 orders of magnitude in AD sludge.

Despite the predominance of TCs and SAs (>75% detection rate in Chinese swine manure), global thresholds for antibiotic residues in agricultural digestate remain undefined. Drawing from Germany's regulatory model, integrated strategies should include source reduction (e.g., restricting high-risk antibiotics with MIC50 <1 µg/mL), process intervention (10% biochar addition achieves >90% sulfonamide adsorption), and legislative controls (ecotoxicology-based MRLs) to mitigate risks.

Heavy metals (HM) is the subject of the contamination studies of the 17 papers we consider for this critical review. The valorization of municipal sludge and livestock manure as organic fertilizers is hindered by heavy metal (HM) contamination, despite their rich nutrient content. China generates over 60 million tons of sludge annually, with notable HM concentrations (e.g., Cu, Zn, Cd, Cr), where Fe, Mn, Cu, and Zn constitute >80% of total HMs in swine manure. Table 2 shows the content of HMs in slurry. Total HM concentrations alone inadequately reflect ecological risks, as bioavailability and toxicity depend critically on chemical speciation—acid-soluble (F1) and reducible fractions (F2) exhibit high mobility, while oxidizable (F3) and residual fractions (F4) remain stable

Table 2. HMs contents in the slurry (mg/L).

Animal Manure	Treatment Condition	Cu	Zn	Cd	As	Pb	Cr	Ni	Mn
PM	Mesophilic digestion	16.34	20.66	-	0.26	-	-	-	-
PM	Mesophilic digestion	4.17	8.92	-	-	0.02	-	-	0.26
PM	Mesophilic digestion	1.32	3	-	-	0.04	0.05	3.62–22.1	-
PM	Mesophilic digestion Mixed with corn silage	14.78	9.71	1.59	-	13.9	-	-	1.88
CHM	Mesophilic digestion	1.79	12.67	-	-	0.05	0.11	6.91–31.4	-
CHM	Thermophilic digestion	15.17	124.51	0.17	27.15	1.94	39.75	-	-
DCM	Mesophilic digestion	3.29	17.45	-	0.06	-	-	1.51–4.96	-
China		0.5	2	0.01	0.05	0.2	0.1	0.2	-

Note. Limit values according to standard for irrigation water quality in China (GB 5084-2021) ; PM: pig manure; CHM: chicken manure; DCM: dairy cattle manure;-: It was not mentioned in the references.

Within anaerobic digestion (AD) systems, HMs undergo dynamic speciation transformations. During initial hydrolysis-acidogenesis, organic acids lower pH to 5.5–6.0, enhancing dissolution of HM ions (e.g., Cu2+, Zn2+). As methanogenesis consumes volatile fatty acids, pH 7.5–8.5, establishing a reductive environment that facilitates HM stabilization through:

- sulfide precipitation (e.g., CuS/ZnS) mediated by sulfate-reducing bacteria;
- humic acid (HA) complexation, with HA-Cu/HA-Zn exhibiting 2–3× higher stability than fulvic acid-bound forms;
- extracellular polymeric substance (EPS) adsorption, achieving 60–85% binding efficiency. Ultimately, >90% of HMs accumulate in digestate solids, with 3–25 µm particles carrying >70% of the HM load.

Toxicity rankings follow Hg > Cd > Cr(III), where Cd poses the highest risk due to its bioaccumulation factor (BCF > 5). Although passivation strategies (e.g., composite additives) reduce Cu bioavailability by 40–60%, global standards for HM thresholds in agricultural digestate remain absent. Future efforts must establish speciation-based risk assessment frameworks and develop microbial enhancement technologies targeting EPS synthesis or sulphur metabolism to achieve controlled HM risks in AD systems.

Response MLavelle: These results indicate that land spreading of digestate requires compliance with the Precautionary Principle in relation to human health & that this Application be refused.

Reference Number 51: Microplastic abundance and characterization in the anaerobic co-digestion of food waste and dairy manure. Whitney AL, Chomiak KM, Babbitt CW, Eddingsaas NC and Tyler AC (2025) *Front. Sustain. Food Syst.* 9:1666814. doi: 10.3389/fsufs.2025.1666814

Microplastics (MP) are an emerging contaminant in organic waste recycling, yet their occurrence and fate in anaerobic digestion (AD) systems remain poorly understood due to challenges in isolating MP from complex matrices. This study developed and validated a novel extraction method using peroxide oxidation and an EDTA–Triton X-100 solution that achieved >96% recovery without polymer degradation. This method was applied to characterize MP in manure, digester effluent (digestate), and lagoon storage at a full-scale food waste–manure co-digestion facility. MP were consistently detected across all sources, with concentrations ranging from 120 MP kg−1 (manure) to >3,300 MP kg−1 (lagoon). Abundance was highly variable over time, shaped by feedstock composition and digester management practices. The MP observed likely stemmed from multiple pathways, including food waste inputs, packaging residues, on-farm sources, atmospheric deposition, and fragmentation of larger plastics during digestion. Polyethylene terephthalate (PET) fibers dominated across all samples. These findings provide the first quantitative evidence of microplastic (MP) occurrence throughout the AD process and highlight how management decisions influence contamination. By advancing extraction methods and generating new field-scale data, this study establishes a foundation for assessing the risks of MP release from AD systems to agricultural soils and downstream ecosystems.

Reference Number 52: Ranking hazards pertaining to human health concerns from land application of anaerobic digestate. Rajat Nag, Paul Whyte, Bryan K. Markey, Vincent O'Flaherty, Declan Bolton, Owen Fentone, Karl G. Richards

, Enda Cummins. Science of the Total Environment 710 (2020) 136297.
https://doi.org/10.1016/j.scitotenv.2019.136297

Farm yard manure and slurry (FYM&S) are important AD feedstock and are typically mixed with agricultural waste, grass and/or food wastes. The feedstock may contain many different pathogens which can survive the AD process and hence also possibly be present in the final digestate.

A scoring system was used to categorise likely inactivation during AD, hazard pathways and finally, severity as determined from reported human mortality rates, number of global human-deaths and infections per 100,000 populations. Five different conditions including mesophilic and thermophilic AD and three different pasteurisation conditions were assessed in terms of specific pathogen inactivation. In addition, a number of scenarios were assessed to consider foodborne incidence data from Ireland and Europe and to investigate the impact of raw FYM&S application (without AD and pasteurisation). A sensitivity analysis revealed that the score for the mortality rate (S3)was themost sensitive parameter (rank coefficient 0.49) to influence the final score S; followed by thermal inactivation score (S1, 0.25) and potential contamination pathways (S2, 0.16). Across all the scenarios considered, the screening tool prioritised Cryptosporidium parvum, Salmonella spp., norovirus, Streptococcus pyogenes, enteropathogenic E. coli (EPEC), Mycobacterium spp., Salmonella typhi (followed by S. paratyphi), Clostridium spp., Listeria monocytogenes and Campylobacter coli as the highest-ranking pathogens of human health concern resulting from AD digestate in Ireland. This tool prioritises potentially harmful pathogens which can emerge from AD digestate and highlights where regulation and intervention may be required.

Harmful pathogens can be present in higher concentrations in animal FYM&S (Jones and Martin, 2003; Avery et al., 2004; Nicholson et al., 2005) compared to food waste (Jones and Martin, 2003), grass and agricultural residues (Seadi and Lukehurst, 2012). Hutchison et al. (2004) reported high numbers of zoonotic pathogens (E. coli O157, Salmonella, Listeria monocytogenes, Campylobacter, Cryptosporidium parvum, Giardia intestinalis) in both fresh and stored animal waste (cattle, pig, poultry and sheep). The application of rawmanure and slurry is standard practice on farms to utilise animal waste while also replenishing nutrients to the soil (Szogi et al., 2015). AD is a process which can also use FYM&S as a feedstock and, by the action of microorganisms, break down biodegradable organic compounds into simpler molecules in the absence of oxygen to produce methane (Abbasi et al., 2012; Manyi-Loh et al., 2013, 2016).

Foodborne illness (gastroenteritis) is a particular global health concern (WHO, 2008; Thomas et al., 2013; Torgerson et al., 2015). Nag et al. (2019)mentioned that the application of raw FYM&S and anaerobic digestate could possibly play a role in pathogen transportation from agricultural land to humans through the food chain (mainly ready to eat RTE crops). According to TIME Health (2017), 351,000 people die of food-poisoning globally every year. Foodborne disease means, according to WHO (2008), any disease of an infectious or toxic nature caused by consumption of food and a foodborne disease outbreak can be defined in the following ways,

a) The observed number of cases of disease exceeds the expected number

b) The occurrence of two or more cases of a similar foodborne disease resulting from the ingestion of a common food.

The Health Protection Surveillance Centre (HSE, 2019) cited by Nag et al. (2019) suggests that Clostridium, Cryptosporidium, E. coli, Salmonella are the main pathogens of human health concern in Ireland. This highlights the importance of considering the severity (fatality/mortality rate) rather than simply the number of confirmed cases in an outbreak.

Tropical diseases; mostly parasites (helminths) and some viral diseases such as yellowfever virus,West Nile virus, dengue virus, tick-borne encephalitis virus, zika virus, ebola virus, lassa virus,marburg virus (Hotez et al., 2007) are not common in Ireland and there is no historical evidence of such outbreaks in Europe.

In some countries such as Denmark, animal manure is treated with mixed municipal sewage (Hartmann et al., 2002). Therefore, pathogens which are present both in animal manure, slurry and human effluent need to be considered in the European context. In contrast, grass, agriculture residues, animal manure and slurry, the organic fraction of municipal solid waste (comprises food and garden waste only) are considered the only feedstock used in AD plants in Ireland (Singh et al., 2010). The pathogenswhich have possible transmission pathways such as air, soil or food, water, and animal contact/zoonotic were considered for this study, while diseases which can be spread only by person-to-person contact (HPSC, 2005) or insect bites were excluded.

Animal diseases found in Ireland and typical symptoms.
(Source: DAFM).

Diseases	Pathogens	Relative frequency of population deaths (%) in 2016
Cattle		
Gastrointestinal infection (Enteritis and Parasitic)	Bovine Diarrhoeal Virus, *Salmonella*, Liver fluke, Rumen fluke, gut worms (stomach and intestinal)	12
Respiratory infections (pneumonia, pleuropneumonia and parasitic bronchitis)	Mycobacterium, Bovine respiratory syncytial virus (RSV), Trueperella pyogenes, Mannheimia haemolytica, Dictyocaulus spp., Mycoplasma bovis, Pasteurella multocida, bovine herpesvirus, Histophilus somni	17
Systemic infection	Escherichia coli	5
Clostridial infection	Clostridium novyi, Cl. Chauvoei, Cl. Sordellii, Cl. perfringens, Cl. septicum, Cl. perfringens, Cl. Botulinum	4
Cardiac infection	Trueperella pyogenes	9.5
Liver disease	Listeria monocytogenes, Liver fluke	3.5
Bovine abortion	Trueperella pyogenes, Salmonella Dublin, Bacillus licheniformis, Listeria moncytogenes, Aspergillus spp.	7.1, 4.8, 4.1, 2.9, 0.6
Bovine mastitis	E. coli, Staphylococcus aureus, Streptococcus uberis	8, 26.8, 12
Sheep		
Parasitic disease	Teladorsagia (Ostertagia) circumcincta, Haemonchus contortus, Trichostrongylus spp., Nematodirus battus	13
Respiratory infections	Mannheimia haemolytica, Less commonly (Pasteurella multocida, Trueperella pyogenes, Bibersteinia trehalosi and Mycoplasma ovipneumonae)	12
Septicaemia	Bibersteinia trehalosi	15
Clostridial and Kidney disease	Clostridium perfringens, Clostridium difficile	7
Enteric disease	rotavirus and coronavirus	7
Ovine abortion	Toxoplasma gondii, Chlamydophila abortus, E. coli, Salmonella Dublin, Trueperella pyogenes, Listeria spp., Streptococcus spp.	40.2, 26.1, 16.5, 0.8, 4.4, 4.0, 2.0
Pig		
Pneumonia	Pasteurella multocida, Mycoplasma hyopneumoniae, Actinobacillus pleuropeumoniae, Trueperella pyogenes, Swine influenza virus	29
Colibacillosis and Enteric infection	E. coli, Salmonella, Clostridium perfringens, Clostridium difficile	22
Septicaemia	Klebsiella pneumoniae, Streptococcus suis, Listeria monocytogenes, E. coli	12
Nervous disease	Streptococcus suis	5
Poultry		
Septicaemia	Escherichia coli, Erysipelothrix rhusiopathiae	26
Digestive	Erysipelothrix rhusiopathiae, Brachyspira spp., adenovirus	6.5
Musculoskeletal	NA	8
Respiratory	Adenovirus	9
Parasitic disease	Dermanyssus gallinae	15

Pathogens considered for Scenario A $_{FOODIRE}$.

Number	Pathogens	Number of confirmed human cases in Ireland[b]										Total number of confirmed cases/100,000 population (notification rates)[b,d]										Avg. value	Score $S3^{a}_{IRE}$
		2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007		
1	*Campylobacter* spp.	2511	2453	2593	2288	2391	2433	1660	1810	1752	1885	53.1	53	56.3	49.8	52.17	54.3	37.15	40.67	39.8	43.7	47.999	0.9
2	*Salmonella* spp.	299	270	259	326	309	311	349	335	447	440	6.3	5.8	5.6	7.1	6.7	6.9	7.8	7.5	10.2	10.2	7.41	0.8
3	*Yersinia* spp.	3	13	5	4	2	6	3	3	3	6	0.06	0.28	0.11	0.09	0.04	0.13	0.07	0.07	0.1	0.1	0.105	0.7
4	*E. coli*	737	598	572	564	412	275	197	237	213	115	15.6	12.92	12.42	12.29	8.99	6.14	4.41	5.33	4.8	2.7	8.56	0.8
5	*Listeria monocytogenes*	13	19	15	8	11	7	10	10	13	21	0.28	0.41	0.33	0.17	0.24	0.16	0.22	0.22	0.3	0.5	0.283	0.7
6	*Coxiella burnetii*	6	4	0	0	5		9	17			0.13	0.09	0	0	0.11		0.2	0.4			0.132	0.7
7	*Echinococcus* spp.	2	0	0	1	1	0	1	1	2	0	0.04	0	0	0.02	0.02	0	0.02	0.02	0	0	0.012	0.6
8	*Brucella* spp.	2	0	3	1	2	1	1	0	2	7	0.04	0	0.07	0.02	0.04	0.02	0.02	0	<0.1	0.2	0.045	0.6
9	*Trichinella* spp.	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	<0.1	0.09	0.6
10	*Mycobacterium* spp.	3	5	3	6	4	6	7	11	5	5	0.06	0.11	0.07	0.13	0.08	0.13	0.16	0.25	0.11	<0.1	0.122	0.7
11	*Toxoplasma gondii*	0	1	0	1	1		1	37			0	1.5	0	1.5	1.4		1.36	0.83			0.941	0.7
12	*Vibrio* spp.																					0.001	0.5
13	*Clostridium* spp.																					0.001	0.5
14	Norovirus							50	28									1.1	0.616			0.858	0.7
15	*Hepatitis A*																					0.001	0.5
16	*Cryptosporidium*[c]		439	394	514	556	428	294	445	416	609		10.38	9.31	12.15	13.14	10.12	6.95	10.52	9.83	14.4	10.755	0.9

[a] Scale for selecting score $S3_{IRE}$ based on the total number of confirmed cases/100,000 population (notification rates).
[b] Blank cells represent unavailability of data in the report.
[c] Only Cryptosporidium data has been collected from The Health Protection Surveillance Centre (HPSC) (2018).

[d]

* Number of confirmed cases/100,000 population range		Score $S3_{IRE}$
100	10	0.9
9.9	1	0.8
0.99	0.1	0.7
0.099	0.01	0.6
0.0099	0.001	0.5
0.00099	0.0001	0.4

Pathogens considered for Scenario B $_{FOODEU}$.

Number	Pathogens	Number of confirmed human cases in the EU[b,c]										Total number of confirmed cases/100,000 population (notification rates)[b,c,d]										Avg. value	Score $S3^{a}_{EU}$
		2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007		
1	*Campylobacter* spp.	246,307	232,134	236,818	214,710	214,300	220,209	215,397	198,725	190,579	200,980	66.3	62.9	66.5	61.4	61.7	50.28	48.56	45.57	40.7	45.2	54.911	0.9
2	*Salmonella* spp.	94,530	94,597	92,012	87,753	94,278	95,548	101,037	110,181	134,580	153,852	20.4	20.9	20.7	20.3	21.9	20.7	21.5	24	26.4	31.1	22.79	0.9
3	*Yersinia* spp.	6861	6928	6435	6352	6215	7017	6780	7578	8356	8803	1.82	1.91	1.83	1.92	1.93	1.63	1.58	1.65	1.8	2.8	1.887	0.8
4	*E. coli*	6378	5929	5900	6042	5680	9485	3656	3583	3159	3271	1.82	1.68	1.75	1.8	1.7	1.93	0.83	0.75	0.7	0.6	1.356	0.8
5	*Listeria monocytogenes*	2536	2206	2242	1883	1720	1476	1601	1654	1425	1581	0.47	0.43	0.46	0.39	0.36	0.32	0.35	0.36	0.3	0.3	0.374	0.7
6	*Coxiella burnetii*	1057	822	780	647	518		1414	1988	1660	605	0.16	0.18	0.18	0.15	0.12		0.36	0.51	0.5		0.27	0.7
7	*Echinococcus* spp.	772	883	820	805	865	781	756	775	909	972	0.2	0.2	0.19	0.18	0.2	0.18	0.16	0.18	0.2	0.2	0.189	0.7
8	*Brucella* spp.	516	437	462	498	503	330	356	404	735	639	0.12	0.09	0.09	0.1	0.1	0.07	0.07	0.08	0.1	0.1	0.092	0.6
9	*Trichinella* spp.	101	156	324	217	301	268	223	750	670	787	0.02	0.03	0.06	0.04	0.06	0.05	0.05	0.16	0.1	0.2	0.077	0.6
10	*Mycobacterium* spp.	170	181	167	144	132	132	165	134	123	113	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	<0.1	0.031	0.6
11	*Toxoplasma gondii*	47	288	258	213	144		21	289	11	16	1.57	8.27	7.4	6.2	4.2		0.56	0.65			4.121	0.8
12	*Vibrio* spp.	76	29						17			<0.01	<0.01									0.009	0.5
13	*Clostridium* spp.	49	60	1727	2009	1729	1050	795	1704	857		0.01	0.01	0.04	0.06	0.03	0.03	0.02	0.03	0.03		0.028	0.6
14	Norovirus	11,993	13,536	3580	2023	13,987	2529	6533	2670	3617		0.08	0.06		0.23							0.123	0.7
15	*Hepatitis A*	155	78	48	1444	116	7	13	2	104		<0.01	<0.01	<0.01								0.009	0.5
16	*Cryptosporidium*	62	120	24	65	11	20,000	12,700		87		<0.01	<0.01	<0.01								0.009	0.5

[a] Scale for selecting score $S3_{EU}$ based on the total number of confirmed cases/100,000 population (notification rates).
[b] Iceland, Norway, Switzerland are excluded; no special agreement for data.
[c] Blank cells represent unavailability of data in the report.
[d]

* Number of confirmed cases/100,000 population range		Score $S3_{EU}$
100	10	0.9
9.9	1	0.8
0.99	0.1	0.7
0.099	0.01	0.6
0.0099	0.001	0.5
0.00099	0.0001	0.4

It can be concluded that pathogens such as Mycobacterium spp., Salmonella enterica spp., Listeria monocytogenes, Enterobacter spp., Clostridium spp. And E. coli are common both in human and animals. The common top ranked pathogens which appeared in the BM(Fig. 5), Scenario A FOODIRE (Fig. 7a), Scenario B FOODEU (Fig. 7b), and Scenario C RAWFYM&S (Fig. 7c) models are Cryptosporidiumparvum, Salmonella enterica spp., norovirus, Streptococcus pyogenes, Entamoeba histolytica, enteropathogenic E. coli (EPEC), Mycobacterium spp., Salmonella typhi followed by S. paratyphi, Clostridium spp., Listeria monocytogenes and Campylobacter coli. A comparison between results of A FOODIRE (Fig. 7a) and Scenario B FOODEU (Fig. 7b) highlights the difference between foodborne pathogens in Ireland and those found in the EU, with Cryptosporidium being noted as a greater issue in Ireland. According to the Health Protection Surveillance Centre (HPSC) (2018), there have been 400 to 600 cases (yearly) of cryptosporidiosis in Ireland since 2004. In the last scenario (Scenario C RAWFYM&S), no heat treatment was applied in terms of AD or pasteurisation; the additional pathogens of concern were Campylobacter jejuni, Vibrio spp., hepatitis A-virus, E. coli O157:H7, E. coli invasive & toxigenic, Streptococcus pneumoniae and rotavirus. A comparison of Fig. 5 and 7c highlights the effect of M-AD in reducing the final risk score for Salmonella typhi (and S. paratyphi) and norovirus. Other pathogens remained unchanged in terms of the ranking score; such as Cryptosporidium parvum, Streptococcus pyogenes, Entamoeba histolytica and Salmonella enterica spp. highlighting their heat resistance.

Likely levels and sources of parasites can be found in urban wastewater and hospital waste.

Pathogen name	Likely levels	Unit	Source	Reference
Ascaris	0.7 to 13.33	eggs l^{-1}	Wastewater	(Amahmid et al., 1999)
	10.08 to 24.36		Urban raw wastewater	(Maya et al., 2006;
	1344 to 4116		Animal wastewater	Hatam-Nahavandi et al., 2015)
Ancylostoma duodenale	100–150	eggs g^{-1}	Affected human stool	(Anderson and Schad, 1985)
	Mean intensity of infection was 250.1 ± 64.4		Affected human stool	(Reynoldson et al., 1997)
Toxocara spp.	0–4.35	eggs g^{-1}	Sand sample contaminated with faeces	(Uga, 1993)
	mean 4.24 ± 4.62 and median 2.17 ± 5.92		Hair sample of contaminated dogs	(Devoy Keegan and Holland, 2010)
Trichinella spp.	2 to 295	larvae g^{-1}	Contaminated meat	(Teunis et al., 2012)
Entamoeba histolytica	2.5 × 10^2 to 5.0 × 10^2	cysts l^{-1}	Wastewater treatment plant influent	(Sabbahi et al., 2018)
	39–308	cysts g^{-1}	Faecal sample collected from infected patients in hospitals	(Voupawoe, 2016)
Echinococcus multilocularis	20–140	eggs g^{-1}	Faecal sample of infected dog; mostly red fox and racoon dogs; very rare disease in Europe	(Allan et al., 1992; Conraths and Deplazes, 2015)
Echinococcus granulosus				

This lists the pathogens (parasites) such as Ascaris, Ancylostoma duodenale, Toxocara spp., Trichinella spp., Entamoeba histolytica, Echinococcus multilocularis, and Echinococcus granulosus and the likely levels in urban wastewater and hospital waste; the presence of these pathogens in FYM&S is rare. It is not recommended to mix urban wastewater with FYM&S in an AD plant, hence limiting the likely presence of these parasites.

Response MLavelle: These results indicate that land spreading of digestate requires compliance with the Precautionary Principle in relation to human health & that this Application be refused.

Reference Number 53: Understanding the extent of emerging contaminants in English soils: Environmental implications of differing organic waste applications John Nightingale, Felicity C.T. Elder, Andrea-Lorena Garduno-

Jimenez, Laura J. Carter. Journal of Hazardous Materials 500 (2025) 140433.
https://doi.org/10.1016/j.jhazmat.2025.140433
The application of differing organic fertilisers to agricultural land is a long-standing practice that supports sustainable nutrient recycling. Despite the widespread use of organic amendments, the occurrence, distribution and fate of Emerging Contaminants (ECs), within agricultural soils remains poorly understood. To address this knowledge-gap, this study presents a comprehensive assessment of ECs across 22 English farms with diverse amendment histories and soil types. We evaluated and developed both a harmonised in-field sampling strategy alongside targeted and non-targeted mass spectrometry approaches, to reveal the presence of a wide range of ECs in soils. The antiparasitic ivermectin had the highest reported concentrations (21.8 ± 7.3–105.9 ± 86.7 ng/g (dw)), followed by the antibiotics oxytetracycline, ofloxacin, enrofloxacin, and plant protection products atrazine, and diazinon. Non-target screening identified 524 chemical entities, 194 were singular occurrences. Prevalent contaminant classes included pharmaceuticals, plasticisers, polymers, fungicides and surfactants; > 40 % of these had not been previously detected in English soils. Dominant pharmaceuticals included antibiotics (n = 9), steroids (n = 4), anticancer (n = 3), and antipsychotic metabolites (n = 3). Here we present a feasible, and accurate approach to soil sampling – analyses which reflects accurate concentrations in field, in addition to the wide-spread occurrence of ECs in English agricultural soils receiving an array of organic fertilisers.

Soil quality underpins agricultural productivity, ecosystem resilience, and ultimately human wellbeing. Historically, agricultural soils have been monitored for legacy contaminants such as heavy metals, nutrients, and persistent organic pollutants (POPs). These substances have relatively well-established analytical methods, known persistence in the environment and well characterised toxicology profiles. As such traditional pollutants, including lead, cadmium, arsenic, mercury, as well as poly aromatic hydrocarbons (PAHs), and polychlorinated biphenyl (PCBs), have been the focus of regulatory frameworks and environmental risk assessments. However, the intensification of agricultural practices and evolving environmental pressures (e.g., the need to reduce synthetic fertiliser production and use), has led to an increase in the use of organic waste amendments (e.g., farm yard manures, biosolids, digestates), that have the potential to introduce a new suite of chemical stressors, emerging contaminants (ECs), into the soil environment. These amendments, while beneficial for soil fertility and structure, can introduce a wide range of chemical residues, including pharmaceuticals, personal care products, pesticides, and industrial chemicals. ECs are not routinely monitored meaning there is a marked deficiency in data on the presence and distribution of ECs in agricultural soils, despite the significant environmental and human health risk they may pose.

Where monitoring data does exist, this has largely focused on the presence of ECs in the United States and Australia. Occurrence and concentrations of ECs in UK soils remain poorly characterised despite the fact that a diverse spectrum of organic waste amendments are routinely applied across the UK's agricultural landscape, ranging from livestock manures, treated sewage sludge (biosolids), wastewater treatment residuals and green waste composts. This knowledge gap is concerning given that farming systems, amendment types, amendment treatments/practices and environmental conditions differ between regions, which can influence contaminant fate and bioavailability. The UK's Circular Economy Package set the aim to achieve a 65 % reduction in municipal waste by 2035. As part of this initiative, wastewater treatment companies are incentivised to reuse biosolids, aligning with the principles of a circular economy. This lack of knowledge is critical, as persistent contaminants can accumulate over time, potentially affecting soil microbial communities, crop health, and food safety, while also posing risks to groundwater and wider ecosystems. Whilst our understanding of chemical presence and fate is evolving; our evaluations of risk are consistently behind that of chemical production and use. Furthermore, there is a clear need to understand how ECs, in particular, can persist in natural systems following repeated applications of organic waste amendment. The importance of addressing this knowledge gap is underscored by technological advances in analytical chemistry, particularly mass spectrometry (MS), techniques. Modern MS methods, including high- resolution and tandem mass spectrometry, enable the detection and quantification of a much broader array of chemical compounds at trace levels than was previously possible. These advances facilitate comprehensive chemical profiling of soils and amendments, providing new insights into the chemical landscape shaped by contemporary agricultural practices. Currently, regulation surrounding ECs in agricultural soils is non-existent in the UK. The introduction of regulatory frameworks to safeguard soil quality and food safety will require robust, validated analytical methods and monitoring strategies. Without baseline data and standardised approaches, risk evaluations will be obsolete thus hindering policymaking. Leading to the potential risks associated with ECs to go unrecognised or unmanaged. Moreover, monitoring studies consistently overlook key analytical components such as sampling strategy and effects of sample transport which ultimately result in a poor understanding of absolute concentrations in the field. A comprehensive evaluation of the persistence of ECs with known ecological and human health concerns under real crop production conditions is urgently needed. This study aimed to;

1) critically assess and devise a harmonised approach of soil monitoring through to analysis (targeted and untargeted), in soils; and

2) determine the presence of ECs in English agricultural soils with diverse organic amendment histories.
To achieve this a multi-residue extraction method was developed targeting 18 analytes that consisted of a wide range of physicochemical properties and optimised for their extraction from soils with varying properties. Liquid chromatography-tandem mass spectrometry (LC-MS/ MS), and liquid chromatography-tandem high-resolution mass spectrometry (HRMS), techniques were employed to capture a broad spectrum of contaminants, enabling a comprehensive assessment of EC presence in soils. To the best of our knowledge, this is the first study to report a wide analysis of ECs in English agricultural soils. Ascertaining representative soils across farming landscapes remains a challenge for environmental scientists; controversial goals between production/farming and environmental research (i.e., farming, academia, and regulatory bodies), continuously stunts our abilities to assess chemical risks towards soils in the environment. To address this, the study adopted a citizen science approach, engaging directly with farmers to raise awareness of the issue associated with chemical contamination in soils. This approach underscores the importance of such studies for improving soil health and advancing our current evaluation of chemical risks. Our approach fosters stakeholder engagement, raising awareness of soil contamination issues and promoting a shared responsibility for environmental stewardship.
Twenty-three farms with contrasting farming practices and application histories were sampled across England; SI Table 1 contains the application histories for the selected farms. In brief, the farm application histories were comprised of, FYM/slurry (n = 9), biosolids (n = 8), food digestate (n = 3), Wastewater Treatment Residuals (n = 2), and unknown (n = 2). Fourteen farms were sampled using a W- transect sampling method following site visits (as described below), and samples from eight farms were shipped to the University of Leeds (1 sample per field). Soil samples were sampled to 0–10 cm depth using a trowel and stored in zip-lock bags and cool boxes containing ice packs (≤ 8 h), before storage at 20 ◦ C.

Table 1
Physicochemical properties and fate parameters of selected target analytes for monitoring and quantification.

Chemical	Pharmaceutical Class	pKa_a	pKa_b	log K_{OW}	K_{OC} (L/kg)	Soil DT_{50} (days)	Biodegradation rate (1/h)
Atrazine	Herbicide	$1.6_{(A)}$		$2.61_{(A)}$	$37–121_{(C)}$	$101_{(D)}$	NA
Carbamazepine	Pharmaceutical – anticonvulsant	$13.9_{(A)}$		$2.77_{(A)}$	$158.48_{(E)}$	$533.2_{(F)}$	$0.26_{(F)}$
Clotrimazole	Antifungal	$4.1_{(A)}$		$6.1_{(A)}$	$57544_{(G)}$	$68_{(H)}$	$0.0213_{(I)}$
Cyclophosphamide	Pharmaceutical – Immunosuppressant	$0.02_{(B)}$		$0.63_{(A)}$	$38_{(J)}$		$0.0372_{(K)}$
Diazinon	Insecticide – Organophosphate	$2.6_{(A)}$		$3.81_{(A)}$	$1493–1589_{(L)}$	$26.6–78.1_{(M)}$	$0–0.056_{(N)}$
Diclofenac	Pharmaceutical – NSAID	$3.99_{(A)}$		$4.51_{(A)}$	$479–956_{(O)}$	$< 5_{(P)}$	$11.79_{(F)}$
Enrofloxacin	Pharmaceutical – Antibiotic	$6.09_{(A)}$	$8.74_{(A)}$	$-0.2_{(A)}$	$987.12_{(Q)}$	$280_{(R)}$	$0.012_{(S)}$
Ivermectin	Veterinary medicine – Anthelmintic				$25800_{(T)}$	$16–67_{(U)}$	
Lamotrigine	Pharmaceutical – Anticonvulsant	$5.7_{(A)}$		$2.5_{(A)}$	$93.13–702.88_{(V)}$	$129–264_{(W)}$	$0.048_{(F)}$
Lincomycin	Pharmaceutical – Antibiotic	$7.6_{(A)}$		$0.2_{(A)}$	$288.3_{(X)}$	$31.35_{(Y)}$	NA
Metformin	Pharmaceutical – Diuretic	$12.4_{(A)}$		$-1.3_{(A)}$	$12–19_{(Z)}$	$5_{(Z)}$	$7.23_{(F)}$
Ofloxacin	Pharmaceutical – Antibiotic	$5.97_{(A)}$	$9.28_{(A)}$	$0.39_{(A)}$	$1657.8_{(AA)}$	1.1–2.01 $years_{(AB)}$	$0_{(AC)}$
Oxytetracycline	Pharmaceutical – Antibiotic	$3.27_{(A)}$	$9.5_{(A)}$	$-0.9_{(A)}$	$4102.59_{(AD)}$	$18–28_{(R)}$	$0.00463_{(AE)}$
Robenidine HCl	Veterinary medicine – Coccodiciostat	$3.3_{(AF)}$		$3.8_{(AF)}$	$> 426{,}580_{(AG)}$		
Sulfamethoxazole	Pharmaceutical – Antibiotic	$1.6_{(A)}$	$5.7_{(A)}$	$0.89_{(A)}$	$94.9_{(AH)}$	$10.81–33.24_{(AI)}$	$0.0289_{(AJ)}$
Triclosan	Personal care product	$7.9_{(A)}$		$4.76_{(A)}$	$12981.75_{(AK)}$	~ 9 $months_{(AL)}$	$0.0578_{(H)}$
Trimethoprim	Pharmaceutical – Antibiotic	$7.12_{(A)}$		$0.91_{(A)}$	$623.8_{(AM)}$	$64.6_{(D)}$	$0.02_{(F)}$
Tylosin	Pharmaceutical – Antibiotic	$7.73_{(A)}$		$1.63_{(A)}$	$623.80_{(AN)}$	$4.5_{(AO)}$	$0.00214_{(AP)}$

Footnote citation key: A =PubChem; B =DrugBank (NA); C =Martins et al.; D =Blume et al.;E=Shao et al.; F =Lautz et al.; G =Chen et al.; H =Sabourin et al.; I =Kahle et al.; J =Mansouri et al.; (Opera prediction); K =˘ Cesen et al.; L =Nemeth-Konda et al.; M =Aggarwal et al.;N=Campo et al.; O =Yu and Bi;P=Al-Rajab et al.; Q =Wu et al.]; R =Li et al.; S =Frade et al.;T=Krogh et al.; U =Krogh et al.; V =Li et al.; W =Menacherry et al.;X=Wang et al.; Y =;Z=Mrozik and Stefa´ nska,]; AA =Straub et al.; AB =Yang et al.; AC =Kümmerer et al.; AD =Jones et al.; AE =Li et al.; AF =Hansen et al.; AG =EFSA; AH =Stoob et al.; AI =Srinivasan and Sarmah; AJ =Gao et al.; AK =Karnjanapiboonwong et al.; AL =Wu et al.; AM =Zhang et al.; AN =Rabølle and Spliid,; AO =Carlson and Mabury, ; AP =Prado et al..

Over 520 chemicals were identified to a high confidence level (Level 1–2), representing 194 unique entities. The contaminant classes most frequently detected were human pharmaceuticals (n = 52, Rank 1) > plasticisers (n = 51, Rank 2) > surfactants (n = 44, Rank 3) > fungicides (n = 40, Rank 4) > polymers (n = 35, Rank 5) > veterinary medicines (n = 23, Rank 6) > herbicides (n = 20, Rank 7) > human or veterinary use pharmaceuticals (n = 16, Rank 8) > disinfectant (n = 14, Rank 9) >pharmaceutical derivative/research chemical (n = 11, Rank 10).
These dominant classes differ from those reported in previous studies, highlighting the importance of context-specific chemical classification when assessing risks to soil, plant and human health. Notably, 46.4 % of the identified pharmaceutical compounds—both veterinary and human—had no prior documentation in the scientific literature, regardless of environmental matrix. This underscores the limitations of current monitoring frameworks and the need for expanded EC surveillance. Quantified concentrations of pharmaceuticals in soils were found to range between 0.06 ± 0.07 (sulphamethoxazole) ng/g (dw)- 105.9 ±86.7 (ivermectin) ng/g (dw), and positive correlations were identified between concentration and K OC. This demonstrates that fate processes play a fundamental role in the presence and concentration of ECs in agricultural soils, and thus their risk towards terrestrial biota (i.e., microbial populations,

earthworms). The potential risks associated with this exposure require further investigation. Although elevated concentrations of ivermectin, oxytetracycline, and ofloxacin raise immediate concerns for soil health, the primary contaminant classes posing leaching risks were plasticisers (35 %), herbicides (26.1 %), plasticisers (21.7 %), fungicides (8.7 %), plant growth regulators (4.4 %), and flame retardants (4.4 %). Overall, our understanding of the risks posed by ECs identified in this monitoring campaign are limited. This underscores the urgent need for a more harmonised approach to contaminant identification in agricultural soils and more comprehensive evaluations of the risks they pose to ecological receptors and connected environmental compartments. The engagement of farmers within this study through citizen science approach not only improved sampling reach but also fostered awareness and stewardship among key stakeholders. This will be critical in maintaining soil health as the UK moves towards a circular economy with increased organic waste reuse within agriculture. This study underscores the urgent need for a more harmonised approach to contaminant identification in agricultural soils and more comprehensive evaluations of the risks they pose to ecological receptors and connected environmental compartments.

Environmental implications
The presented study demonstrates that the reuse of contaminated organic fertilisers contributes to the widespread occurrence, and accumulation of emerging contaminants in agricultural soils. Over 520 contaminants were identified, some reported for the first time in England, with concentrations ranging from 0.06 ± 0.07–105.9 ± 86.7 ng/ g (dw). Notably, 46.4 % of pharmaceuticals had not been detected in previous monitoring campaigns, underscoring the unknown risks these chemicals pose in arable soils. There is a clear need to accurately assess the risks associated with different organic fertiliser applications to protect both environmental and consumer health.
Response MLavelle: These results indicate that land spreading of digestate requires compliance with the Precautionary Principle in relation to human health & that this Application be refused.

Issue 7: Effects of RED III on the biomethane market: What impact will the sustainability requirements from Article 29 of RED III have on the biomethane market?
The analysis answers the question of what impact the increased sustainability requirements from Article 29 of RED III will have on the biomethane market. As a result, a large proportion of the biomethane currently used in biomethane CHP plants would very likely not fulfil the greenhouse gas reduction requirements set out in Article 29 of RED III. This could affect around two-thirds of the biomethane used under the German Renewable Energy Sources Act, meaning that around 2.3 TWh of renewable heat and 1.9 TWh of renewable electricity could then no longer be generated.

Reference Number 54: Biogas Production in Agriculture: Technological, Environmental, and Socio-Economic Aspects. Krzysztof Pilarski, Agnieszka A. Pilarska and Michał B. Pietrzak. Energies 2025, 18, 5844. https://doi.org/10.3390/en18215844
Anaerobic digestion involves intensive water use, while digestate management determines the extent to which nutrient leaching or groundwater pollution may occur.
In biogas plants, water plays a vital role as a process medium—it is used for substrate preparation and dosing, cleaning of installations, cooling of cogeneration units, and feeding steam boilers. In conventional energy systems, water consumption can reach several dozen litres per kilowatt-hour (kW · h; 3.6 MJ) of electricity produced. Under conditions of declining water availability and increasing frequency of extreme weather events (droughts, heatwaves), this creates significant operational and environmental risks. Increasing demands for environmental protection and resource efficiency (energy, nutrients, and water) are driving the development of systems that treat process water as a valuable resource and seek to close the water loop within the technological process.
The positive environmental impact of biogas technology is not automatically guaranteed—management of production and digestate handling is crucial, especially regarding water quality.
The literature shows varied views on how anaerobic digestion (AD) affects water quality, particularly groundwater and surface water. Ferdes et al. (2019) state that a well-designed biogas plant poses no risk to these waters, as no process wastewater is produced. Digestate is processed, and recovered water is reused in the system. Excess water treated by two-stage reverse osmosis reaches a quality suitable for industrial and agricultural use. Small amounts of wastewater may be sent to local treatment plants, and roof rainwater is directed to separate drainage systems, reducing contamination risks.
Agrohydrological simulations suggest that the impact of biogas production on water quality may be ambivalent. If digestate is applied at rates similar to untreated slurry without any modification of agricultural practices, nitrogen leaching into groundwater may remain unchanged. This indicates that anaerobic digestion alone does not ensure improved water quality; appropriate agronomic measures—such as optimising fertiliser application rates, timing, and methods are essential.

A management approach based on sustainable agricultural principles, including crop rotation and site-specific fertilisation planning, has been shown to reduce nitrogen losses to surface and groundwater. However, such strategies may also result in lower yields, thus highlighting the need to balance economic performance with the protection of natural resources.

Logan and Visvanathan (2019) emphasise the importance of digestate quality and its appropriate management. They point out that direct application of digestate to agricultural land can contribute to pollution if sanitary and environmental requirements are not met. Therefore, current management strategies—often focused primarily on maximising energy recovery—should also incorporate environmental protection objectives, particularly with regard to water resources.

Therefore, the influence of biogas production on water quality depends on substrates, fermentation technology, digestate management, and farm practices. When performed sustainably, with advanced purification and appropriate fertilisation, biogas production can improve groundwater and surface water quality. Poor management may worsen eutrophication and nitrate contamination. A systemic, interdisciplinary approach to biogas plant planning and operation is essential, combining energy, environmental, and agronomic factors.

The schematic below (see Figure 7) presents the impact of biogas production on water management and soil quality, highlighting the importance of digestate management to limit nutrient leaching—particularly nitrogen and potassium—into groundwater. It also demonstrates the beneficial use of digestate as a fertiliser, supplying essential nutrients (N, P, K) to crops. This topic will be briefly discussed in the following subsection

Effective digestate utilisation requires meeting certain conditions. Separating liquid and solid fractions improves nutrient bioavailability. Digestate is most suitable for crops with high organic matter demands, provided that soil nutrient levels and groundwater quality are regularly monitored. Its application should be carefully aligned with crop nutrient needs and seasonal timing to minimise losses. Excessive application can cause soil degradation and environmental harm.

Response MLavelle: The Biogas proposal indicates a constant supply of manure for 12 months. Crop nutrient needs & seasonal timing involve the growing seasons. However, the spreading of digestate is not possible for the 5 months outside of the growing season. Spreading in this 5month period means run off into the adjoining river & underground aquifer.

At the same time, it is important to consider that, despite these benefits, wider environmental impacts related to biomass sourcing cannot be overlooked. The growing demand for energy crops used in biogas production may encourage the expansion of monoculture systems, which carries risks of biodiversity loss and soil degradation. Intensive cropping without adequate rotation often leads to increased soil erosion, depletion of soil organic matter, and elevated nutrient runoff, thereby worsening eutrophication pressures. Furthermore, large-scale cultivation of biogas feedstocks typically requires substantial fertiliser and pesticide use, which can adversely affect groundwater quality and potentially reduce some of the environmental gains achieved through digestate recycling.

Therefore, sustainable biogas production must involve not only careful digestate management but also responsible feedstock sourcing. Agroecological practices, such as multispecies cover cropping and integrating catch crops and agricultural residues, offer effective ways to reduce these risks while ensuring sufficient feedstock supply.

Response MLavelle: This report indicate the unsuitability of development of a Biogas plant in an area of karstic limestone with the risks of pollution of the surface & groundwater drinking water schemes from the same aquifer.

Best Regards,

Martin Lavelle, BE
2nd April 2026

An Coimisiún Pleanála,
64 Marlborough Street,
Dublin 1,
D01 V902
Date: 21st April 2026.

Planning Application Reference Number 324132-26
An Coimisiún Pleanála - Case Reference: VA92.324132

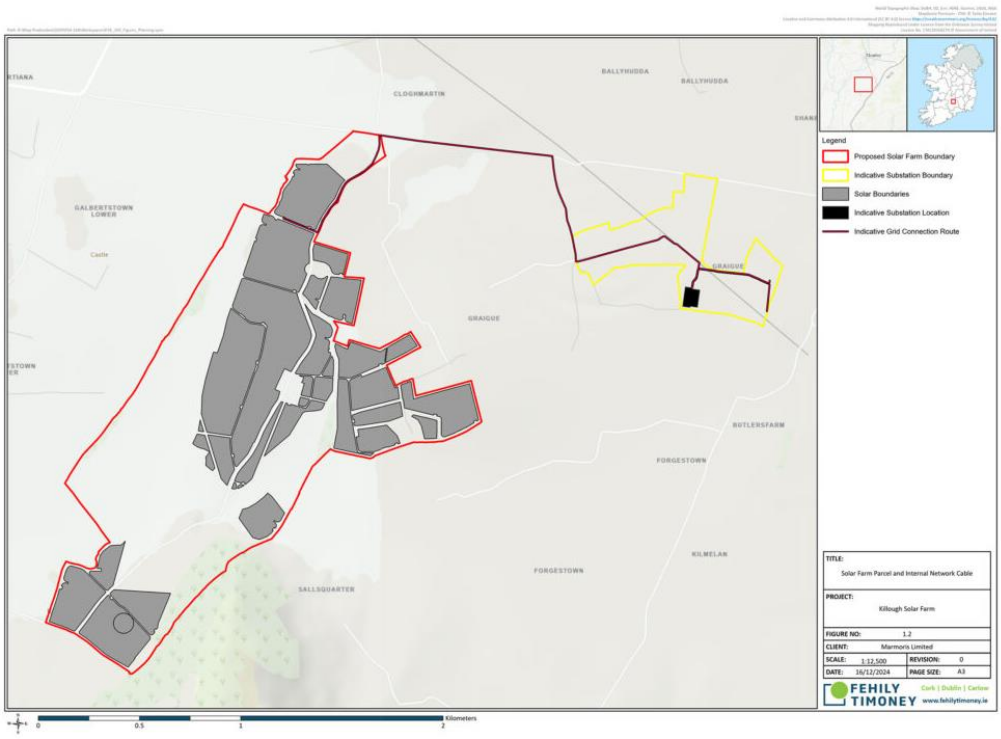
Applicant Name: Marmoris Limited Trading as Killough Solar.

Description of Development: Proposed development of a 110kV GIS substation providing connection to the national grid via a loop in/ loop out connection to the already existing Killhill - Thurles 110kV Overhead line and ancillary development.

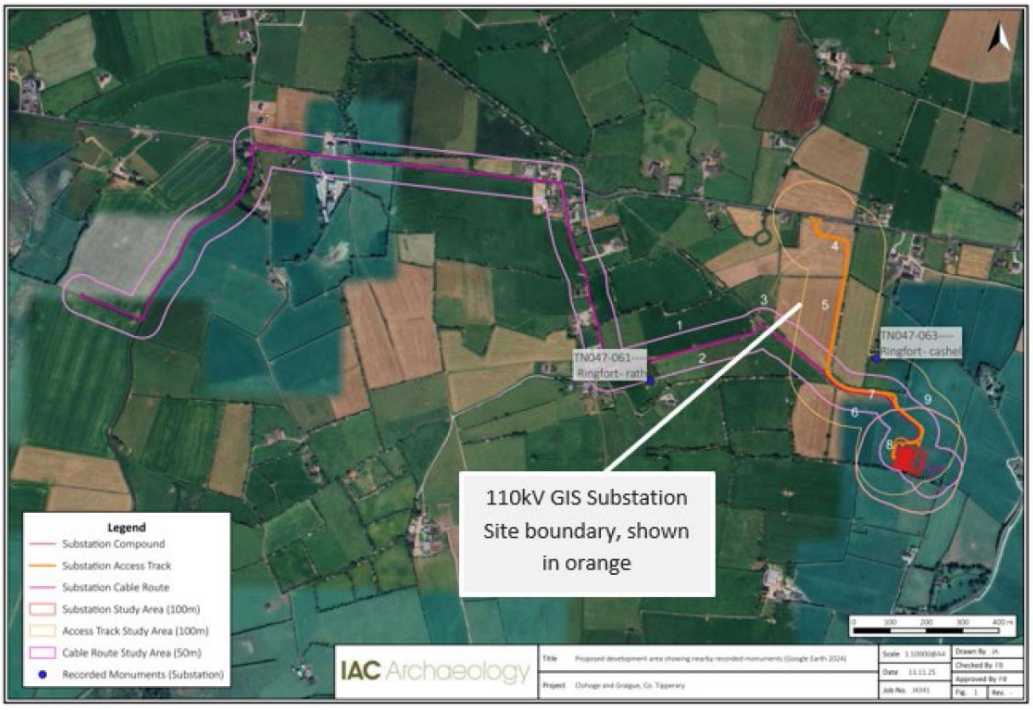
To Whom It May Concern,
As residents of Moycarkey village, living within 200 metres from the proposed substation site, we have reservations about the proposed development with respect to the impact this development will have on our residential amenity, the life and character of the village, the heritage and biodiversity of the surroundings of Moycarkey Village and its sustainability in the future.

Our observation is as follows:

1. Location of Substation:



The plans shown on the left shows the original location of the substation on the planning application for the solar farm.



The map shown on the left shows the proposed location of the substation.

Plate 12-1: Cable Route and 110kV Substation Site

Grounds for Observation:

- It is concerning that Moycarkey village is not meaningfully addressed in the planning application, beyond a reference to the electoral district, despite the proposed substation being located within 390 metres of the village, and in close proximity to St Peter's Church.

- As can be seen from the images above at the time planning permission was granted for the solar farm, the substation was identified in a different location to that now proposed. The location appears to have moved approximately 300 metres closer to the village.

- The proposed development represents a substantial industrialisation of a rural landscape currently characterised by agricultural land use, open countryside, and low-density development.

- At a community consultation held with a TD in October 2025, the issue was raised as to why the substation cannot be co-located within the proposed solar farm.

- There is no evidence in the application that genuinely alternative sites were assessed. The relocation appears limited to adjustments within the same landholding rather than a comparative site selection process.

- In our view, the proposal does not demonstrate that this is the most suitable or least impactful location for this type of infrastructure, particularly given the availability of alternative options that appear not to have been properly explored.

- We believe the current proposal would have an unnecessary and avoidable impact on local residents and does not represent proper planning and sustainable development.

- The introduction of large-scale electrical infrastructure, associated buildings, perimeter security fencing, lighting, and increased vehicular movements would materially alter the established rural character and visual amenity of the area.

- By introducing an industrial-scale structure into a rural setting, the proposal would diminish the overall quality and attractiveness of the area and hinder any future development of the village. Under the most recent county development plan the council is encouraging housing inside speed zones.

- The proposed substation site is about 3.5 km from an active quarry, and this is a concern because blasting at the quarry can cause ground vibration and air pressure waves that may affect sensitive equipment and structures. Because of this, the site presents a real and avoidable risk to the safe operation of the substation, and this risk has not been properly addressed.

2. Size and Visual Scale of the Substation:

Figure 2-1: Typical 110kV GIS Station Layout (Source: H&MV)

Grounds for Observation:

- The comparison of the proposed substation to a 'large farm shed' is misleading. A 110kV substation is an industrial installation in both scale and function and bears no resemblance to typical agricultural structures in the area.

- The proposed substation (Figure 2-1: above) would be an industrial-scale development placed within a rural field and cannot reasonably be compared to a typical farm shed.

- Despite references to existing and proposed hedgerows, such screening would take years to establish and would not adequately conceal the scale or visual impact of the structure in the interim. This locality is closely monitored by Birdwatch Ireland and Cabragh wetlands, due to the unique and special biodiversity of species in the area, and removing hedgerows will be detrimental to the safeguarding of protected bird and bat species.

- The introduction of a large, engineered facility clad in so-called 'natural' or 'earthy' materials does not negate its fundamentally industrial appearance, which would be out of keeping with the surrounding countryside.

- While acoustic insulation and 'stringent noise limits' are referenced, the presence of external transformers raises legitimate concerns regarding continuous low-level noise, which can significantly impact residential amenity and rural tranquillity. The proposal therefore risks introducing visual intrusion and persistent noise into what is currently a quiet, agricultural landscape. Furthermore, electromagnetic pulses and vibrations from the substation will prove a nuisance to local residents. Substations can produce a low-frequency hum and vibrations that may be perceived as a nuisance by residents, especially in our quiet, rural setting in Moycarkey Village.

- A structure measuring 16.5 metres in height is comparable to a five-storey building and is therefore significantly out of scale with the surrounding rural dwellings and typical farm buildings in the area.

- The Tipperary County Development Plan 2024–2029 highlights that a key consideration in site layout is the protection of neighbouring amenities. Furthermore, Figure 8 of the same document emphasises that developments should, where possible, complement the existing landscape. While this document is presented as a rural housing design guide, the underlying principles regarding scale, visual impact, and integration into the landscape should reasonably be applied to all forms of development, including infrastructure such as substations.

- The proposed palisade fencing appears to function solely as a security measure. In addition, a 1.5-metre-high boundary fence is proposed externally. However, both rail structures remain visible beyond the screened enclosure, which undermines the effectiveness of the purported visual mitigation measures.

- The proposed 3-metre-high lamp posts for external lighting, as indicated on drawing P24169-FT-XX-XX-DR-PL-0600, appear to include two light fixtures per pole, directed towards the 16.5-metre-high substation structure. This arrangement is likely to result in light reflecting off the building, contributing to increased levels of nighttime visual intrusion and light pollution within a rural setting.

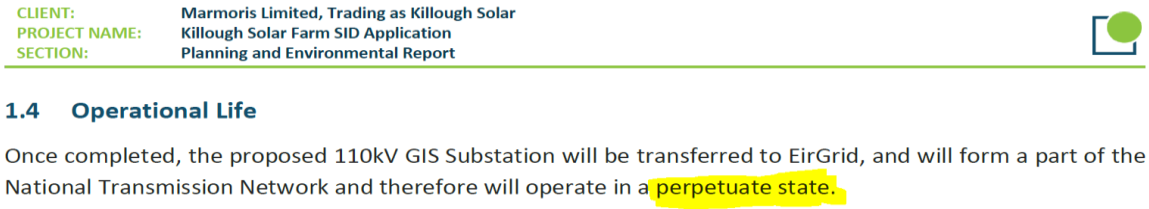
- Such impacts would be particularly pronounced during the winter months, when longer periods of darkness in the mornings and evenings would exacerbate these visual effects.

- Such a transformation risks establishing a precedent for further industrial-type development on lands that are neither zoned nor intended for such purposes, thereby undermining the integrity and policy objectives associated with the rural environment.

- The proposed 21.5m high overhead line towers, in combination with the existing 17.0m structures, would form a visually dominant and intrusive feature in the landscape, resulting in a substantial obstruction of views and an erosion of the area's open rural character.

- There is a discrepancy between the application documents and the accompanying drawings, with the former referring to 4 Nr 16.5 m high monopole lighting masts and the latter identifying these structures as lightning masts. This inconsistency requires clarification.

3. Insufficient Information on Possible Future Development:



CLIENT: Marmoris Limited, Trading as Killough Solar
PROJECT NAME: Killough Solar Farm SID Application
SECTION: Planning and Environmental Report

1.4 Operational Life

Once completed, the proposed 110kV GIS Substation will be transferred to EirGrid, and will form a part of the National Transmission Network and therefore will operate in a perpetuate state.

While the application relates to a 110kV substation, the supporting documentation indicates that the proposed development may form part of a broader, longer-term installation within the national transmission network.

Grounds for Observation:

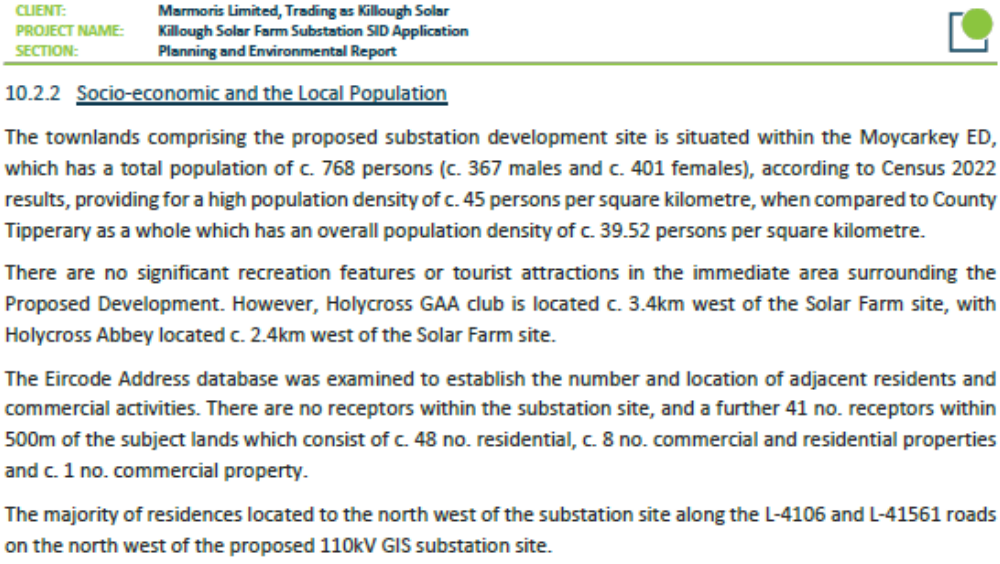
- There is insufficient clarity as to whether the proposal has been designed to accommodate future expansion, additional infrastructure, or increased capacity.

- There is a significant concern that the site could be subject to incremental expansion over time, without a comprehensive assessment of the cumulative impacts on the surrounding area. Such impacts may include effects on visual amenity, noise levels, and traffic generation.

- It is essential, in the interests of proper planning and sustainable development, that the full extent of the proposed development — including any reasonably foreseeable future expansion is clearly defined, assessed, and subject to appropriate environmental evaluation at this stage.

- The scale of the proposed 110kV GIS substation appears disproportionate to the operational requirements of the permitted solar farm. This raises legitimate concerns that the infrastructure may be designed to facilitate additional future grid connections. Consequently, questions arise regarding the adequacy of the environmental assessment and whether the cumulative impacts of the overall development have been properly identified, assessed, and mitigated.

4. Inconsistency in Baseline Data (Number of Receptors)



CLIENT: Marmoris Limited, Trading as Killough Solar
PROJECT NAME: Killough Solar Farm Substation SID Application
SECTION: Planning and Environmental Report

10.2.2 Socio-economic and the Local Population

The townlands comprising the proposed substation development site is situated within the Moycarkey ED, which has a total population of c. 768 persons (c. 367 males and c. 401 females), according to Census 2022 results, providing for a high population density of c. 45 persons per square kilometre, when compared to County Tipperary as a whole which has an overall population density of c. 39.52 persons per square kilometre.

There are no significant recreation features or tourist attractions in the immediate area surrounding the Proposed Development. However, Holycross GAA club is located c. 3.4km west of the Solar Farm site, with Holycross Abbey located c. 2.4km west of the Solar Farm site.

The Eircode Address database was examined to establish the number and location of adjacent residents and commercial activities. There are no receptors within the substation site, and a further 41 no. receptors within 500m of the subject lands which consist of c. 48 no. residential, c. 8 no. commercial and residential properties and c. 1 no. commercial property.

The majority of residences located to the north west of the substation site along the L-4106 and L-41561 roads on the north west of the proposed 110kV GIS substation site.

Grounds for Observation:

- The documentation states that there are 41 nearby properties (receptors) located within 500 metres of the site. However, the breakdown provided appears to identify approximately 48 dwelling houses, 8 mixed-use buildings (comprising residential and commercial use), and 1 commercial property. This gives a total of approximately 57 properties, rather than 41, and therefore presents a clear inconsistency in the figures relied upon in the assessment.

- As no adequate explanation is provided as to whether these categories overlap, whether certain properties have been grouped together, or whether some receptors have been excluded from the total, it appears that the overall number of nearby properties may have been reported incorrectly. This is a significant matter, as the reliability of the environmental assessment depends on the accuracy of the baseline data. If the receptor numbers are incorrect, the conclusions reached in relation to potential impact may likewise be unreliable.

- Accordingly, the applicant should be required to provide a corrected and verified total number of nearby properties, together with a clear explanation of the methodology used to classify and count each receptor.

(Excerpt from the planning application)

11.3.4.1.2 110kV GIS Substation

The main construction activities associated with the construction of the proposed 110kV GIS Substation are set out in Table 11-3. Table 11-3 also sets out the predicted noise levels at locations where the highest noise levels are predicted from the proposed Substation works. The nearest noise sensitive locations to this activity are R81, a property located c. 200m east of the proposed substation. Also presented is R118, which is located c. 680m north of the proposed substation and close to the site entrance of the substation. Assuming all activities occur simultaneously for each phase, the highest predicted noise levels during substation works are 56 dB $L_{Aeq,1hr}$ and 53.8 dB $L_{Aeq,1hr}$ at receptors R81 and R118, respectively. This is below the proposed construction daytime noise threshold of 65dB $L_{Aeq,1hr}$. The effects associated with the construction of the 110kV GIS substation are predicted to be moderate, negative and short-term in duration.

- This statement appears to directly conflict with earlier sections of the documentation which indicate that there are no receptors within 500 metres of the site. If a noise-sensitive receptor is identified at approximately 200 metres from the proposed substation, then the earlier description of the receiving environment is clearly inaccurate or incomplete.

5. Landscape and Visual Impact:

Although the planning application contains a Visual Impact Assessment with photomontages, it notably omits viewpoints from the village of Moycarkey and residential properties most directly impacted by the proposed substation. This represents a significant deficiency, as it fails to accurately assess the true visual impact of residents in the village.

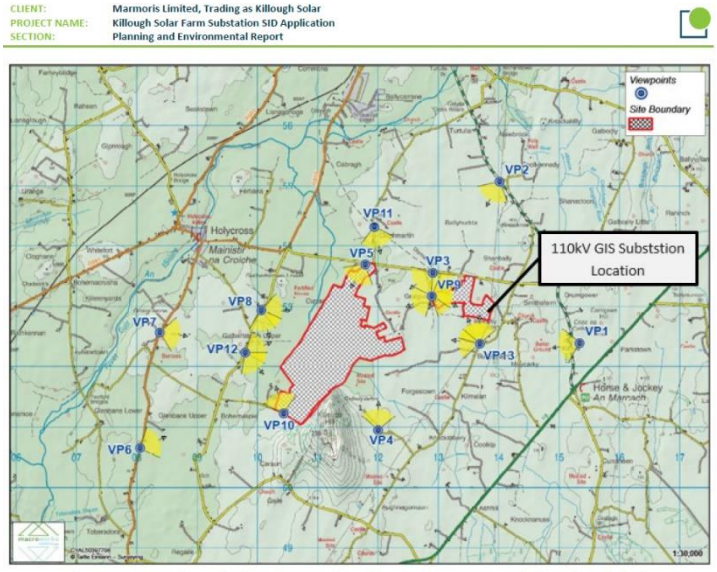
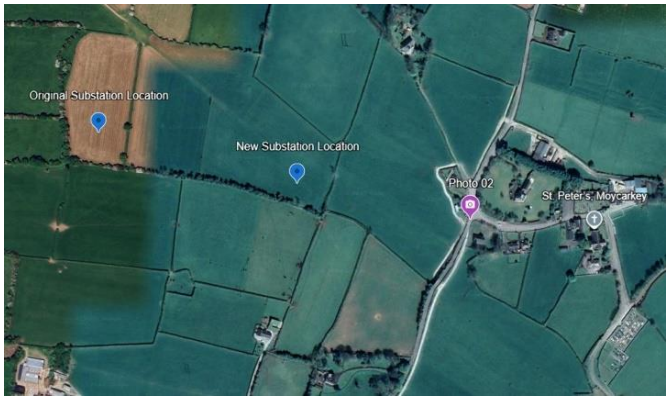


Figure 13-1: Viewpoint location map (showing viewing extents and direction of view)

Grounds for Observation:

- No visual impact assessment has been provided from Moycarkey village or from the approach roads leading to the village, where there are direct lines of sight to the proposed substation site.

Photos below represent the views we believe were omitted.




Original Substation Location
New Substation Location
Photo 03
St. Peter's, Moycarkey


PHOTO 03

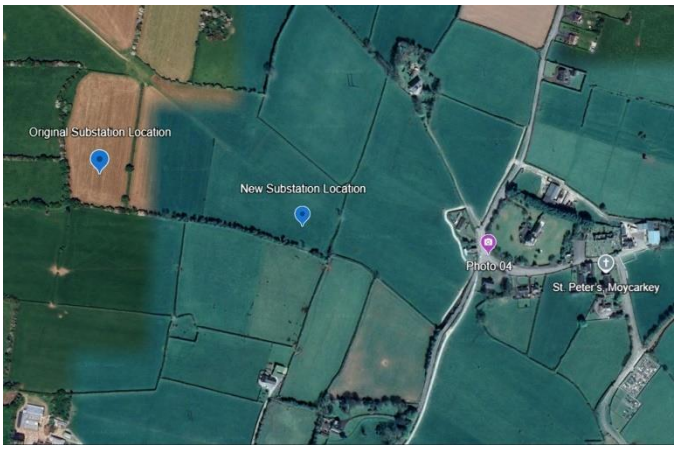

Original Substation Location
New Substation Location
Photo 04
St. Peter's, Moycarkey


PHOTO 04


Original Substation Location
New Substation Location
Photo 05
St. Peter's, Moycarkey


PHOTO 05

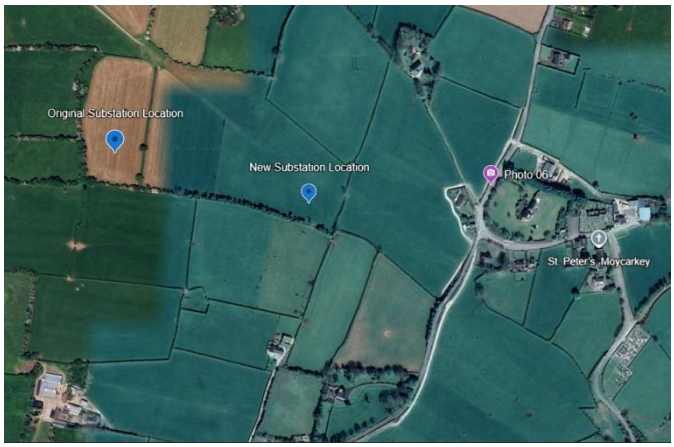

Orginal Substation Location
New Substation Location
Photo 06
St Peter's, Moycarkey


PHOTO 06

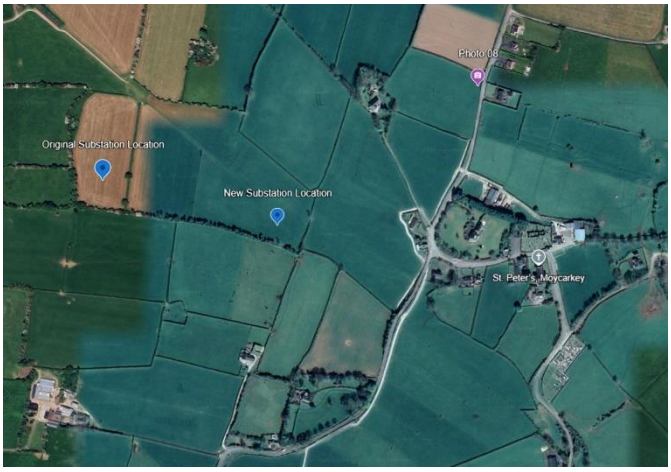


Photo 08
Orginal Substation Location
New Substation Location
St Peter's, Moycarkey


PHOTO 08

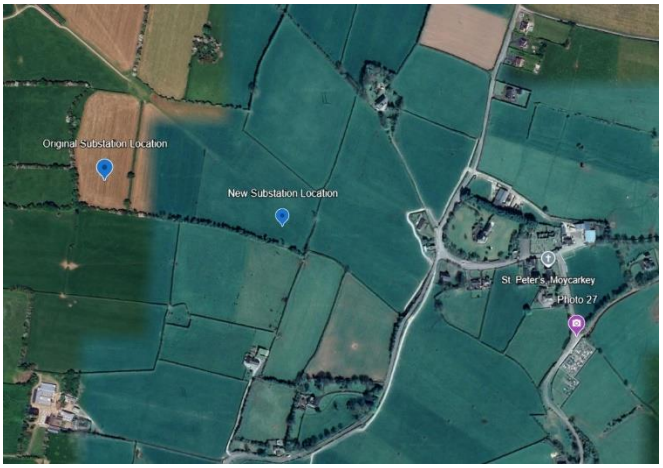
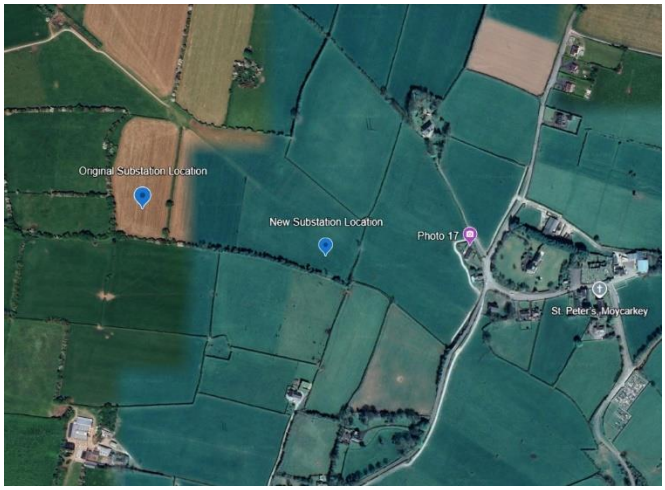
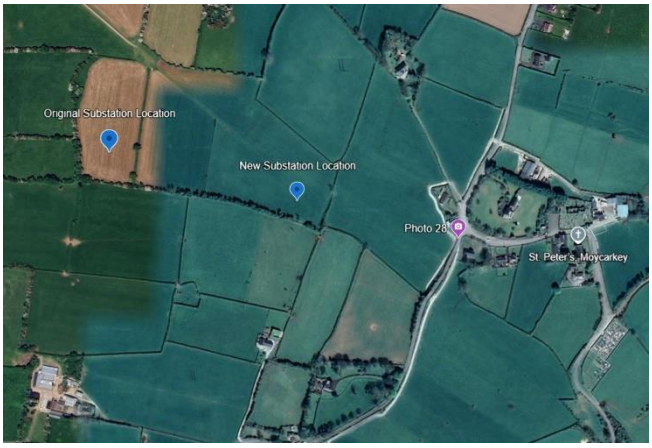

Orginal Substation Location
New Substation Location
St Peter's, Moycarkey
Photo 27


PHOTO 27





From the photos we provide above we would like to point out the following.

- Photo 04: is from the village of Moycarkey which is approximately 14.3 metres above sea level, with lower areas at around 10.1 metres. The proposed substation site, at approximately 29.9 metres above sea level, would therefore be positioned on substantially higher ground. This elevation difference would increase the visibility and visual dominance of the development when viewed from the village and surrounding approach roads

- Photo 08: highlights a key approach road into Moycarkey village, where there are uninterrupted views towards Killough Hill (pNHA, Site Code 00959). The proposed siting of a substation in this location would result in a visually intrusive development that would obscure and materially degrade these important views.

- Photo 28: highlights a valued sunset view from Moycarkey village. The introduction of a substation at the proposed location would result in an irreversible change to this landscape, significantly diminishing its visual quality and rural character.

This aerial views below clearly demonstrates the close proximity of the proposed development to nearby residential properties, raising concerns regarding its potential impact on residential amenity. Aerial footage of Moycarkey village can be viewed on the following link.

https://www.youtube.com/watch?v=t8hfOY3qK50
https://www.youtube.com/watch?v=v2p1PDudXkY
https://www.youtube.com/watch?v=vLLHPcrEgUs

6. Noise

The application states that no baseline noise survey was carried out.

Grounds for Observation:

- The entire noise assessment is based on assumptions rather than measured data. This undermines its reliability and fails to demonstrate that nearby residents will not be adversely affected.

- The applicant acknowledges that construction noise limits will be exceeded at multiple residential properties along the grid connection route. This demonstrates that the development will result in significant disturbance to nearby residents during construction. The reliance on mitigation measures such as temporary barriers does not negate the fact that unacceptable noise impacts are predicted to occur.

- The assessment is not based on measured conditions. Without baseline data, it's impossible to verify existing quiet levels and the true impact of added noise.

- Continuous Transformer Hum (24/7 Noise Source) introduces a continuous low-frequency noise source into a rural environment, which is likely to adversely affect residential amenity, particularly during night-time periods.

- The applicant has not demonstrated that tonal noise will not arise. Reliance on post-construction mitigation is not an acceptable substitute for proper assessment and design at application stage.

- The operational noise predictions are based on assumed equipment specifications and modelling scenarios, rather than confirmed final design data, introducing uncertainty into the assessment.

- The combined impact of several sources of electrical noise has not been adequately assessed in terms of long-term effects, including how it may affect nearby residents.

- With reference to the noise sensitive locations within 1km of the proposed site. The 1km study area contains a substantial number of residential properties, demonstrating that the development is located within an established rural community rather than an isolated setting. The scale of potential impact is therefore considerable.

- The development is spread over a large area, combining a solar farm, substation and grid connection, resulting in cumulative impacts across a wide rural area.

7. Strategic Interaction with the Proposed Clonmel–Thurles Greenway:

The proposed development must also be assessed in light of its interaction with other strategic objectives and investments, including the proposed Clonmel–Thurles Greenway, which is identified in policy as a long-term active travel, recreation, and tourism asset.

The Greenway constitutes:

- A high-value public amenity
- A linear infrastructure asset with bridges, retaining structures, embankments, and surface layers
- An environment intended for continuous public occupation, including vulnerable users.

Grounds for Observation:

The proposed Clonmel to Thurles Greenway available here https://e0c54cdc1d.clvaw-cdnwnd.com/9aff0b0e95dbfeff53733807fa95d85c/200000076-176f3176f5/TGW-RP-AL-0001-I02-2.pdf?ph=e0c54cdc1d represents a significant opportunity to support and enhance tourism and cultural connectivity within County Tipperary. As outlined in the feasibility report, the development of a greenway aligns strongly with regional objectives to promote sustainable tourism, recreation, and access to heritage assets.

The route would also complement and strengthen access to nationally and internationally important heritage sites, including the Cashel UNESCO heritage area, by improving sustainable travel options and encouraging longer visitor stays within the region.

At a more local level, the greenway would enhance connectivity to community-based and cultural attractions such as the Littleton Labyrinth and other cultural destinations, supporting their visibility and accessibility while contributing to the local economy.

Furthermore, consideration should be given to the presence of historically significant mass paths within the study area. These routes form an important part of the cultural and social history of rural communities, and their integration into or protection alongside the greenway would add heritage value and deepen the cultural experience for users.

We are objecting to this proposed development because we are concerned about the negative impact it could have on the surrounding residential area. The size and type of the development don't feel suitable for this location, and it doesn't seem to properly take into account the area's biodiversity or the long-term sustainability of Moycarkey village.

Yours faithfully,

Michael and Liz Ryan
Moycarkey Village,
Thurles,
Co Tipperary.
E41K5C6

Submission to An Coimisiún Pleanála
Re: Proposed 110kV GIS Substation and Associated Development at Graigue, Co. Tipperary
Reference: ACP-324132-26

A submission is hereby made in relation to the above-referenced proposed development, comprising a 110kV Gas Insulated Substation (GIS), a loop-in/loop-out connection to the existing Killhill–Thurles 110kV overhead line, and associated ancillary works.

While the strategic importance of enhancing grid infrastructure is acknowledged, a number of concerns are considered to warrant careful examination as part of the assessment process.

Scale and Visual Impact of GIS Building
The proposed GIS building, with a stated floor area of approximately 774 square metres and a height of 16.5 metres, is of substantial scale. It is considered that such a structure may represent a significant visual intrusion within the receiving rural landscape. The height and massing of the building may adversely affect the character of the area and the amenity of nearby dwellings.

Should permission be granted, it is considered necessary that the positioning of the GIS building within the landholding be re-examined, with a view to setting the structure further back where feasible. This may assist in reducing its visual prominence particularly from the nearby village. Furthermore, it is recommended that a comprehensive and enforceable landscaping and screening plan be conditioned, incorporating native planting and appropriate boundary treatments to mitigate visual impact.

In conclusion, while the broader objectives of the development are recognised, it is submitted that the concerns outlined above require detailed consideration. It is respectfully requested that

these matters be fully addressed, and that any permission granted be subject to stringent conditions to ensure the protection of residential amenity and the character of the local landscape.

Yours faithfully,

Michael Lowry T.D.
Abbey Road,
Thurles,
Co. Tipperary

Cllr. Micheal Lowry
Raheen,
Holycross,
Co. Tipperary

Dear Sir/Madam,

On behalf of Moycarkey Community Association, I wish to submit a formal observation in respect of the Strategic Infrastructure Development application by Marmoris Limited (trading as Killough Solar) for a proposed 110kV Gas Insulated Switchgear (GIS) substation and associated works at Graigue, County Tipperary.

An Coimisiún Pleanála – Case Reference: VA92.324132

Please find attached a detailed submission outlining the concerns of the local community in relation to this proposed development. These concerns relate in particular to the scale, siting, visual impact, proximity to Moycarkey Village, potential implications for future residential development, flood risk, health considerations, and the cumulative impact of associated infrastructure.

The Association acknowledges the importance of national energy infrastructure; however, it is our considered view that the proposed development, as currently designed and located, raises significant issues in respect of proper planning and sustainable development.

Request for Oral Hearing

We respectfully request that An Coimisiún Pleanála exercise its discretion to convene an Oral Hearing in relation to this application.

Given the scale, complexity, and potential long-term implications of the proposed development, together with the level of community concern, an Oral Hearing would allow for a full and transparent examination of the issues and ensure that all perspectives are properly considered.

We would appreciate confirmation of receipt of this submission.

Yours faithfully,

THOMAS O DWYER

For and on behalf of
Moycarkey Community Association

Contact Name : Thomas O'Dwyer
Address : Graigue, Thurles, Co Tipperary
Email : thomasodwyer31@gmail.com
Phone Number : 086 6673003

OBSERVATION SUBMISSION

Strategic Infrastructure Development Application

To: An Coimisiún Pleanála
Re: Proposed 110kV GIS Substation and Associated Works
Applicant: Marmoris Limited (trading as Killough Solar)
Location: Graigue, County Tipperary
On behalf of: Moycarkey Community Association
Date: 20/04/2026

Case Reference: VA92.324132

1. Introduction

Moycarkey Community Association submits this observation in respect of the proposed 110kV Gas Insulated Switchgear (GIS) substation at Graigue, County Tipperary.

While recognising the importance of national energy infrastructure and the transition to renewable energy, the Association has serious concerns regarding the **location, scale, and cumulative impacts** of the proposed development, particularly given its proximity to Moycarkey Village and surrounding residential areas.

2. Proximity to Moycarkey Village and Residential Context

The proposed development is located in close proximity to Moycarkey Village and established residential properties.

Concerns include:

- Inappropriate siting of large-scale electrical infrastructure adjacent to a rural settlement
- Conflict with the existing residential character
- Insufficient separation between strategic infrastructure and the community

3. Scale and Dominance Relative to Village and Dwellings

The development is excessive in scale relative to:

- Moycarkey Village
- Nearby homes and agricultural holdings

Structures up to 16.5 metres in height will:

- Visually dominate the area
- Be disproportionate to the surrounding built environment
- Introduce a strong industrial character

4. Elevated Site and Visual Impact

The site occupies an elevated position approx. 4 metres above Moycarkey village.

No proposals outlined to help mitigate this visual impact e.g. Tree screening.

Impacts include:

- High visibility across the landscape
- Skyline intrusion from lighting masts and structures
- Significant long-range visual effects

This results in a prominent and intrusive development within a rural setting.

5. Conflict with County Development Plan and Settlement Strategy

The proposal conflicts with key objectives of the Tipperary County Development Plan, including:

- Supporting sustainable growth of rural villages
- Encouraging residential development within settlements
- Protecting residential amenity

Potential impacts:

- Restriction of future expansion of Moycarkey Village
- Reduced attractiveness for residential development
- Undermining long-term planning strategy

6. Property Devaluation

There are concerns regarding:

- Devaluation of nearby residential properties
- Reduced desirability of the area

This reflects a broader impact on residential amenity and community wellbeing.

7. Lack of Community Consultation

The community considers that:

- Meaningful engagement did not take place
- Residents were not adequately consulted

Given the scale of the project, early and transparent engagement should have been undertaken.

8. Alternatives and Site Selection

There is insufficient evidence that alternative sites were properly considered.

Key concerns:

- Why co-location with the permitted Killough Solar Farm was not pursued
- Why proximity to existing infrastructure (e.g., 110kV line at Ballytarsna) was not prioritised

A robust alternatives assessment is required.

9. Flood Risk and Surface Water

Moycarkey has been identified historically as an area of flood risk, including:

- References in the Tipperary County Development Plan (2010)
- Local knowledge of flooding events (1960s and 1970s)

Concerns include:

- Increased runoff due to significant concrete infrastructure
- Alteration of drainage patterns
- Potential downstream flooding impacts

10. Health Considerations and Fire Safety

The proximity of high-voltage infrastructure raises concerns regarding:

- Potential health impacts
- Public perception and stress
- Fire safety – local fire station knowledge and means to deal with fires on site.

A precautionary approach should be applied in siting such infrastructure near homes.

11. Lighting Impact

The proposal includes significant lighting infrastructure:

- 15 lamp poles
- 4 high mast lights (16.5m)

Impacts:

- Light pollution
- Impact on residents and wildlife
- Loss of rural dark sky environment

12. Future Greenway Impact

Concerns exist regarding:

- Impact on potential Greenway development
- Reduced recreational and tourism value

The development may conflict with future amenity and tourism objectives.

13. Cumulative Impact

The development must be assessed alongside:

- The permitted Killough Solar Farm
- Associated infrastructure

This represents:

- A significant intensification of development
- Gradual industrialisation of a rural landscape

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14. Conclusion and Request

Moycarkey Community Association respectfully requests that An Coimisiún Pleanála:

- Carefully assess the **appropriateness of this location**, particularly given its proximity to Moycarkey Village
- Require a **comprehensive and transparent alternatives analysis**
- Fully consider the **impact on residential amenity and future village expansion**
- Reassess **visual, landscape, lighting, and cumulative impacts**
- Ensure that **flood risk and surface water management** are robustly addressed
- Give due consideration to **health concerns and community wellbeing**

Oral Hearing Request

In addition, given the **scale, complexity, and potential long-term impacts** of the proposed development, together with the level of community concern, Moycarkey Community Association formally requests that an **Oral Hearing** be convened under the Planning and Development Act 2000 (as amended).

An Oral Hearing would:

- Allow for a full and transparent examination of the issues
- Enable direct engagement between the applicant, the Board, and the community
- Ensure all concerns are properly explored and tested

Given the significance of the proposal and its potential impact on Moycarkey Village, an Oral Hearing is considered **necessary in the interests of proper planning and sustainable development**

Signed:
Moycarkey Community Association

Submission on 324132

To Whom it May Concern,

I am writing to you about the above planning permission of which I have significant concerns and to which I wish to make a number of observations on.

1. The road infrastructure at at Graigue Lane, Moycarkey is solid rock and will not be able to take the heavy traffic and will not support been dug up and discommoded for cabling of this nature.l
2. The development will come close to the village of Moycarkey and will hinder and future development of the village. Given that under the most recent county development plan the council is encouraging housing inside speed zones this proposal runs contrary to the County Tipperary Development Plan 2024-29.
3. Why was the option of co-location of the substation and the Solar farm at Killlough not explored? The solar farm was granted planning permission earlier this year. If this colocation option had been explored it would have rendered this cabling application obsolete.
4. This planning application will cause prolonged disruption to the lives of local residents some of whom have working farms on Graigue Lane. No provision is made in the plans for the movement of fodder etc. Also no provision has been made to the disruption to the lives of the 45 people who live of Graigue Lane.
5. There is no provision in the plans for structural damage to houses etc in the area of Graigue Lane. Surely the provision of a bond should be in the terms and conditions.
6. There has been little or no consultation with local residents which would have helped alleviate concerns.
7. There is also a huge risk to critical infrastructure in the area most particularly the water table. Many homes in this area are connected to a rural water scheme and this development poses a huge risk to the water supplies in this area.
8. The application fails to explain what greenfield options were explored or exhausted for the cabling route as an alternative to disturbing the public realm.

I would be very grateful if you could consider these concerns.

Many Thanks,

Cllr Sean Ryan

22 Church View,
Littleton,

Thurles, Co. Tipp

An Coimisiún Pleanála
64 Marlborough Street
Dublin 1
D01 V902

Re: Planning Appeal / Observation

Case Reference: VA92.324132
Proposed Development: Substation and associated works
Location: Graigue - Moycarkey, County Tipperary

1. Introduction

This submission is made pursuant to the Planning and Development Acts in respect of the above-referenced proposed development. The development is of a significant industrial nature within a rural village setting, and it is respectfully submitted that the proposal, as currently designed and sited is contrary to the proper planning and sustainable development of the area.

Moycarkey is a historically significant village of exceptional cultural value, with continuous settlement dating from Early Christian times, predating Norman occupation and reaching prominence during the 13th and 14th centuries. The proposed development would detrimentally alter this historic landscape and undermine the character and amenity of the village.

This submission raises concerns in relation to:

- Inappropriate siting and setback
- Failure to adequately protect residential amenity
- Landscape and visual impact
- Impact on cultural heritage incudinga Mass Path
- Incompatibility with tourism and greenway objectives
- Absence of demonstrable local or community benefit
- Non-compliance with the Tipperary County Development Plan 2022–2028

2. Inappropriate Siting and Setback

The proposed substation is located unacceptably close to existing dwellings and mature landscape features. It is respectfully submitted that the development should be relocated a

minimum of 150 metres in the direction of the originally proposed site in order to mitigate its visual, environmental, and acoustic impacts.

This request is consistent with the precautionary principle embedded in the Tipperary County Development Plan, which seeks to protect rural amenity and ensure that infrastructure is sensitively located and integrated.

Relevant Policies:

- TCDP Policy CDP-SP-01 – Requires development to be consistent with the proper planning and sustainable development of the county
- TCDP Policy CDP-CE-07 – Seeks to protect the amenity and character of rural communities from inappropriate development

3. Landscape Integration and Screening Deficiencies

The proposal fails to provide meaningful or effective landscape screening. Substation developments require comprehensive landscape treatment as part of the site selection and Environmental Impact Assessment process.

Should this application be approved, we must insist that the substation be set sufficiently back from the existing high hedgerow to allow for the planting of 3 staggered rows of semi-mature trees to provide permanent, year-round screening.

Recommended Planting Specification:

- Minimum 35 cm circumference
- Root-balled specification
- Mixed species planting including:
    - Carpinus (Hornbeam)
    - Sorbus aucuparia (Mountain Ash)
    - Quercus ilex (Holm Oak – evergreen)

This approach would provide visual mitigation, ecological enhancement, and limited attenuation of noise and light pollution.

Relevant Policies:

- TCDP Policy CDP-BIO-02 – Protection and enhancement of biodiversity and ecological connectivity
- TCDP Objective CDP-LCA-01 – Protection of landscape character and scenic value
- Development Management Standards – Sections 3.4, 3.6 & 3.7 (Urban Greening, Noise, Biodiversity)

4. Impact on Residential Amenity

The Planning Authority must give proper consideration to the protection of residential amenity in line with Tipperary County Council Development Plan. The proximity of the substation, combined with insufficient screening, will materially injure the living conditions of nearby residents through:

- Visual dominance,
- Noise generation
- Light pollution
- No 3D models or definitive mapping have been provided, from the perspective of Moycarkey village residents. Indeed, Moycarkey residents have not been consulted in any meaningful way as enshrined in both Irish and European Law, and the Aarhaus Convention, particularly article 6.

This aerial views below clearly demonstrates the close proximity of the proposed development to nearby residential properties, raising concerns regarding its potential impact on residential amenity. Aerial footage of Moycarkey village can be viewed on the following links:

killough.ie/moycarkey_village/

https://www.youtube.com/watch?v=t8hfOY3qK50&t=9s

https://www.youtube.com/watch?v=v2p1PDudXkY

https://www.youtube.com/watch?v=vLLHPcrEgUs&t=195s

The developer has not demonstrated that all reasonable mitigation measures have been taken.

Relevant Policies:

- TCDP Policy CDP-DEV-09 – Protects residential amenity from adverse impacts
- TCDP Development Management Standards, Section 3.6 (Noise)

5. Tourism, Amenity and Proposed Greenway

It is noted that a proposed Greenway linking Thurles to Clonmel passes through this area and that a feasibility study has already been commissioned. This aligns with national and county policy promoting active travel, recreation, and sustainable tourism. Indeed, plans are afoot for an application for Cashel to achieve Unesco heritage status, and greenways and blueways in close proximity to the architectural heritage in the local area should be duly considered. Many medieval sites are extant in this area, recorded on https://www.archaeology.ie and gis websites- https://heritagedata.maps.arcgis.com/apps/webappviewer/index.html?id=0c9eb9575b544081b0d296436d8f60f8

The introduction of a visually intrusive industrial installation at this location risks undermining:

- The scenic and recreational value of the route
- Long-term tourism investment
- Public enjoyment of the landscape

Relevant Policies:

- TCDP Policy CDP-TOU-04 – Supports sustainable tourism and greenways
- TCDP Policy CDP-TR-06 – Promotion of walking, cycling, and amenity routes
- National CycleConnects & Greenway objectives referenced by the NTA

6. Cultural Heritage – Historic Mass Path

A historic Mass Path runs along the boundary ditch and crosses a corner of the subject site, clearly identifiable on agricultural and historical mapping. Such routes form an important part of the intangible cultural heritage of rural Ireland.

The proposal fails to adequately protect or respect this heritage feature, either physically or in its setting.

Relevant Policies:

- TCDP Policy CDP-BH-01 – Protection of built and cultural heritage
- TCDP Policy CDP-BH-05 – Protection of non-designated heritage features including historic routes and patterns

7. Lack of Demonstrable Community Benefit

The village of Moycarkey is a small, rural settlement valued for its character and amenity. This proposal offers no identified long-term benefit to local residents, and notably:

- No binding commitment to return generated output to the local or national grid
- No assurance of continued local access to the proposed National Heritage Area
- No community gain, benefit fund, or amenity enhancement proposed
- Failure to engage with the community in an open and honest manner where the full project was outlined to the community of Moycarkey, and where 3D imaging should have been presented so that the full implications of the project could be considered in its entirety

This is contrary to the principles of sustainable development and will constitute a nuisance for local residents.

Relevant Policies:

- TCDP Core Strategy – Balanced development that benefits communities
- TCDP Policy CDP-SOC-01 – Supports development that strengthens rural communities and quality of life

8. Failure to Deliver Promised Community and Amenity Benefits

At a public open day, representatives of Killough Solar stated commitments to:

- Providing a social amenity accessible to local residents
- Maintaining continued access to woodland within the Proposed Natural Heritage Area

However, these commitments are entirely absent from the planning application documentation. This represents a material inconsistency between public representations and the formal planning submission.

Planning decisions must be based on what is applied for, not informal assurances. The absence of these elements significantly undermines the credibility of the proposal.

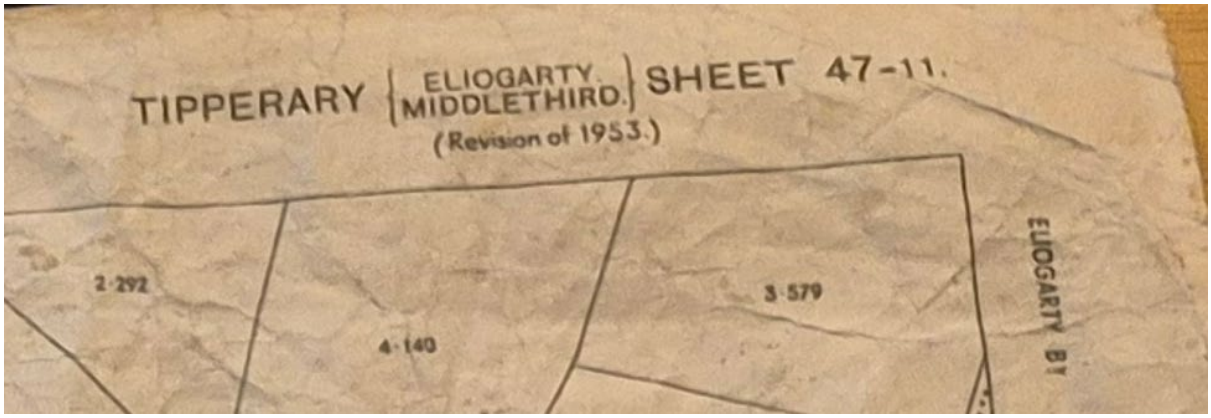
9. Conflict with Proposed Greenway and Strategic Tourism Assets

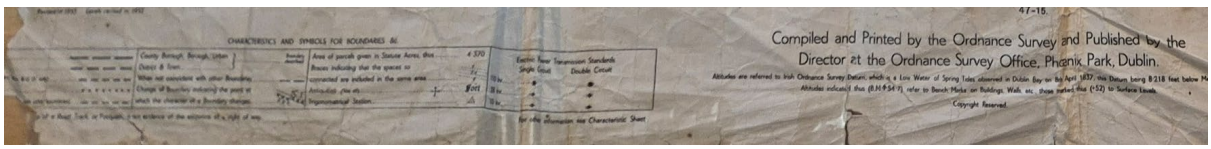
(Tipperary County Development Plan; National and Regional Planning Policy)

The proposed substation conflicts directly with a proposed greenway corridor for which a feasibility study has already been completed and which is currently under consideration by Tipperary County Council. This was omitted from pre planning documents with An Coimisiún Pleanála.

This greenway holds strategic importance due to its links with:

- Tipperary tourism development
- The Cashel UNESCO heritage area
- The Littleton Labyrinth and other cultural destinations
- A historically significant mass path





10. Impact on Archaeological and Cultural Heritage

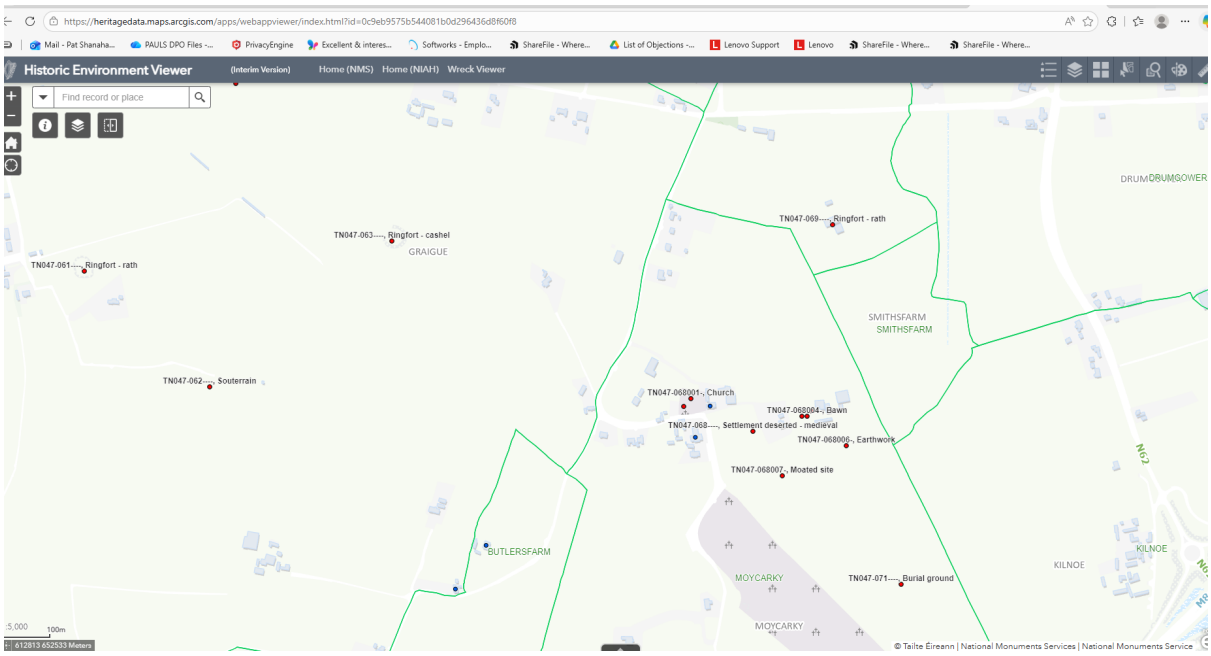
The Moycarkey area is a concentrated archaeological landscape, containing:

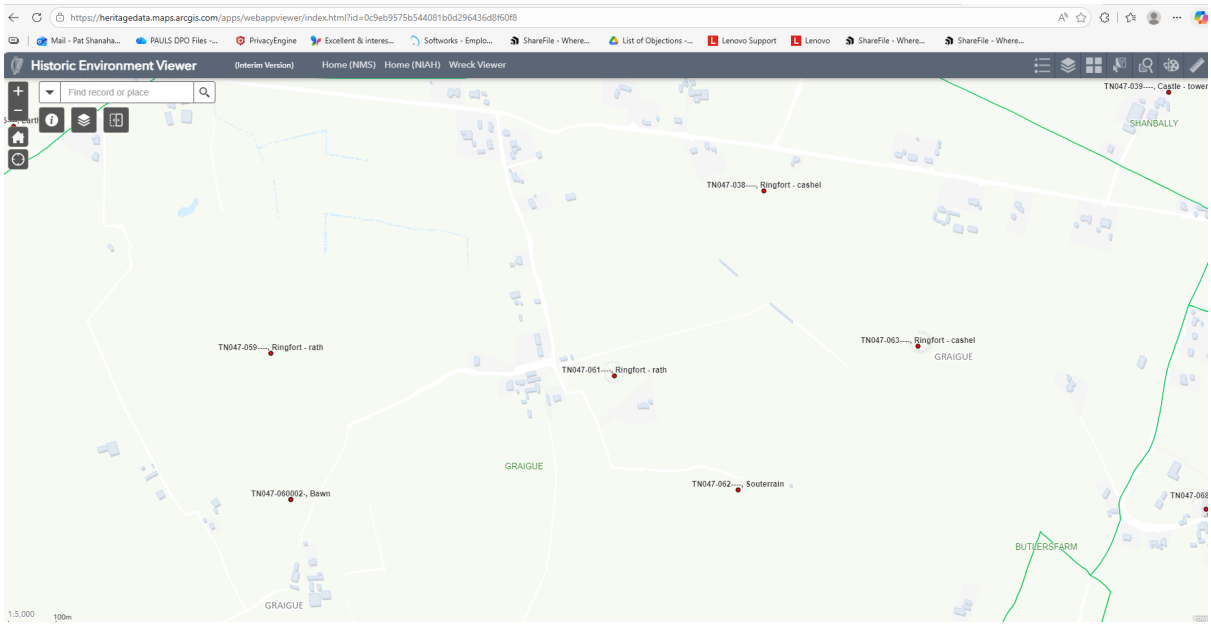
- Moycarkey Castle (medieval tower house and bawn)
- The ruins of the former parish church
- An associated historic graveyard
- The historic village core evidencing continuous settlement

The proposed cable route/substation is within close proximity of a recorded National Monument (**TN047-061**). The area around Moycarkey Village is a culturally rich area, with several recorded antiquities and monuments registered in the area: [Historic Environment Viewer https://heritagedata.maps.arcgis.com/apps/webappviewer/index.html?id=0c9eb9575b544081b0d296436d8f60f8](https://heritagedata.maps.arcgis.com/apps/webappviewer/index.html?id=0c9eb9575b544081b0d296436d8f60f8)

These features are protected under the Record of Monuments and Places and national planning legislation. Their significance extends beyond individual footprints to include their historical setting.

The applicant has failed to demonstrate that impacts on this heritage landscape have been avoided or that reasonable alternatives have been fully explored, contrary to national heritage policy and the precautionary principle.





11. Biodiversity and Protected Species

Moycarkey lies within a surveyed Bird Atlas square, with recorded presence of conservation-priority species, including:

- Yellowhammer, Barn Owl, Corncrake
- Whooper Swan, Grey Partridge
- Lapwing, Golden Plover, Kingfisher
- Buzzard and Skylark

Disturbance from excavation, vibration, and hedgerow loss can have disproportionate impacts on such species and must be assessed under:

- The EU Birds Directive
- The Planning and Development Act 2000
- The EIA Directive

Additionally, bat species known to occur in the area include common pipistrelle, soprano pipistrelle, Leisler's bat, brown long-eared bat, Daubenton's bat, and potentially lesser horseshoe bat. All bats and their roosts are protected under the Wildlife Acts and the EU Habitats Directive.

In the absence of comprehensive, site-specific ecological and bat surveys conducted at appropriate times of year, the proposal fails to apply the precautionary principle and does not comply with biodiversity protection requirements. The development is also located in close proximity to Cabragh Wetlands and the Lower River Suir SAC.

12. Suitable Site Alterative and Screening

As the applicant has previously moved the location of the proposed Substation, to allow for proper planning, we would request that the applicant be instructed to move the proposed Substation to an area 270 meters extra away from the village of Moycarkey in the direction of the original site, which would support a more appropriate distance from recipients and the village. This site would also facilitate for adequate screening, with semi mature root balled trees.

12. Conclusion

For the reasons set out above, it is respectfully submitted that the proposed development:

- Is inappropriately sited
- Fails to adequately mitigate landscape and residential impacts
- Conflicts with tourism, heritage, and greenway objectives
- Does not comply with key provisions of the Tipperary County Development Plan 2022–2028

Accordingly, it is requested that An Bord Pleanála refuse permission, or alternatively require substantial relocation, redesign, screening and enhanced mitigation measures as a minimum.

Yours faithfully,

Thomas J. Cummins
Martina Cummins

Sancta Maria
Garigue
Moycarkey
Horse and Jockey
Thurles
Co Tipperary
E41DK02

FEHILY TIMONEY

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A SUSTAINABLE FUTURE

APPENDIX 2

IAC Archaeology Response to Appeal Submissions

IAC Archaeology

12th June 2026

Proposed 110kV GIS Substation at Graigue, Co. Tipperary, Application Ref. ACP-324132-26

Response to Appeal Submissions

Submissions from Liam and Teresa Shanahan and Thomas and Martina Cummins have noted the presence of a mass path in proximity to the proposed development and have noted that this has not been assessed as part of the planning application. Neither submission provides a map of the mass path, but the Cummins submission notes that it 'runs along the boundary ditch and crosses a corner of the subject site, clearly identifiable on agricultural and historical mapping'.

A footpath is shown on the 1905 Ordnance Survey map, which runs in an east-west direction to the immediate south of the field boundary that forms the southern boundary to the proposed development area. Footpaths are not generally included in heritage assessments, unless they have a specific designation, as they form part of the landscape in the same way roads and field boundaries do. It slightly cuts the corner of the field that forms the southeast corner of the development area but it is not located within the footprint of the proposed substation – see below reference image. The footpath is not marked on the first edition Ordnance Survey map of 1843, although it is possible an earlier road once ran along this alignment to Morkarky village, as suggesting in the mapping. This is not unusual, when old roads go out of use.

Extract from the 1905 OS map showing the proposed substation and route of footpath (highlighted in green)

No documents have been identified that identify this former footpath as a mass path. It is not marked as such within the historic mapping and no records of it were identified during a review of the National Folklore Collection[1]. Whilst the footpath may be known locally as a mass path, if there are no documents to indicate this designation, it cannot be assessed as part of the baseline

[1] https://www.duchas.ie/en/info/cbe

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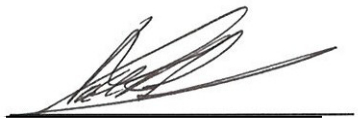
Directors
Rob Lynch, Conor Gormley
Company Reg. No. 288812
VAT Reg. No. IE 8288812U

analysis undertaken as part of the heritage assessment. Notwithstanding that, the route of the path will remain unaffected by the proposed development.

The Cummins submission also notes that the 'applicant has failed to demonstrate that impacts on this heritage landscape have been avoided', when referencing the village of Moycarky. The village is outside of the study area for the heritage assessment that was completed for the application but reference to it is included the historic background of the report as part of the wider landscape content. The recorded graveyard is located c. 440m east of the proposed development, with the recorded church c. 460m to the east. The site of the medieval settlement is recorded c. 500m east of the development area, whilst the castle is 690m east of the proposed substation. The proposed development will not result in impacts on these heritage sites, given the distance of separation between the monuments and the development.

We trust the above information is clear and addresses the submissions received in relation to cultural heritage.

Yours faithfully



Faith Bailey MA, BA (HONS), MIAI, MCIfA
Senior Archaeologist

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APPENDIX 3

MacroWorks Landscape and Visual Response

Landscape and Visual Response

Request for Further Information

Killough Substation (planning ref. ACP-323453-25)

By Macro Works

June 2026

Introduction

This landscape and visual response has been prepared in relation to a Request for Further Information (RFI) by An Coimisiún Pleanála (ACP) in relation to an application for a 110kV substation relating to a permitted solar PV development at Killough. The RFI invites the applicant to respond to submissions received in relation to the proposed development, some of which relate to landscape and visual concerns. The project Landscape and Visual Impact Assessment (LVIA) was produced by Macro Works Ltd and therefore it is appropriate for Macro Works to respond to the relevant submissions.

This RFI response is prepared by Richard Barker (MLA, MILI) Divisional Director of Macro Works Ltd. - a specialist LVIA company with over 25 years of experience in the appraisal of effects from a variety of energy, infrastructure and commercial developments. Relevant experience includes LVIA work on over 200 solar projects, including related substations and grid connections. Macro Works and its senior LVIA staff members are affiliated with the Irish landscape Institute.

Key Landscape and Visual Issues raised in submissions

Five submissions include reference to landscape and visual effects are these include both statutory bodies and 3rd parties – see below;

- Tipperary County Council
- Moycarkey Community Association & Mr Jim Ryan
- Michael Lowry
- Margaret C Byrne
- Catherine McGrath

The submissions have been reviewed and for the purpose of a consolidated response, the landscape and visual related concerns can be summarised into three key themes, which will be responded to in sequence thereafter. The themes include;

1. Excessive visual intrusion due to the scale and location of the proposed substation relative to surrounding receptors – particularly Moycarky Village

2. The proposed substation development is out of keeping with the rural landscape character of the area.

3. Visual proliferation of cumulative energy / infrastructure developments

4. Elevated and open nature of the substation site

Response to Landscape and Visual submission themes

1 - Excessive visual intrusion due to the scale and location of the proposed substation relative to surrounding receptors – particularly Moycarky Village

It is accepted that the proposed location of the substation is closer to village of Moycarky than the original location of the substation and will be more visible as a result. However, at over 300m away it still remains at a discrete distance from the village where it will not be a visually dominating feature or perceived as part of the built fabric of the village. Buffer distances of c. 300m and greater from residential dwellings and the nearest edge of the village would be typical of separation distances from solar or wind farm substation developments that are applied throughout the country. Such separation distances are employed in order to avoid significant visual effects at surrounding residential receptors and usually ensure that there is at least one agricultural field / field boundary between the substation and the receptor. For these reasons, it is considered that the visual effects from the proposed substation will not be significant either.

In terms of views from Moycarky village, it should be noted that the western side of the village is defined by a consolidated and mature treeline that surrounds a substantial residential property. Consequently, views to the west are not readily afforded from the village core where the church, graveyard and majority of dwellings are located. To illustrate this point, a Zone of Theoretical Visibility (ZTV) map has been produced using Digital Surface Model (DSM) data which accounts for screening by terrain, vegetation and buildings (See Figure 1). This shows the substantial degree of screening afforded by the vegetation lining the western edge of the village. Even for the two residential dwellings that occur on the western side of the road that defines the western edge of the village, there is consolidated screening in the direction of the proposed substation at the property boundary.

In addition to the ZTV map at Figure 1, an indicative 'wireline view' of the proposed substation has been prepared using Google Streetview imagery from the western edge of Moycarkey Village. This is a simple mass model of the substation that also includes the new pylons and it is spatially accurate (See Figure 2). The view illustrates that the proposed substation will be a distinct feature of the westerly view across hinterland farmland from this side of the village. However, it will not be a spatially dominant feature and does not block views of the landscape beyond. The substation will increase the scale and intensity of built development within the view, but is not out of place in a view across this productive rural landscape that already contains a high voltage electricity line. Whilst it represents a negative visual effect, it is not deemed to be a significant one.

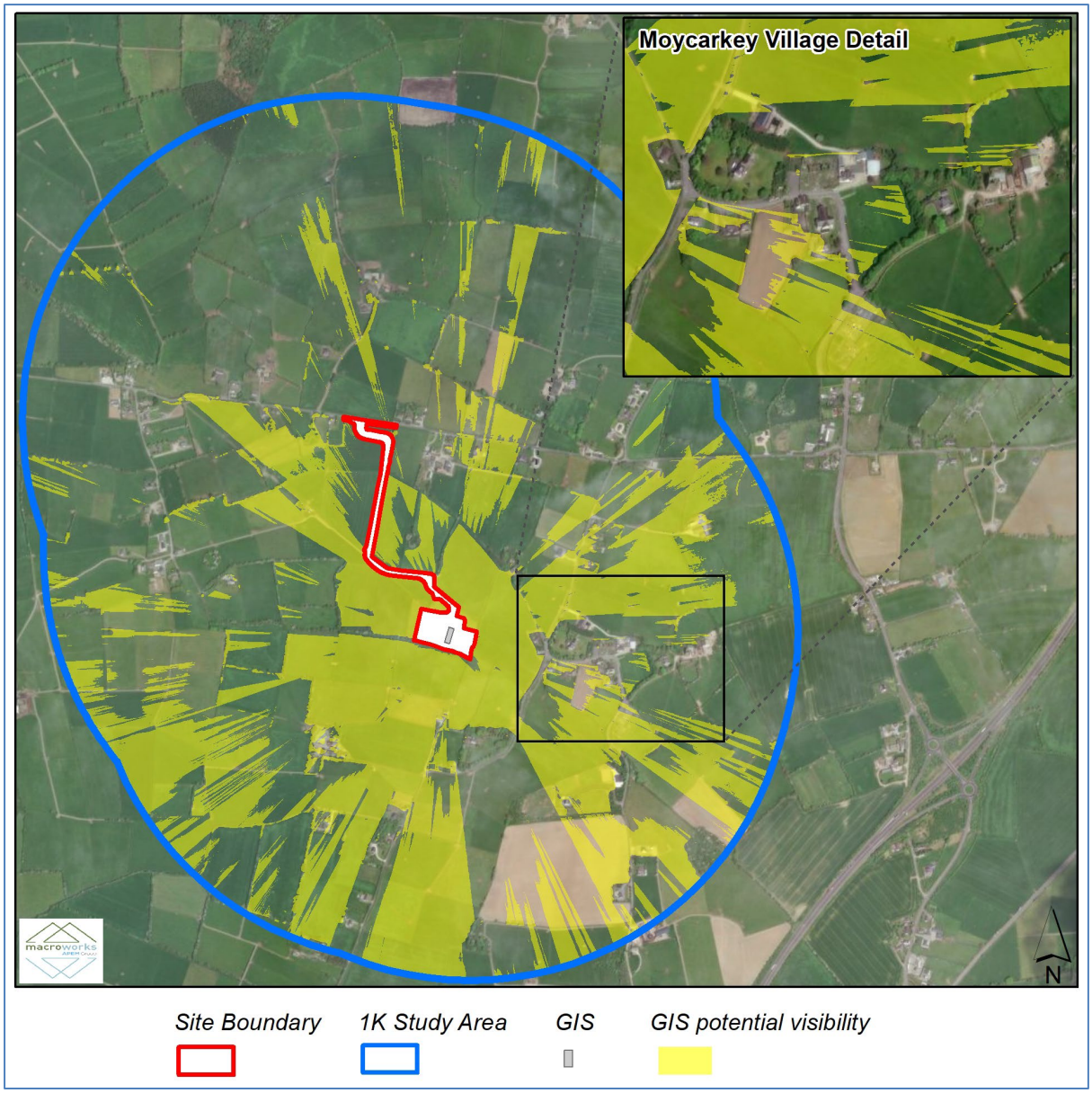

Figure 1 – DSM based ZTV map illustrating the degree of terrain and vegetation screening within 1km of the proposed substation

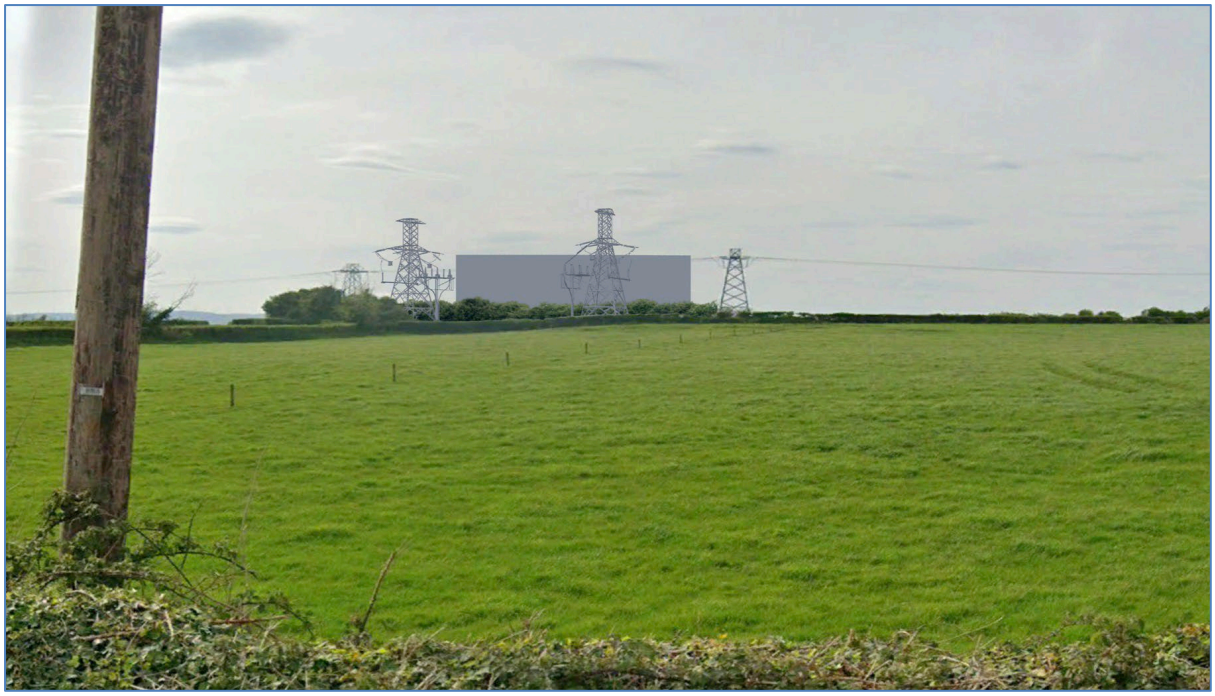

Figure 2 – Wireline Streetview montage from the local road that defines the western edge of Moycarkey Village. Montage view includes proposed mitigation planting to the fore of the substation.

2 - The proposed substation development is out of keeping with the rural landscape character of the area

This was a general theme for most of the 3rd party submissions, but also the single comment (discordant in the landscape) from Tipperary County Council. By way of response, this rural landscape is typical of agricultural farming landscapes throughout the country. In addition to agriculture, it also contains a variety of other productive land uses such as forestry and extractive industries as well as a motorway, high voltage transmission lines, settlements and dispersed rural dwellings/farmsteads. It is a modified and productive rural landscape where landscape values are associated with sustaining the rural economy at least as much as rural amenity or scenic and naturalistic value.

Electrical infrastructure has long been a part of rural landscape character and views throughout the country, however, it is acknowledged that its scale and prevalence is generally increasing as we meet the challenges of generating and distributing renewable energy. This is part of a paradigm shift in the use of rural land for renewable energy as well as traditional primary production. Rural landscapes are dynamic and evolve and revert depending on the priorities of the time. As noted by Judge Humphreys in relation to the 2024 Coom Wind Farm judicial review (case no. ABP-315656-23):

> *"In order to address Climate Change, I would suggest that other elements of our environment and the context within which the environment is perceived must also change. This includes in particular the visual context of an area which cannot be expected to remain unchanged in perpetuity but particularly within the context of a climate emergency".*

Whilst the proposed substation and associated grid connection will increase the scale and intensity of electrical infrastructure, it does so in the immediate context of an existing 110kV overhead line and pylons. Furthermore, once Killough Solar Farm is constructed, there will be an obvious thematic link between the generation and distribution of electricity within this local context.

For the reasons outlined above, it is not considered that the proposed development will give rise to significant effects on the prevailing rural landscape character.

3 - Visual proliferation of cumulative energy / infrastructure developments

Similar to the response provided above in relation to Theme 2, it is acknowledged that the scale and frequency of energy and electrical infrastructure developments will increase in the local context as a result of the proposed development in combination with the Killough Solar Farm that it serves. Once constructed, the proposed substation will read as an ancillary development to the solar farm development with less of a sense of indiscriminate proliferation. The proposed substation is not a separate development in the context of the solar farm it is simply required to follow a separate SID planning route.

4 - Elevated and open nature of the substation site

One of the submissions references that the substation site is located on ground that is at a 4m higher elevation than the ground levels in and around Moycarkey Village and suggests that this will contribute to its visual prominence. By way of response it should be noted that a 4m change in level across a distance of 300m is a minimal slope (1:75) and effectively reads as flat to mildly undulating land. This will not have a noticeable bearing on the visual presence of the proposed substation.

It is accepted that the substation is contained in a relatively open rural context with large field and maintained hedgerows that do not provide a strong degree of enclosure. It can be seen from the DSM based ZTV map at Figure 1 that relatively open visibility of the proposed substation will be afforded from within the nearest 300-400m in most directions, albeit this area is predominantly contained in agricultural farmland with few dwellings present. However, beyond this distance, the incremental sequences of field boundary vegetation soon precludes visibility or affords only sporadic shards of visibility through vegetation.

In order to aid screening and visual absorption of the proposed substation, it is proposed to plant the perimeter of the substation compound with native hedgerow species and once established, to manage that a height of 6-8m in height. This will not fully screen the proposed substation, but will leave only the upper profile visible and serve to blend it into the surrounding rural context to a greater degree.

Conclusion

On the basis of the response to landscape and visual themes raised in submissions, it is not considered the proposed substation development will give rise to significant landscape and visual effects. Indeed such effects are typical of such electrical infrastructure facilities associated with wind and solar developments throughout the country. Although setback distances from Moycarkeyare reduce

Killough Substation RFI

Moycarkey Village View

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