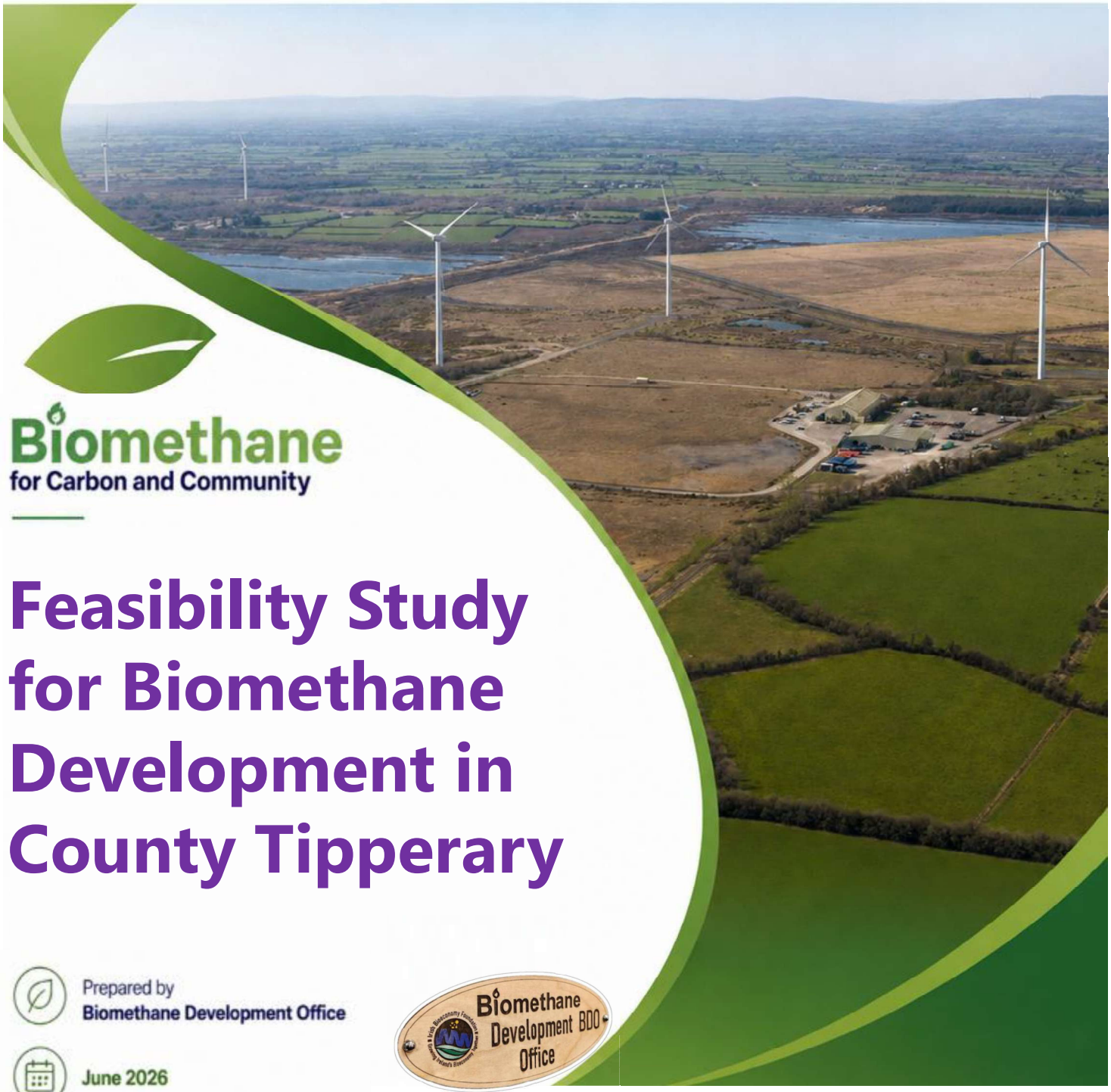
Comhairle Contae Thiobraid Árann
Tipperary County Council

TUS

TIPPERARY energy AGENCY



Biomethane
for Carbon and Community

Feasibility Study for Biomethane Development in County Tipperary

Prepared by
Biomethane Development Office

June 2026

Biomethane Development BDO Office

RECOGNITION

AD&BIOGAS INDUSTRY AWARDS 2026 AND GALA DINNER
8 JULY | THE VOX | BIRMINGHAM | UK
Nominated for the **2026 AD & Biogas Industry Awards – Education Campaign of the Year**.

World Sustainable Energy Days
24 - 27 February 2026, Wels/Austria
BCC Project's paper selected for **the World Sustainable Energy Days 2026.**

ISEC 4th INTERNATIONAL SUSTAINABLE ENERGY CONFERENCE 2026
BCC Project's poster selected for **ISEC 2026**

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Partner Organisations members and the brief details of the organisations:

Partner/ Organisation Name	About
Comhairle Contae Thiobraid Árann Tipperary County Council	**Tipperary County Council (Lead partner of the BCC project),** as the Local Authority for Tipperary, provides an extensive range of infrastructural services, and plays an active role in the development of the county's industry, business, social, arts, heritage and cultural affairs. It also functions as the regulatory body for certain matters at local level.
TUS	**Technological University of the Shannon (TUS)** is a multi-campus institution prioritizing accessibility, inclusivity, and innovation. Spanning seven campuses in Ireland's Midwest and Midlands, TUS fosters regional growth through education, research, and collaboration. With over 15,000 students annually, TUS combines student-focused learning with industry partnerships, driving progress and shaping the future of education and innovation.
IRISH BIOECONOMY FOUNDATION Growing Ireland's Bioeconomy Together	**The Irish Bioeconomy Foundation (IBF)** is a pioneering hub for transforming Ireland's natural resources into sustainable, high-value products. Based at the National Bioeconomy Campus in Lisheen, Co. Tipperary, IBF fosters collaboration among agribusiness, forestry, marine, and energy sectors, driving innovative projects, creating synergies, and building a globally competitive bioeconomy that supports local communities and sustainable development.
TIPPERARY energy AGENCY	**The Tipperary Energy Agency (TEA)** is a not-for-profit social enterprise driving Ireland's energy transition. Funded through innovative engineering services, education, and European grants, TEA enables local authorities, communities, and businesses to deliver renewable energy and efficiency projects. With over 40 European projects completed, TEA bridges climate targets and results through innovation, collaboration, and leadership.

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EXECUTIVE SUMMARY

This feasibility study evaluates the potential for developing a sustainable biomethane industry in County Tipperary, with particular relevance to the Mid-Tipperary Decarbonising Zone and the National Bioeconomy Campus at Lisheen. It considers feedstock availability, anaerobic digestion and upgrading technologies, markets, infrastructure, regulation, environmental performance, community acceptance and commercial viability.

Tipperary has a strong agricultural base, extensive dairy and beef activity, significant quantities of slurry and manure, grass silage, and supplementary residues from dairy, food and vegetable processing. These resources provide a credible foundation for biomethane production, although seasonal slurry availability, fragmented farm structures, transport distances, competing uses for grass and digestate-management requirements must be addressed through long-term supply agreements and detailed logistics planning. For the expected small-to-medium, agriculture-led deployment model, membrane separation is identified as the preferred biogas-upgrading technology because it is modular, comparatively simple and scalable, with water scrubbing as a potential alternative for larger or wetter feedstock systems. Development models should prioritise sites close to feedstock sources, suitable roads, heat users or gas infrastructure. Where direct grid connection is not economical, virtual-pipeline transport to central injection facilities may be considered, subject to cost, safety and emissions assessment.

The National Bioeconomy Campus can act as an anchor for demonstration, skills development, validation and collaboration. Tipperary's planning framework supports appropriately located farm-scale and mixed-biomass facilities, while requiring protection of residential amenity and the environment. A cluster approach could share infrastructure, expertise and services.

Potential markets include gas-grid injection, industrial heat, combined heat and power, bio-CNG and contracted renewable-gas supply. However, project bankability depends on secure offtake, predictable certificate value, capital support and clarity on sustainability verification. The Renewable Heat Obligation is expected to provide demand-side support, but its proposed 1.5-times certificate treatment for indigenous biomethane did not clear the EU notification process in its original form. Revenue models should therefore avoid assuming that multiplier and should account for revised, EU-compliant support arrangements. Environmental benefits may include avoided methane emissions from slurry, displacement of fossil gas, improved organic-waste management and recycling of nutrients through properly managed digestate. These benefits depend on sustainable feedstocks, methane-loss control, water protection, nutrient planning and compliance with planning, environmental, animal-by-product and safety requirements.

Community confidence is equally important. Early engagement, accessible information, transparent traffic and odour management, local benefit-sharing and farmer or cooperative participation can strengthen social acceptance. Overall, Tipperary is a credible location for phased biomethane deployment, but investment should proceed through site-specific feasibility, verified feedstock contracts, robust environmental assessment, commercially secure offtake and coordinated support from public bodies, farmers, communities, industry and research organisations.

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ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to everyone who contributed to the finalisation of this Feasibility Study on Biomethane Production in Co. Tipperary for the Biomethane for Carbon and Community (BCC) project. This document showcases the collaborative efforts of all stakeholders dedicated to achieving the goals of the biomethane development office and preparing for the sustainability of the project in phase 2, specifically the planning of a biomethane development facility in the County Tipperary region.

We would like to express our gratitude to the Government of Ireland and the European Union for their support, particularly through the Just Transition Fund (JTF), which has been crucial for this initiative. We also thank the Eastern and Midland Regional Assembly and Pobal for their strategic guidance in achieving our objectives and ensuring effective reporting for the BCC project.

We would like to express our heartfelt gratitude to the Advisory Board Members, whose strategic oversight and expertise have been crucial to the success of the BCC project. The distinguished members of the board include **Matthew Halpin**, Assistant Agricultural Inspector at DAFM; **Sean Finan**, CEO of IrBEA; **John Brosnan**, Bioeconomy Executive at ICOS; **Dr Anne Marie Henihan**, Centre Director at DPTC; **James Claffey**, Deputy CEO at IRL; and **Barry Caslin**, Energy & Rural Development Specialist at Teagasc. T Their expertise has greatly shaped the project's direction and impact. Thank you for your invaluable contributions

We sincerely recognize and deeply appreciate the significant contributions of our esteemed partners— **Tipperary County Council** (Sharon Scully, Michael Moroney, Clare Lee, Elaine Cullinan, Gearóid McDermott and the entire TCC team), **the Technological University of the Shannon** (Seamus Hoyne, Mercedes Alonso-Gomez, Deirbhile Tuohy, and Yvonne Doyle, Helen Mooney, and the entire SDRI team), **the Irish Bioeconomy Foundation** (Stephen Napier, Sean O'Grady, and the entire IBF team), and **the Tipperary Energy Agency** (Lisa Vaughan, Mary Buckley, and the entire TEA team)— whose expertise, insights, and commitment to innovation have been essential to our success. The collaborative efforts of local communities, farming stakeholders, and industry representatives have played a crucial role in shaping a project that is inclusive, impactful, and of great significance to the region.

We proudly extend our sincere appreciation to the dedicated team members of the Biomethane Development Office (BDO) (Ajay Kumar Sutrakar, Alan Walsh, David Mulcahy, Daniel Robinson, and Kevin Ryan) for their unwavering commitment to advancing the objectives of the BCC project. Your outstanding efforts in preparing this feasibility study for phase 1 are crucial to our success. Together, we are confidently paving the way for a sustainable and resilient future.

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GLOSSARY

Core Process & Materials

Term	Definition
Anaerobic Digestion	A natural process where microorganisms break down organic material (like slurry, food waste, or crop residues) in sealed tanks with no oxygen present, producing biogas and a leftover material called digestate.
Biogas	The gas produced by anaerobic digestion. It is mostly methane (roughly 50-80%) and carbon dioxide, with small traces of other gases. It can be burned directly for heat and electricity.
Biomethane	Biogas that has been "cleaned up" (upgraded) to remove carbon dioxide and impurities, so it is almost pure methane (96% or higher). It behaves just like natural gas and can be injected into the gas grid or used as vehicle fuel.
Feedstock	The raw organic material fed into an anaerobic digester, such as animal slurry, grass silage, food waste, or crop residues.
Digestate	The nutrient-rich leftover material produced after anaerobic digestion. It can be spread on land as a fertiliser substitute in place of chemical fertiliser.
Volatile Solids (VS)	The proportion of organic (biodegradable) material in a feedstock that can be broken down by microorganisms during anaerobic digestion; a key measure of how much biogas a feedstock can produce.

Biogas Upgrading Technologies

Term	Definition
Biogas Upgrading	The process of removing carbon dioxide and other impurities from raw biogas to produce high-purity biomethane.
Membrane Separation	A biogas upgrading method that uses a thin filter-like material (a membrane) to let methane pass through while blocking carbon dioxide and other gases. It is low-cost and is the technology recommended as the best fit for Tipperary in the feasibility study.
Water Scrubbing	A biogas upgrading method where raw biogas is passed through water, which absorbs the carbon dioxide and leaves cleaner methane behind. Also called physical scrubbing.
Chemical Scrubbing (Amine Washing)	A biogas upgrading method that uses a chemical liquid (an amine solution) to absorb carbon dioxide out of the biogas.
Pressure Swing Adsorption	A biogas upgrading method that uses a solid material (like carbon or zeolite) to trap carbon dioxide under high pressure, then releases it when the pressure drops.
Cryogenic Separation	A biogas upgrading method that cools and compresses biogas so that carbon dioxide and methane separate at different temperatures, similar to how different liquids separate at different boiling points.

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Grid Connection, Transport & Markets

Term	Definition
Grid Injection	Feeding biomethane directly into the national natural gas pipeline network so it can be delivered to homes and businesses like ordinary gas.
Central Grid Injection Hub	A shared facility where biomethane from several nearby producers is gathered and injected into the national gas grid together, avoiding the cost of each producer building its own pipeline connection.
Reverse Grid Compression	A technical solution that compresses biomethane from a local, lower-pressure gas pipeline up into the main national gas pipeline, used where local gas production is greater than local demand can absorb.
Virtual Pipeline / Trailering	Transporting biomethane by road in high-pressure containers to a grid connection point, instead of building a physical pipeline.
Bio-CNG	Biomethane that has been compressed for use as a vehicle fuel, mainly in trucks and buses, as a low-emission substitute for diesel.
Bio-LNG	Biomethane that has been chilled into liquid form for use as a vehicle fuel, offering a longer driving range than compressed gas.
Combined Heat and Power	Equipment that burns biogas to produce both electricity and useful heat at the same time from a single fuel source.
Guarantee of Origin	An official certificate confirming that a specific quantity of gas was produced renewably (e.g. from biomethane), allowing buyers to prove and claim its green credentials.
Gas Purchase Agreement	A contract between a biomethane producer and a buyer (such as a utility or large company) that sets the price and terms for supplying renewable gas, often paired with a Guarantee of Origin.
Off-take Agreement	A contract in which a buyer agrees in advance to purchase a producer's output (e.g. biomethane or a by-product), giving the producer guaranteed revenue and helping to secure project financing.
Renewable Heat Obligation	A planned Irish government rule that will require gas suppliers to blend a minimum share of renewable gas, such as biomethane, into the heat they supply.
Renewable Transport Fuel Obligation	A rule requiring fuel suppliers to ensure a minimum percentage of transport fuel sold comes from renewable sources, such as biomethane or biofuels.
Hydrotreated Vegetable Oil	A renewable diesel substitute made from vegetable oils or fats, currently a major competitor to biomethane in the renewable transport fuel market.

Regulation, Planning & Safety

Term	Definition
Nitrates Directive	An EU law, applied in Ireland through the Good Agricultural Practice (GAP) Regulations, that limits how much nitrogen (from fertiliser, slurry, or digestate) can be applied to land to protect water quality.
Good Agricultural Practice (GAP) Regulations	Ireland's rules implementing the EU Nitrates Directive, setting limits and conditions for spreading slurry, digestate, and fertiliser on farmland.
Industrial Emissions Directive (IED) Licence	An environmental permit required from the EPA for larger anaerobic digestion plants (processing more than 100 tonnes of waste per day) due to their higher pollution risk.
Environmental Impact Assessment	A formal study required for larger or higher-risk projects that examines the likely effects of a proposed development on water, air, biodiversity, landscape, and human health before planning permission is granted.

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Environmental Impact Assessment Report	The written report submitted with a planning application that documents the findings of an Environmental Impact Assessment.
Appropriate Assessment	A legally required check on whether a proposed project could harm a protected wildlife site (a Natura 2000 site), carried out as part of the planning process.
ATEX	An EU safety standard for equipment used in areas where flammable gases (like biogas) could create an explosion risk; ATEX-certified equipment is designed to prevent sparks from igniting the gas.
DSEAR	Irish/UK safety regulations requiring operators of sites with flammable gases or pressurised systems (such as AD plants) to assess and manage explosion and fire risks.
Control of Major Accident Hazards	Safety regulations that apply to sites storing large volumes of hazardous substances, including certain biogas facilities, requiring stricter accident-prevention planning.
Nutrient Management Plan	A farm plan setting out how much fertiliser, slurry, or digestate can be applied to specific fields, based on soil and crop needs, to avoid over-application and pollution.

Bioeconomy & Policy Concepts

Term	Definitions
Circular Economy	An economic model that keeps materials and nutrients in use for as long as possible, for example by turning farm waste into energy and returning the leftover digestate to the land as fertiliser, instead of discarding it.
Just Transition	The principle of moving to a low-carbon economy in a fair way that supports workers and communities affected by the change, such as those previously reliant on peat or other declining industries.
Decarbonising Zone	A designated geographic area (in this case, Mid-Tipperary) targeted for coordinated action to reduce greenhouse gas emissions, including through projects like biomethane production.
Life-Cycle Assessment	A method of calculating the total environmental impact (including greenhouse gas emissions) of a product or process from start to finish, e.g. from growing feedstock through to using the biomethane produced.
Bioeconomy	An economy that uses renewable biological resources (like crops, farm waste, and residues) instead of fossil resources to produce energy, materials, and products.
Biorefinery	A facility that processes biomass (organic material) into multiple useful outputs, such as energy, chemicals, and other products, like how an oil refinery processes crude oil into different fuels and products.

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ABBREVIATIONS

Abbreviation	Full term
ABP	Animal byproducts
AD	Anaerobic digestion
ATEX	Atmosphères explosibles
BCC	Biomethane for Carbon and Community
bcm	Billion cubic metres
BDO	Biomethane Development Office
bio-CNG	Compressed biomethane (compressed natural gas of biological origin)
bio-LNG	Liquefied biomethane (liquid natural gas of biological origin)
CAP	Climate Action Plan
CAPEX	Capital expenditure
CCUS	Carbon capture, utulisation and storage
CGI	Central grid injection
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COMAH	Control of major accident hazards
CRU	Commission for Regulation of Utilities
CSTR	Continuously-stirred tank reactor
DAFM	Department of Agriculture, Food and the Marine
DECC	Department of Environment, Climate and Communications
DMEA	Di-methyl-ethanol-amine
DPS	Dairy processing sludge
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
DZ	Decarbonising Zone
EBA	European Biogas Association
EIA	Environmental impact assessment
EoW	End of Waste
EPA	Environmental Protection Agency
ESR	Effort Sharing Regulation
EU	European Union
FPR	Fertilising Products Regulation
GAP	Good Agricultural Practice
GHG	Greenhouse gas
GNI	Gas Networks Ireland
GO	Guarantee of origin
GPA	Gas purchase agreement
GWh	Giga-Watt hour (equal to one million kilo-Watt hours)

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GWP	Global warming potential
H_2	Hydrogen gas
H_2O	Water
H_2S	Hydrogen sulphide
Ha	Hectare
HGV	Heavy goods vehicle
HSA	Health and Safety Authority
HVO	Hydrotreated vegetable oil
IrBEA	Irish Bioenergy Association
JTF	Just Transition Fund
LACAP	Local authority climate action plan
LCA	Lifecycle assessment
LDAR	Leak detection and repair
LPG	Liquefied petroleum gas
LU	Livestock unit
MAPP	Major Accident Prevention Policy
N_2	Nitrogen gas
NAP	Nitrates Action Programme
NBPP	National Biorefinery Pilot Plant
NH_4	Ammonium
NMP	Nutrient management plan
NORA	The National Oil Reserves Agency
NSAI	National Standards Authority of Ireland
NVZ	Nitrate vulnerable zone
OPEX	Operational expenditure
PPA	Power purchase agreement
PSA	Pressure swing adsorption
PSSR	Pressure Systems Safety Regulations
RED	Renewable Energy Directive
ReNure	Recovered Nitrogen from Manure
RGFI	Renewable Gas Forum Ireland
RHO	Renewable Heat Obligation
RTFO	Renewable Transport Fuel Obligation
SAO	Syntrophic acetate oxidizer
SCADA	Supervisory control and data acquisition
SEAI	Sustainable Energy Authority of Ireland
SLO	Social licence to operate
TCC	Tipperary County Council
TEA	Tipperary Energy Agency
TRL	Technology readiness level
TWh	Tera-Watt hour (equal to one billion kilo-Watt hours)
UASB	Upflow anaerobic sludge blanket
VFA	Volatile fatty acid

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INTRODUCTION

As Ireland pursues its renewable energy objectives and moves towards a more sustainable and circular economy, the production of biomethane emerges as a noteworthy opportunity. The national biomethane strategy highlights that the massive agricultural practices in Ireland provide promising resources for sustainable biomethane production within the country. One of the centred agricultural regions is County Tipperary. Given its robust farming community and abundant agricultural by-products, Tipperary is the ideal location to promote a locally integrated biomethane industry. This initiative has the potential to significantly contribute to national decarbonisation efforts while also enhancing economic and environmental outcomes for the region.

Biomethane is a purified and upgraded form of biogas generated through the anaerobic digestion of organic waste. This bio-based gas offers a clean and renewable alternative to traditional fossil-based natural gas. In County Tipperary, the agricultural community produces various organic waste, including slurry, manure, crop residues, and other by-products. This agricultural waste represents not just a challenge, but a valuable opportunity for creating sustainable biomethane industry. By adopting the potential of bringing up biomethane production within the region, several benefits can be achieved. This sustainable green strategy will reduce greenhouse gas emissions, improve waste management practices, and open new economic opportunities for farmers and rural communities.

This feasibility study examines the potential for developing a biomethane production project in County Tipperary. The primary focus is on creating a commercially viable business plan that ensures economic sustainability while also achieving positive socio-environmental outcomes. Key elements of the study include:

1. Assessment of the availability of local feedstock and supply chains
2. Evaluation of appropriate anaerobic digestion and upgrading technologies
3. Analysis of potential markets for biomethane, including grid injection, transport fuel, and local energy use
4. Overview of the regulatory, policy, and incentive landscape in Ireland
5. Environmental assessment, focusing on emissions reduction
6. Social acceptance and community trust concerning biomethane developments in Ireland
7. Evaluation of financial viability, investment requirements, and associated risk factors

The study aims to inform a diverse group of stakeholders, including local communities, government agencies, investors, farmers, and feedstock suppliers, about the practical steps, challenges, and opportunities associated with establishing a regional biomethane industry in Tipperary. In addition, it seeks to promote collaborative efforts that will provide long-term environmental, economic, and social benefits for the county and contribute to Ireland's broader climate and energy goals.

A. Tipperary County as A Key Region for Biomethane Industry Development in Ireland

Tipperary County Council (TCC) with its partner, Tipperary Energy Agency (TEA) and other stakeholders have developed a collaborative and positive climate action, namely Tipperary County Council Climate Action Plan 2024-2029 (LACAP). In this LACAP, the Mid-Tipperary Decarbonising Zone (DZ) has been identified (**Figure 1**), centred on the National Bioeconomy Campus, located within the European Union Just Transition Fund (EU JTF) area. The Mid-Tipperary DZ is the only inland, rural DZ in Ireland, and this designation will bring opportunities for this area, for Tipperary and for the region.

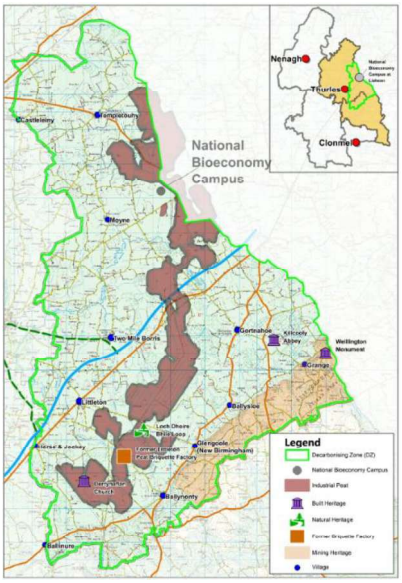


Figure 1. Location map of the Mid-Tipperary DZ area

The Irish government has targeted to deliver of up to 5.7 TWh of biomethane production by 2030, which is approximately 10% of Ireland's total natural gas demand. Meeting this ambition will require the construction of an estimated 150 to 200 new biomethane plants around the country. If the target can be achieved, it could save gas emissions equal to nearly two million tonnes of carbon dioxide equivalent yearly. According to the Ireland's Draft National Biomethane Strategy 2024, the biomethane development will maximising the available resources from agriculture sector as the suitable feedstocks for biomethane production. The type of potential feedstock in the country can include agricultural and non-agricultural-based feedstocks, such as animal slurries, energy crops (such as grass silage), food waste, municipal solid waste from households and organic solid waste from industry.

County Tipperary is strategically positioned as a leading region for biomethane industry development in Ireland, supported by its strong agricultural base, extensive livestock sector, and a progressive planning framework that actively facilitates renewable energy deployment. Agriculture remains a cornerstone of

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the county's economy, generating significant volumes of livestock slurry and organic residues that present both an environmental management challenge and a valuable renewable energy resource. The Tipperary County Development Plan 2022–2028[1], through Appendix 2: Renewable Energy Strategy, explicitly recognises the role of biogas and biomethane in supporting a resilient, agriculture-linked renewable energy sector and contributing to national climate and decarbonisation objectives.

This strategic direction is reinforced through Policy RE4: On-Farm Anaerobic Digestion/Fermentation, which provides explicit support for the installation of on-farm AD and fermentation facilities utilising slurries produced on-site, with the option to import supplementary feedstocks from the surrounding local area (Tipperary County Development Plan 2022–2028). This policy acknowledges the operational requirements of farm-scale AD systems, where co-digestion of local agricultural and organic materials can enhance process efficiency, gas yields, and system stability. Policy RE4 further provides important spatial and operational clarity by encouraging the location of such facilities within existing farm complexes, the utilisation of excess heat on-site, and connection to the national electricity grid where appropriate. Collectively, these provisions directly support the development of integrated, farm-based biomethane systems that align with circular farming principles and minimise environmental and visual impacts.

In addition to supporting farm-scale AD, the Tipperary County Development Plan also facilitates more integrated and flexible bioenergy configurations through Policy RE5: Mixed Biomass Processing Installations. This policy supports mixed biomass processing using a range of technologies and mixed feedstocks, including biological waste imported from surrounding areas, on suitable sites. Policy RE5 emphasises the importance of locating such facilities close to both the energy source and the point of demand, where adequate transport infrastructure exists and where waste heat can be effectively utilised. Most importantly, proposals are assessed against the capacity of the receiving environment to accommodate development without adverse impacts on residential amenity or the natural environment, ensuring that biomethane and bioenergy development proceeds in a balanced and sustainable manner.

Policy anchor	Just Transition fit	Local authority role	Communities
The National Biomethane Strategy target of 5.7 TWh/year by 2030 gives the sector a defined national delivery benchmark.	Tipperary/Lisheen sits within a place-based transition narrative: rural enterprise, skills, bioeconomy and regional decarbonisation.	Tipperary County Council and the Mid-Tipperary DZ provide governance, convening power and planning relevance.	Acceptance depends on traffic, odour, benefit sharing, transparency and early engagement.

Policy RE5 also provides a clear framework for assessing biomethane and bioenergy projects that cater for regional energy demand or utilise feedstocks imported from the wider region. By requiring alignment with relevant regional plans, strategies, and policies, the Council ensures that larger-scale or multi-feedstock biomethane initiatives contribute coherently to regional energy and climate objectives. Together, Policies RE4 and RE5 demonstrate that Tipperary County Council's planning framework

[1] Tipperary County Council. 2016. Tipperary County Development Plan 2022-2028. Appendix 2 Renewable Energy Strategy. Volume 3 Renewable Energy Strategy.pdf. Accessed on 29 January 2025.

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supports biomethane and bioenergy development across the entire county, from farm-scale anaerobic digestion to mixed biomass processing installations, subject to appropriate site selection and environmental safeguards. This comprehensive and enabling policy environment positions Tipperary as one of Ireland's most favourable regions for biomethane demonstration, deployment, and long-term industry development.

In 2024, Tipperary County Council collaborated with Technological University of the Shannon, The Irish Bioeconomy Foundation and the Tipperary Energy Agency in the Biomethane for Carbon and Community (BCC) project, funded by the Govt. of Ireland and the European Union through the EU Just Transition Fund Programme 2021-2027. Under this project, a new Biomethane Development Office (BDO) has been established, located in the National Bioeconomy Campus at Lisheen, Thurles, Co. Tipperary (**Figure 2**).



Figure 2. Biomethane development office at the national bioeconomy campus, Thurles, Co. Tipperary

The BCC project will enable Tipperary, and its hinterland respond to new national policy direction and supports for biomethane development, including the new National Biomethane Strategy. This project will ensure that local communities are at the forefront of biomethane development (with associated reduced reliance on fossil fuel and a focus on biodiversity and economic benefits in the form of local jobs) and will look to prepare the conditions for future investment with a supportive network of farmers/biomass suppliers in the area.

Sustainable biomethane production requires sustainable feedstock supply, which is processed through anaerobic digestion technology, in the biomethane plant, to produce carbon-neutral renewable biogas[2]. This Teagasc research also estimated that to feed a biomethane plant (20 GWh) would require approximately 37,000 tonnes of feedstock, consisting of energy crops (60%) and animal slurry (40%). Although biomethane can be produced from several types of feedstocks, the key potential feedstock

[2] Teagasc. 2022. Developing an Irish Biomethane Industry. Environment - Developing an Irish Biomethane Industry - Teagasc | Agriculture and Food Development Authority. Accessed on 26 November 2024.

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suitable for biomethane production in Ireland comes from animal slurry/manure and agricultural residues[3].

The BDO aims to drive biomethane development in the Mid-Tipperary DZ, working with farmers and local communities to support sustainable biomethane production in the region. The BDO operates from the National Bioeconomy Campus at Lisheen, which also hosts the National Biorefinery Pilot Plant (NBPP), formally launched by Minister Martin Heydon as a "first-of-its-kind" National Biorefinery Pilot Plant and Bioeconomy Demonstration Initiative (Figure 3). The NBPP advances Irish bio-innovations from TRL4 to TRL7 using local feedstocks such as dairy residues, forestry side streams, and organic waste, positioning Lisheen as a strategic anchor for biomethane deployment alongside the BDO's community and farmer engagement role. Therefore, this feasibility study for biomethane production sustainability in the region is important, both to guide local deployment and to draw on the wider innovation infrastructure already established at the campus.[4]



Figure 3. Launch of National Biorefinery Pilot Plant, Lisheen

The feasibility study conducted by the BDO directly focuses on the investigation of potential anaerobic digestion feedstock and potential key stakeholders' identification in the Mid-Tipperary DZ area and nearby locations for the biomethane development facility planning in the region (from feedstock to energy end-use) which also consider its environmental, social and economic impacts. It will also provide the local community with a roadmap for the deployment of anaerobic digestion plants in the region and guide the next steps for the related project development as the regulations and policy related to biomethane development is also discussed within this report.

[3] Presentation by Henrik V. Laursen from Bigadan - RFI infomation event (29 November 2022). Biomethane Energy Report by Gas Networks Ireland. https://www.gasnetworks.ie/docs/renewable/Biomethane-Energy-Report.pdf. Accessed on 26 November 2024.

[4] 'Minister Heydon launches first-of-its-kind National Biorefinery Pilot Plant and Bioeconomy Demonstration Initiative' (2026) *gov.ie/DAFM* [Preprint]. DAFM. Available at: https://www.gov.ie/en/department-of-agriculture-food-and-the-marine/press-releases/minister-heydon-launches-first-of-its-kind-national-biorefinery-pilot-plant-and-bioeconomy-demonstration-initiative/ (Accessed: 17 July 2026).

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EVALUATION OF APPROPRIATE ANAEROBIC DIGESTION AND BIOGAS UPGRADING TECHNOLOGIES



A. Introduction to Anaerobic Digestion

Anaerobic digestion technology can be defined as the digestion of simple and complex organic matters through several biochemical pathways with the help of anaerobic microorganisms without the presence of oxygen to produce renewable energy and biogas5[6]. Organic materials, whether simple or complex, serve as valuable feedstock for anaerobic digestion. Researchers worldwide are actively exploring various types of organic matter to uncover high-potential feedstock for biogas production. It can be highlighted that potential feedstock can come from non-food and non-feed sources, including agricultural waste, agro-industrial byproducts, household waste, wastewater, forestry residues, and municipal solid waste.

By utilising waste- or biomass-based feedstocks, anaerobic digestion technology presents a promising solution for effective waste management practices. This approach not only enables the generation of renewable energy as a sustainable alternative to fossil fuels but also contributes significantly to waste reduction efforts. The integration of anaerobic digestion into our waste management strategies holds

[5] Teagasc. 2020. Anaerobic Digestion. Anaerobic Digestion - Teagasc | Agriculture and Food Development Authority. Accessed on 13 February 2025.

[6]

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great promise for a greener future7. Anaerobic digestion technology presents a promising approach to circular waste management and serves as an effective implementation of the bioeconomy concept.

Anaerobic digestion technology generates a promising renewable energy source known as biogas. This valuable gas mainly comprises methane (CH_4) at concentrations between 50% and 80%, and carbon dioxide (CO_2) representing 20% to 50%. Furthermore, it contains beneficial trace amounts of nitrogen (N_2), hydrogen (H_2), ammonium (NH_4), and hydrogen sulphide (H_2S), each at less than 1%8. The concentration of methane can be used to assess the quality of biogas, with higher CH_4 levels indicating better quality because it burns more easily. The type of feedstock used in anaerobic digestion significantly influences the composition of biogas since the carbon and nitrogen content of the feedstock can affect the different phases of the digestion process9.

Feedstock characteristics are crucial to consider before performing anaerobic digestion. There are two types of anaerobic digestion systems based on the number of feedstocks used in a single bioreactor: mono-digestion and co-digestion. The mono-digestion system utilizes a single type of feedstock, while the co-digestion system incorporates multiple types of feedstocks. Research has shown that biogas production tends to be lower in mono-digestion systems compared to co-digestion systems. This is because mono-digestion can lead to the accumulation of toxic inhibitors that hinder the anaerobic digestion process. In contrast, co-digestion systems can help balance the nutrients required for anaerobic digestion and dilute these toxic inhibitors10.

Figure 4 illustrates how anaerobic digestion technology can be an effective waste management solution for Ireland while also supporting the vision of a bioeconomy. Biowaste sources, such as animal slurry, grass silage, crop biomass, and food waste, can serve as potential feedstock for anaerobic digestion. Through biochemical reactions, this biowaste and biomass can be transformed into renewable energy in the form of biogas, with some undigested compounds remaining, referred to as digestate.

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[7] Sustainable Energy Authority of Ireland. 2020. Anaerobic Digestion for On-Farm Uses – Technology Guide. Anaerobic-Digestion-Technology-Guide.pdf. Accessed on 18 February 2025.

[8] Teagasc. 2020. Anaerobic Digestion. Anaerobic Digestion - Teagasc | Agriculture and Food Development Authority. Accessed on 13 February 2025.

[9] Choi et al. 2020. Influence of carbon type and carbon to nitrogen ratio on the biochemical methane potential, pH, and ammonia nitrogen in anaerobic digestion. J Anim Sci Technol. 2020 Jan 31;62(1):74–83. doi: 10.5187/jast.2020.62.1.74.

10 Biswanath Saha, Sumona Koley, Meena Khwairakpam, Ajay S. Kalamdhad. 2022. Comparative study between mono-digestion and co-digestion of terrestrial weed (Parthenium hysterophorus). Cleaner Engineering and Technology. https://doi.org/10.1016/j.clet.2022.100560.

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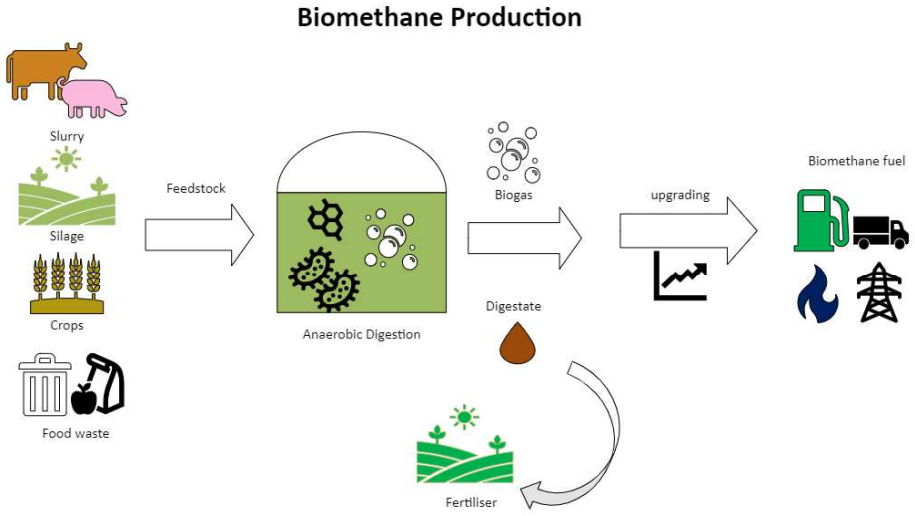


Figure 4. Biomethane production scheme

Furthermore, an upgrading technology can be applied to biogas to separate carbon dioxide (CO_2) from methane (CH_4), resulting in the production of biomethane. Compared to biogas, biomethane contains up to 95-99% CH_4, which provides higher purity and can enhance thermal energy.

Biomethane can be utilised in the same ways as natural gas without the need to modify any equipment. Since biomethane is primarily composed of methane, it can easily replace natural gas, allowing for a seamless blend of the two fuels within the gas grid. This means that Gas Networks Ireland can introduce biomethane into the gas grid without any negative impact, enabling sustainable biomethane to support cooking and home heating just like conventional natural gas does. Given that roughly half of Ireland's electricity is generated using natural gas, integrating biomethane can also make electricity generation more sustainable, especially during times when solar and wind energy are not available. Recent study by Marconi & Rosa (2023)[11] identified that Ireland has the potential to offset 14-17% of its natural gas consumption with biomethane. This transition could lead to a reduction of approximately 9% in gas system emissions, assuming that biomethane is produced with 90% emissions savings and replaces 10% of the country's natural gas usage.

In this feasibility study, the potential feedstock for anaerobic digestion to produce biomethane in Ireland, especially in County Tipperary and its nearby regions analysed based on two categories, namely agricultural-based and non-agricultural-based feedstocks. As the biomethane for carbon and community project is aiming at encouraging the local communities as well as farmers to contribute as the main stakeholders, mapping the feedstock based on these categories is necessary.

[11] Pietro Marconi, Lorenzo Rosa. 2023. Role of biomethane to offset natural gas. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2023.113697.

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B. Study on Anaerobic Digestion Development in Ireland

Anaerobic digestion (AD) is a mature and widely adopted technology across the EU and UK for producing renewable biogas and biomethane. The process uses microbial communities in oxygen-free conditions to break down organic matter. Anaerobic digestion (AD) represents a proven and valuable technology that has been effectively implemented across the EU and the UK to produce renewable biogas and biomethane. This innovative process exploits the power of microbial communities to decompose organic matter, including materials like animal slurry, food waste, and energy crops, in oxygen-free conditions. As a result, it generates biogas composed of roughly 55-65% methane and 35-45% carbon dioxide. By utilizing AD, a sustainable waste management practice can be achieved while also promoting renewable energy production.

Biogas presents valuable opportunities as renewable energy. It can be utilized directly for combined heat and power (CHP) and can also be upgraded to biomethane (purified methane ≥ 97%) for grid injection or as a vehicle fuel, contributing significantly to sustainable energy initiatives. As of 2020, there were around 18,774 biogas plants operating in Europe, with about 1,067 of those upgrading biogas to biomethane for injection into the natural gas grid (EBA, 2022)[12].

Based on the feedstock types and characteristics, anaerobic digestion process can be operated in various system. The variation of anaerobic digestion system is selected based on several parameters including the type of nutrients, solids content, and overall production cost. The aims of choosing the best optimized anaerobic digestion system are to generate high yield of methane content with less production cost. The following table presents some types of anaerobic digestion process that has been operated widely.

Table 1. Anaerobic digestion process types

Type	Description	Best Applications
Wet AD (liquid-fed)	Most common; uses slurry, food waste, energy crops	Farm-based AD, municipal AD
Dry AD (Solid-fed)	Lower moisture (~25–35% TS); batch or continuous	Food waste, green waste
Two-stage AD	Separates hydrolysis & methanogenesis	Improves CH_4 yield & stability
High-rate reactors (e.g. UASB)	Industrial wastewater digestion	Beverage/dairy effluent

[12] European Biogas Association (EBA). 2022. EBA Statistical Report 2021. EBA Statistical Report 2021 | European Biogas Association. Accessed on 1 June 2025.

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Until today, only 43 biogas plants and 2 biomethane facilities injecting methane into the national grid in Ireland. This in total producing biogas up to 580 GWh and biomethane up to 75 GWh per year. Meanwhile, following the target in National Biomethane Strategy, Ireland aiming at producing 5.7 TWh of biomethane by 2030 from anaerobic digestion of agricultural feedstocks[13]. To achieve this target, at least 200 biomethane plants need to be operated by 2030.

Study has estimated the requirement of feedstock to supply the biomethane production demand for producing 5.7 TWh biomethane yearly. Over 20% of all winter cattle slurry in Ireland would be required. Also, the National Biomethane Strategy has estimated that an equal mix of grass foliage and slurry as feedstock from a total land area of 120,000 hectares would be needed to produce the silage as a feedstock for biomethane plants to achieve the target[14].

Gas Network Ireland has identified the potential for 14.8 TWh of biomethane from over 170 prospective producers. Even so, to achieve the national biomethane target by 2030, significant investment and scaling up from the current biomethane production level is needed.

Current operational biomethane facilities injecting into the national gas grid is only equivalent to 0.001% of the current gas demand of the country. Most of the biomethane produced in the country is further used in the transportation sector under the Renewable Transport Fuel Obligation. In comparison, the 43 biogas production facilities are currently used in combined electricity and heat (CHP) generation.

Here is a list of some biogas production projects in the country:

1. Bia Energy[15]
   This biogas production plant in Co. Dublin previously generated 4.8 MWe of renewable electricity from anaerobic digestion of various types of feedstocks, such as, packaged food, food waste, food processing residues, and agricultural feedstocks (i.e. cattle slurry and chicken litter). It has since installed biogas upgrading equipment to produce biomethane.
2. Greengate Biogas[16]
   This proposed biomethane facility will digest up to 700,000 tonnes of agricultural residues (i.e. cattle and pig slurry, farmyard straw manure and poultry manure) to produce approximately 250 GWh of biomethane per year as well as capturing 30,000 tonnes of biogenic CO_2. The biomethane produced will be injected into the local gas network, generating enough sustainable energy to provide head demand of approximately 22,700 households. This facility will be located

[13] Ireland's State of the Environment Report. 2024. Ireland's State of the Environment Report 2024. Accessed on 13 May 2025.
[14] Ireland's State of the Environment Report. 2024. Ireland's State of the Environment Report 2024. Accessed on 13 May 2025.
[15] Bia Energy. Launch of new €63m Bia Energy AD/Biomethane Plant - Bia Energy. Accessed on 18 May 2025.
[16] Greengate Biogas. Greengate Biogas announces plans to build a biomethane plant in Powerstown, County Carlow. Accessed on 18 May 2025.

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in Co. Carlow and is one of seven large-scale biomethane plants Greengate Biogas aims to develop across the country.

3. Nephin Renewable Gas[17]

   This biomethane production company is currently building its first biomethane plant near Ballinrobe, Co. Mayo, which is expected to produce roughly 90 GWh of biomethane per annum. Nephin Renewable gas has ambitions to become Ireland's leading biomethane development company, contributing to Ireland's biomethane targets.

4. Teagasc Grange[18]

   This is a pilot-scale anaerobic digestion plant. To start up the anaerobic digestion, the digester is firstly inoculated with cattle slurry as a source of microorganism. The microorganism is then allowed to develop because its community is very critical to the production of biogas. Following this step is feeding the digester with grass silage and cattle slurry. During Currently the biogas yield produced reach 4 m3 of gas per m3 of slurry with the methane content ranged from 55-64%. In the near future, this facility will upgrade the biogas into biomethane, contributing to Ireland's biomethane goals.

5. Nua Bioenergy[19]

   This biomethane production facility plan has been recently approved by Tipperary County Council. This large-scale plant will have 98,000 tonnes of feedstock to produce biomethane and then injected into the national gas grid. The feedstock proposed is a mix between 8,000 tonnes of wholecrop silage,30,000 tonnes of farmyard manure, 30,000 tonnes of bellygrass sludge, 15,000 tonnes of dairy sludge and dewatered manure and 15,000 tonnes of broiler manure as feedstock each year. The success of this plan will help Ireland achieve the 5.7 TWh biomethane production target by 2030. The biomethane facility is in former Lisheen Mines near Thurles, Co. Tipperary.

C. Biomethane Production

Biomethane is a renewable gas that comes from organic materials and presents an effective way to decarbonise the energy, transport, and agricultural sectors. As an upgraded version of biogas, biomethane can be used interchangeably with natural gas. It can either be injected into the gas grid or utilised as fuel for vehicles. With global efforts focused on achieving climate targets, biomethane production is rapidly gaining attention across Europe, including in Ireland. In Ireland, agricultural-based resources and supportive policies are driving new developments in this area.[20]

[17] Nephin Renewable Gas. Why NRG? — Nephin Renewable Gas. Accessed on 18 May 2025.
[18] Irish Farmers Journal. 2025. Biogas plant approved on former Lisheen mine in Tipperary - Premium. Accessed on 18 May 2025.
[19] Irish Farmers Journal. 2025. Why NRG? — Nephin Renewable Gas. Accessed on 18 May 2025.
[20] National Biomethane Strategy. 2024. national-biomethane-strategy.pdf. Accessed on 20 May 2025.

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Biomethane is produced by upgrading biogas, a gaseous product of the anaerobic digestion (AD) of organic materials. Raw biogas usually consists of Methane (CH_4) (50–75%); Carbon dioxide (CO_2) (25–50%); and Minor components of H_2S, ammonia, siloxanes, water vapor[21]. To allow injection of biogas into the natural gas grid or the use as a vehicle fuel, it must be upgraded which means that carbon dioxide is removed whereas the share of methane is increased to usually above 96% so that it meets the quality standards for natural gas.[22] Through biogas upgrading technologies, methane content is enriched to over 99% and so called biomethane. This biomethane is suitable for Grid injection into national or regional gas networks, Vehicle fuel in the form of compressed biomethane (bio-CNG) or liquefied biomethane (bio-LNG), and Industrial and residential heating, especially in off-grid locations[23].

Feedstock is required to be collected in certain amount depending on the anaerobic digester size. For example, Teagasc has estimated that a 20 GWh biomethane plant would require about 37,000 tonnes of feedstock, consisting of 60% of crops residue/grass silage and 40% of animal slurry[24]. It is important to ensure that the feedstock availability is stable, so that the biomethane production can be sustained. Feedstock that can be considered in Ireland Biomethane industry includes animal slurry/manure, food and agricultural waste, energy crops, and sewage sludge. Following the feedstock collection is conducting the anaerobic digestion process to produce biogas and generated some undigested materials, namely digestate. Biogas is further upgraded through biogas upgrading technologies, for example membrane separation, pressure swing adsorption, water or chemical scrubbing, and cryogenic separation to produce biomethane with high purity of methane. The final product, biomethane, will then be ready to inject into natural gas grid, or to be used as transport fuel in the form of compressed gas, or to use in the combined heat and power system.

D. Biogas Upgrading Technologies

Biogas upgrading is an essential process that upgrades biogas into high-quality biomethane. Biomethane is well-known as a renewable gas that can replace fossil natural gas in heating, transportation, and electricity generation. Countries across Europe considers the importance of biomethane in decarbonisation has increasingly significant. The EU, UK, and Ireland are all investing in biogas upgrading infrastructure. The following are the most used biogas upgrading technologies to date:

1. Membrane Separation

Biogas components will be separated using membrane as the permeable material. This membrane separation technique will separate CH4 from all the contaminants, including, CO2, H2S, N2 and H2O.

[21] European Biogas Association. eba_biomethane_factsheet.pdf. Accessed on 20 May 2025.
[22] European Biogas Association. eba_biomethane_factsheet.pdf. Accessed on 20 May 2025.
[23] Gas Network Ireland. 2023. Biomethane Energy Report. Accessed on 24 May 2025.
[24] Teagasc. 2022. Environment - Developing an Irish Biomethane Industry - Teagasc | Agriculture and Food Development Authority. Accessed on 26 May 2025.

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The advantages of this technology is it is environmentally friendly, low energy consumption, low cost, and requires a simple process. The disadvantages of this technology are low membrane selectivity, requires a pre-treatment, and the biomethane product is relatively low (96%). The figure 6 showed the process of membrane separation technology[25].

2. Pressure Swing Adsorption (PSA)

The PSA technology working principle is started with the CO_2 adsorbed on surface of an adsorbent by the van der Waals forces. Following this, pressure increase will result in gas adsorbed and vice versa. This PSA technology requires four steps including adsorption, depressurization, desorption, and pressurization. The adsorbent material used in this technology is carbon and zeolites. The advantages of this technology include high gas quality, low methane losses, dry process, low energy demand, and no chemical use. The disadvantages of this technology include complex process, pre-treatment needed, a couple of streams is needed to increase the biogas quality. The technology can be seen in figure 7[26].

3. Physical Scrubbing

This technology separates CO_2 from the CH_4 in biogas, according to Henry's Law. The raw biogas will be injected to flow through a counter flow of a liquid in a column. This liquid will absorb CO_2, leaving biogas with high content of CH_4. The type of liquid majorly used is water, so that this technology is often called as water scrubbing. The advantages of this technology are simple process, high methane purity, less methane loss, low operation and maintenance cost. The disadvantages of this technology is it requires huge amount of water, high energy, external heat, and might lead to biological contamination. Figure 8 showed the physical scrubbing technology[27].

4. Chemical Scrubbing (Amine Washing)

The fact that CO_2 is more reactive than CH_4 is used as the working principle of this technique. The raw biogas will flow through a counter flow of a chemical solution in a column. Then, the CO_2 will react with the chemical solution, and the reaction rate is directly proportional with the temperature. The chemical solution will absorb the CO_2 leaving biogas with high CH_4 content. The type of chemical solution commonly used is mono-ethanol-amine (MEA) or di-methyl-ethanol-amine (DMEA) for amine scrubbing. Different types of solution resulting in different CH_4 final content. The advantage of this technology is that more CO_2 dissolved per unit volume, high methane purity, low methane loss, and faster process than physical scrubbing. The disadvantage of this technology is that high energy needed to produce steam, pretreatment required, difficulties in handling the solvent, possibility of salt precipitation, foaming and poisoning of amine. Figure 9 showed the chemical scrubbing technology[28].

5. Cryogenic Separation

[25] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.
[26] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.
[27] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.
[28] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.

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The working principle of this technology depends on the fact that different gases condes at different temperatures-pressure domains. Boiling point of CO_2 was higher than CH_4, allowing the separation of both gases. Biomethane produced by gradual decrease in temperature and compressing the biogas. The equipment's required for this technology include compressor, turbine, heat exchanger, and cooler. The advantages of this technology is high gas quality, low methane losses, environmentally friendly, produce liquid biomethane with low extra energy. The disadvantage of this technology is the high investment and operational cost, pretreatment needed, high energy required for cooling, and technology is still under development. Figure 10 showed the cryogenic separation technology[29].

Apart from CH_4, the remaining components in biogas are undesirable and considered as impurities. Basically, there are two steps involved in biogas treatment, cleaning (removal of minor unwanted components of biogas), and upgrading (removal of CO_2 content). After the processes, the final product is called biomethane which composed of CH_4 (95–99%) and CO_2 (1–5%), with no trace of H_2S. Biogas cleaning is usually considered the first step for biogas applications and is an energy-demanding process. The second treatment is called "biogas upgrading" and aims to increase the low calorific value of the biogas, and thus, to convert it to a higher fuel standard. The mature technologies that are today currently applied for biogas upgrading including those five technologies mentioned previously[30].

However, some biogas components released from biogas upgrading are associated with GHG, especially CO_2. The direct impacts of excessive CO_2 emission are global warming, ocean acidification, and carbon fertilization. The released CO_2 needs to be disposed of. It includes the processes of CO_2 liquifying and injection into underground aquifers. The drawback of this process is the possibility of CO_2 leaking and returning to the surface. Furthermore, the cost of CO_2 disposal is very high and uncertain (among the factors that contribute to cost are the size of the plant and the distance). Thus, a possible solution for this problem is through CO_2 utilization technology. This technology holds big potential for a new way of upgrading biogas, since the benefits of utilizing CO_2 could potentially overcome the cost of CO_2 disposal and reduce the cost of biogas upgrading[31].

Instead of separating CO_2, there is a technology related to utilizing CO_2. The biogas upgrading via CO_2 utilization technology could decrease the impact of GHGs emissions.

1. **Chemical processes technology**

It is well known that using CO_2 as a feedstock for the synthesis of commodity chemicals and fuels has the potential to be beneficial for the economy and environment. Methanation reaction, also called a Sabatier reaction is a reaction between CO_2 and H_2 to produce CH_4 and water (H_2O). Although the reaction is between CO_2 and H_2, there is the potential of using biogas directly as feedstock for CO_2 methanation as CH_4 content in the biogas has only a little influence on the reaction at high pressure. So,

[29] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.

[31] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.

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in this methanation technology, the CO_2 and H_2 will be utilized through the hydrogenotrophic to produce CH_4 and H_2O. However, this kind of technology is still requiring further research, especially finding the most suitable catalyst[32].

2. **Biological processes technology**

Biological processes complement chemical options due to its uniqueness of carbon utilization resource requirements and product opportunities. It focuses on the aptitude of microorganisms to convert CO_2 into useful products. Biological fixation of CO_2 is a sustainable solution to reduce CO_2 content in biogas due to its nature which is environmentally friendly and eliminates the step of captured CO_2 disposal. Unlike chemical processes that requires a catalyst, biological processes require hydrogenotrophic methanogens. One of the biological methods to utilize CO_2 in biogas relies on the utilization of H_2 for the conversion of CO_2 to CH_4 based on the action of hydrogenotrophic methanogens (microorganisms). The challenge of this technology is to have sufficient H_2 supply because the microorganisms requires both CO_2 and H_2 (as electrons). The CO_2 is converted to acetate acid with the help of homoacetogenic bacteria. Then the acetate acid is converted into CH_4 with the present of acetoclastic methanogenic archaea. H_2 plays a crucial role in the whole process of anaerobic digestion. Exogenous addition of H_2 results in the increase of both hydrogenotrophic methanogens and homoacetogenic species, producing acetate from H_2 and CO_2. The downside of adding H_2 to the process is the inhibition of syntrophic acetogens which are involved in propionate and butyrate degradation and syntrophic acetate oxidizers (SAO). It is important to control the concentration of H_2 to ensure the equilibrium of biochemical reactions[33].

A continuous stirred tank reactor (CSTR) has been commonly used to study this technology. However, the process requires a heavy connection with the pH level within the reactor. Therefore, the main challenge of this technology is to maintain the pH and prevent it from increase above 8.5 because it will lead to methanogenesis inhibition. Another challenge arises from the oxidation of the volatile fatty acid and alcohols associated with the concentration of the injected hydrogen. As a solution, to prevent the increase of the pH and VFA oxidation, a co-digestion with acidic waste and an injection of high H_2 concentrations in reactor is proposed. [34]

E. Status of Biomethane and Biogas Upgrading in the EU

By upgrading anaerobic digestion product into biomethane, the energy yield can be increased, contributing to wider energy applications. If the biomethane production is based on the utilization of organic waste, forest residues, agricultural residues, and others waste-based resources to avoid implications for land use and food security, then the technology helps to achieve the goal in circular

[32] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.
[33] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.
[34] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.

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economy action plan[35,36]. According to European Biogas Association (2024)[37], a total of 1322 biomethane producing facilities is recorded, with the detail of the biomethane facilities development in Europe by years can be seen in Figure 5. Biomethane production doubled from 2018 to 2022, with France, Italy, Denmark, and the UK being the fastest-growing countries

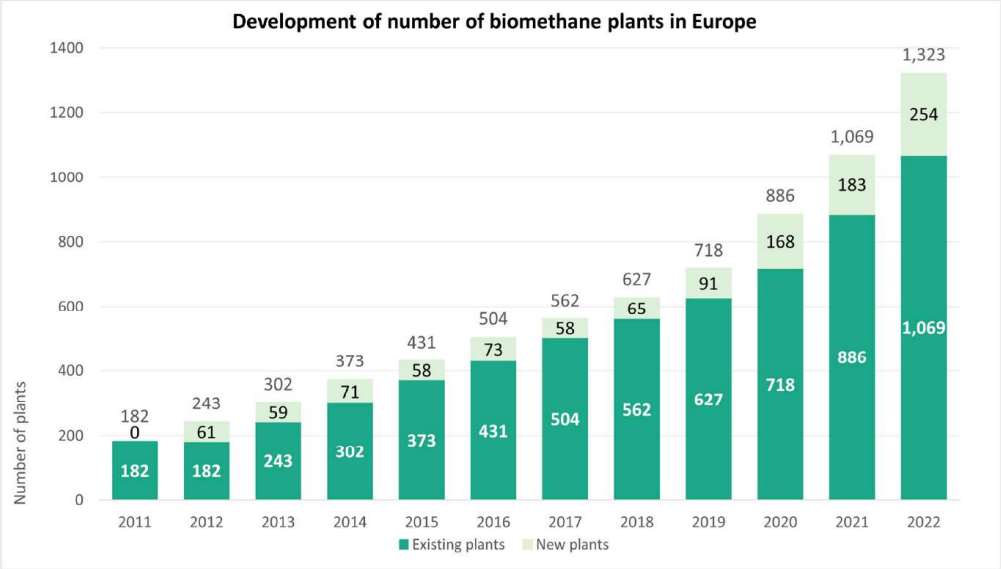


Figure 5. Number of biomethane facilities in Europe from 2011-2022

The best known and most mature technologies are sorption methods, including adsorption and absorption techniques, and separation, which refers to membrane use and cryogenic methodology[38]. More than ¾ of the biomethane plants currently active use either membrane separation (39%), water scrubbing (22%) or chemical scrubbing (18%) as upgrading technologies (Figure 6)[39].

[35] Francisco López, A. 2024. From Biogas to Biomethane: An In-Depth Review of Upgrading Technologies That Enhance Sustainability and Reduce Greenhouse Gas Emissions. Accessed on 5 June 2025.
[36] Circular Economy Action Plan. Assistance to assessing options improving market conditions for bio-methane and gas market rules - Publications Office of the EU. Accessed on 5 June 2025.
[37] EBA. 2024. EBA Statistical Report 2023 | European Biogas Association. Accessed on 5 June 2025.
[38] Adnan, A I. et al. 2019. Technologies for Biogas Upgrading to Biomethane: A Review.
[39] EBA. 2021. EBA Statistical Report 2021 | European Biogas Association. Accessed on 5 June 2025.

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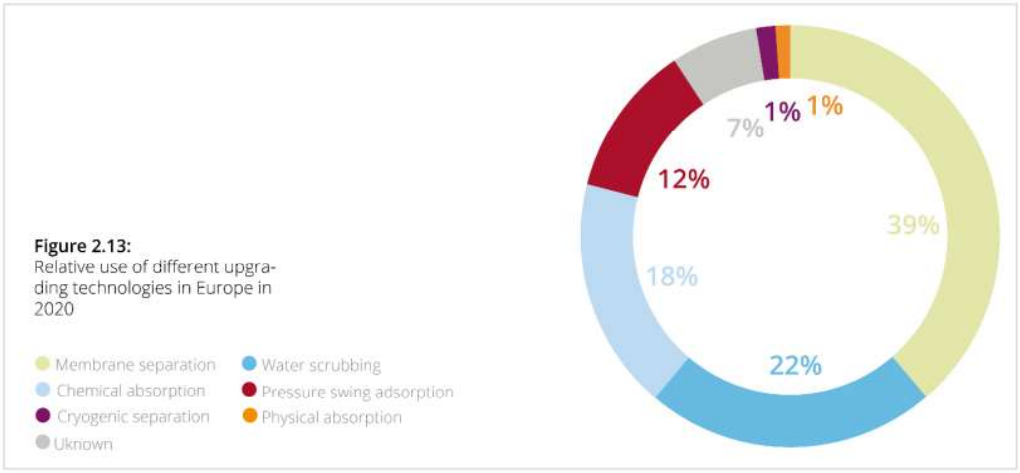


Figure 6. Relative use of different biogas upgrading technologies in Europe in 2020. [40]

Biogas upgrading is an essential enabler for the widespread use of biomethane across Europe. While countries like Germany and France have already developed mature markets with a range of technologies, Ireland is poised to scale its deployment by leveraging modular, cost-efficient systems like membrane separation.

A clear policy framework, investment incentives, and integration with existing agricultural systems will be crucial to achieving national and EU-wide climate and renewable energy targets.

For Ireland, and Co. Tipperary specifically, membrane separation is the most suitable upgrading technology, followed by water scrubbing. Membrane separation already dominates the EU market at 39% of active plants, ahead of water scrubbing (22%) and chemical scrubbing (18%), reflecting its maturity, modularity, and lower operating complexity compared to chemical routes. This modularity matters most for Ireland's deployment model: national strategy is built on approximately 140–200 small-to-mid-scale, slurry-led plants (targeting 5.7 TWh/y by 2030) rather than a handful of mega-facilities, and a 20 GWh plant requires only around 37,000 tonnes of feedstock sourced within a 10–15 km working radius. Membrane systems scale down economically to this size far better than cryogenic separation and require less specialised chemical handling than amine or chemical scrubbing. A clear advantage for farmer-led or co-operative projects without large technical operating teams.

Co. Tipperary is particularly well placed to adopt this approach. The county already hosts the National Bioeconomy Campus at the former Lisheen mine site, identified as a hub for skills, infrastructure, and clustering that can de-risk and accelerate biomethane deployment[4], and it has hosted demonstration and networking events, including Mainstreaming Small-Scale Biorefineries (June 2024), showcasing small-scale AD and biorefinery models via the Rural BioRefarmeries project.

[40] EBA. 2021. EBA Statistical Report 2021 | European Biogas Association. Accessed on 5 June 2025.

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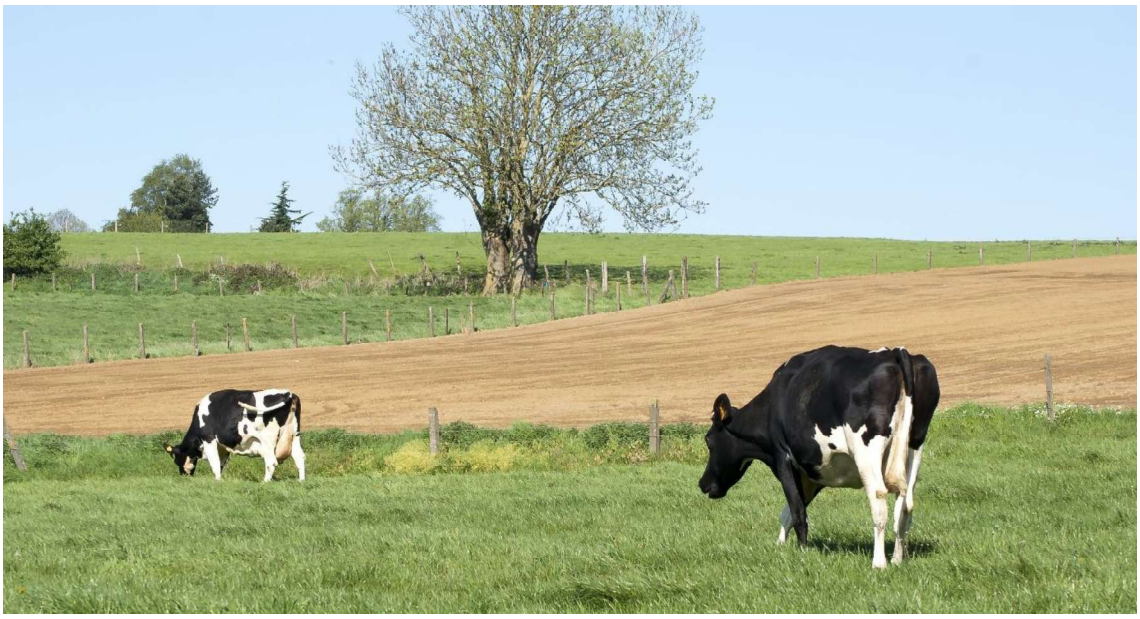
Cross-referencing the case studies reinforces this recommendation. The Den Eelder Farm case shows that even simple mono-digestion systems require a relatively basic, low-maintenance gas-conditioning step (moisture and sulphur reduction) before the gas engine or upgrading unit can run smoothly, while the Tully Biogas Plant demonstrates that biogas treatment, cooling to remove condensate, is a prerequisite before any upgrading route, regardless of which final technology is chosen.

For Co. Tipperary, membrane separation is the most suitable biogas upgrading technology because its characteristics match the county's small-to-mid-scale, slurry-led deployment model. Compared with the other four technologies reviewed in the Feasibility Study, membrane separation is the only one combining low energy consumption, low capital cost, and process simplicity, qualities that matter most for Tipperary's farmer-led and co-operative project structures, which lack large technical operating teams. Pressure Swing Adsorption's multi-step, multi-stream process, chemical scrubbing's steam and solvent-handling requirements, and cryogenic separation's high investment and cooling-energy needs all demand a level of technical and operational complexity that sits poorly with Tipperary's distributed, farm-scale plant model. Membrane separation's main limitations are; a pre-treatment requirement and ~96% purity output, are comparatively minor and manageable at the 20 GWh plant scale the national strategy favours for the county.

This fits directly with Tipperary's feedstock base: as Ireland's second-highest biomass producer, generating over 3 million tonnes of slurry annually across 7,404 farms, the county's feedstock is dominated by slurry supplemented with grass silage, the same composition (60% slurry, 40% silage) the Study uses to size membrane-compatible plants. The Study explicitly identifies membrane separation as the best-fit upgrading route for Tipperary's deployment model, modular and economically scalable to this plant size, with water scrubbing recommended as a secondary technology for larger or wetter slurry-heavy feedstocks within the county.

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ASSESSMENT OF THE LOCAL FEEDSTOCK AVAILABILITY AND SUPPLY CHAINS



A. Potential Resources for Anaerobic Digestion Feedstock

Potential feedstocks for anaerobic digestion aimed at producing biomethane can be sourced from the agricultural sector. This presents an opportunity for farmers to not only supply valuable feedstock but also potentially enhance their profitability. Key agricultural feedstocks for anaerobic digestion include grass silage and animal slurry. Farmers have the options of selling the agricultural waste generated on their farms, providing an additional revenue stream; or getting involved in the biomethane industry as a business partner, giving an opportunity of profit-sharing.

The agricultural waste can be efficiently converted into energy through anaerobic digestion, in which the process will result in the production of undigested matters, which can be further used as fertilizer on the farm. This process reflects a promising circular bioeconomy system, where nutrients are continuously recycled, benefiting both the environment and the financial wellbeing of farmers.

To optimize anaerobic digestion, it is important to use feedstock composed of biodegradable materials. An ideal feedstock encompasses organic matter in both simple and complex structures, including carbohydrates, proteins, and fats. Agricultural waste is particularly valuable as it is predominantly rich in carbohydrates, especially in the form of lignocellulose. This type of feedstock can be effectively sourced

from crops such as hay, silage, straw, and root vegetables, providing an opportunity to utilize materials that might otherwise go to waste.

Moreover, cultivating energy crops specifically for anaerobic digestion can further enhance feedstock availability and efficiency. Examples of these energy crops include grass silage, corn silage, and clover crops, all of which can significantly contribute to the biomethane production process. However, planting energy crops for biogas production is not considered as an environmentally viable way as it is not helping the waste management process. Although implementation can ensure the sustainability of biomethane production, as the green energy industry can secure its feedstock sustainability. Therefore, selecting those types of agricultural waste as feedstock that is more readily available is important to ensure biomethane production sustainability and securing its main goal of reducing organic waste that led to environmental problems. By leveraging these resources, sustainable practices in waste management and energy production can be promoted[41].

In Ireland, Teagasc has focused on developing research to enhance biogas production with a high yield of methane by co-digesting grass silage and cattle slurry. It is because of the challenge with using animal slurry as the sole feedstock is that it has a low energy yield per tonne of material. This issue can be addressed by mixing cattle slurry with silage or crops that have higher energy yields.[42] Furthermore, research at Teagasc Grange is investigating alternative combinations of feedstock in anaerobic digestion, with the overall aim of optimizing biomethane production.

County Tipperary is ideally positioned for biomethane feedstock sourcing due to its robust agricultural sector. Key feedstocks expected from Tipperary include[43]:

- **Manures & Slurries**: Cattle, pig, and poultry slurries are available year-round from livestock farms.
- **Crop Residues and Silage**: Whole crop and grass silage, harvested during peak season, offer seasonal batch feedstock.
- **Agri-Industrial Sludges**: Dairy and vegetable processing by-products.

Furthermore, the in-depth assessment of feedstock availability within County Tipperary is conducted. The study highlights some potential agricultural-based feedstock that is available in County Tipperary and Its nearby regions, as follows:

[41] Sustainable Energy Authority of Ireland (SEAI). 2020. Anaerobic Digestion for On-farm Uses-Overview. Anaerobic-Digestion-Overview-Guide.pdf. Accessed on 10 March 2025.
[42] Teagasc. 2023. Anaerobic digestion: What does it offer farmers?. Environment - Anaerobic digestion: What does it offer farmers? - Teagasc | Agriculture and Food Development Authority. Accessed on 10 March 2025.
[43] Robb, S. 2024. A look under the bonnet of Ireland's future AD plants. Irish Farmers Journal 18 December 2024. Accessed on 16 May 2025.

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1. ANIMAL SLURRY AND MANURE

According to the census of agriculture performed by Teagasc in Tipperary region in 2020[44], farm types in this region are dominated by dairy and beef farms. There are 180,352 dairy cows and 53,232 suckler cows recorded in this census. Compared to the 2010 census, the milk production reported from this region has increased by almost 70% while the suckler cows' number for beef production has dropped from 74,186. From this census, the number of farms recorded was 7,404 with the average agricultural area per farm is 42 Ha and 32% of the farms are less than 20 Ha. Besides dairy cows and suckler cows, the farms in Tipperary region also include 276 sheep producer farms and 260 tillage producer farms. In addition, there is also a small number of pig farms in this region, namely 22 commercial pig producers with an average size of 655 sows.

The massive number of cows recorded in the Tipperary region requires attention as it also means that massive animal manure and slurry are also generated from the farms. It has been reported that agricultural sector contributes for 36% of GHG emissions in Ireland, indicating that a strategy to reduce these negative impacts of massive agricultural practices is important. As reducing the practices is not possible, therefore the reducing GHG emissions as set by the Government of Ireland to be reduced by 22-30% by 2030 can be achieved through some alternative way, such as decarbonising strategy.

According to Attard et al. (2020)[45], Co. Tipperary has been recorded as the 2nd highest biomass producer in Ireland after Co. Cork. More than 3 million tonnes of biomass that were dominated by dairy cattle manure and pig manure from Co. Tipperary have been recorded in this research study. Furthermore, the data was updated and further data of slurry and animal manure in Tipperary has been collected and analysed by InformBio with the latest update recorded in 2024[46]. From the dairy cattle, 61,743 tonnes of slurry are generated annually, while 19,836 tonnes of slurry are generated from suckler cows. In addition to this, slurry from cattle rearing per dry stock for 3 years was also generated up to 93,955 tonnes. There is also slurry from pig farms accounted for 39,296 tonnes, slurry from bulls up to 1,025 tonnes and chicken manure up to 30 tonnes. The amount of animal waste from agricultural practices in Tipperary can be seen in **Figure 7**.

[44] Teagasc. 2021. Regional Review: Teagasc Tipperary Advisory Region. Tipperary-Regional-Review-2021.pdf. Accessed on 07 May 2025.
[45] Attard, J, McMahon H, Doody P, Belfrage J, et al. 2020. Mapping and analysis of biomass supply chains in Andalusia and the Republic of Ireland. *Sustainability MDPI*, 12, 4595.
[46] InformBio. 2024. Integrated Framework for Mapping, Modelling and Monitoring Ireland's Bioeconomy. InformBio Project Outputs - InformBio Project. Accessed on 07 May 2025.

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Figure 7. Animal waste in the form of slurry/manure recorded from Tipperary region

A biomethane plant of 40 GWh requires cattle slurry and grass silage as a feedstock from 130 cattle farms of 50 ha and a livestock unit (LU) of 2.1 LU/ha to meet the feedstock requirements of this AD plant. Therefore, considering the number of cattle farms in Tipperary based on the census data collected in 2020, building 40 GWh biomethane plant in this region is possible. A planning on building a biomethane plant should consider the location, especially related to the feedstock supplier locations. The biomethane plant that can be built near to the feedstock supplier will not only reduce the production cost and transportation cost but also minimize the carbon emission of the whole industry operations.

2. GRASS SILAGE/TILLAGE

There is also 19,692 HA tillage from 837 farms recorded in Tipperary region in 2020 census of agriculture. This tillage production is mainly used to supply feed to the livestock sector as well as producing a range of raw materials for the drinks industry. It is important to note that adding grass silage/tillage to co-digest animal manure/slurry could enhance the methane yield produced. According to Himanshu et al. (2019)[47], 280,038 m3/year biomethane can be generated from co-digesting silage and cattle slurry with the ratio of 0.8:0.20 based on VS basis, while digesting slurry alone could only generate up to 92,814 m3/year biomethane. This report suggests that the higher biomethane yield can be achieved through co-digesting the cattle slurry and grass silage.

The availability of grass silage/tillage in the county of Tipperary along with the availability of cattle slurry is enough to support the co-digestion method of biomethane production planning. However, it is also important to consider that the grass silage/tillage within this county is mainly used to supply animal feed so that the priority of grass silage utilization is still goes to the animal feed, instead of using it for energy

[47] Himansu, H, Murphy, J D, Lenehan, J J, O'Kiely, P. 2019. Impacts of characteristics of grass silage and cattle slurry feedstock on the cost of methane production. Biofuels, Bioproducts & Biorefining, 13: 129-139.

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production. Even so, it is still also possible to use the co-digestion with the ratio recommended by Teagasc,[48] namely 0.4:0.6 for silage and slurry.

Grass silage is abundant in Tipperary's farm landscape, with farmers already producing in the tens of thousands of tonnes annually. Research shows energy extraction from grass silage could supply over 90% of local AD plant seasonal needs, reflecting high feedstock volume[49]. This study also highlights that cattle slurry and grass silage are primary feedstocks for Anaerobic Digestion system in County Tipperary. The county has been identified as the significant potential for rural anaerobic digestion utilizing grass silage and cattle slurry[50]. A life-cycle assessment study in County Tipperary found that the optimal co-digestion of 40% silage with 60% slurry based on weight of volatile solids produced net environmental benefits[51].

3. DAIRY-PROCESSING AND VEGETABLES-PROCESSING RESIDUES

County Tipperary features several dairy processing facilities whose wastewater treatment generates dairy processing sludge (DPS), a rich organic waste with strong potential for biogas production. Nationally, DPS volumes rose by about 39% from 2012 to 2017, reaching roughly 127,000 tonnes wet weight by 2017[52]. While Tipperary would hold a fraction of this total, its vibrant local dairy sector suggests annual sludge contributions in the several thousand tonnes range, sufficient to supplement livestock-based feedstocks.

Other potential additional feedstock for anaerobic digestion in County Tipperary is vegetable-processing waste and sludges. This type of feedstock can be used as the additional or supplemental feedstock to slurry and silage-based feedstock as an effective way of integrating feedstock supports supply flexibility and establishes closed-loop system: digestate returns to farms as biofertilizer, displacing synthetic fertilizer and reducing environmental impacts. Combining DPS or vegetable-processing sludges with slurry boosts biogas outputs and supports balanced digestion processes[53]. The study also found that there is a better consideration to build on-site anaerobic digestion plants at dairy-processing industries,

[48] Beausang, C, McDonnell, K, Murphy, F. 2021. Assessing the environmental sustainability of grass silage and cattle slurry for biogas production. Journal of Cleaner Production, Vol 298, 126838.
[49] Beausang, C, McDonnell, K, Murphy, F. 2021. Assessing the environmental sustainability of grass silage and cattle slurry for biogas production. Journal of Cleaner Production, Vol 298, 126838.
[50] O'Shea, R, Wall, D M, Kilgallon, I, Browne, J D, Murphy, J D. 2017. Assessing the total theoretical, and financially viable, resource of biomethane for injection to a natural gas network in a region. Applied Eneergy, Vol 188: 237-256.
[51] Beausang, C, McDonnell, K, Murphy, F. 2021. Assessing the environmental sustainability of grass silage and cattle slurry for biogas production. Journal of Cleaner Production, Vol 298, 126838.
[52] Teagasc. 2020. What is in dairy processing wastewater sludge (DPS)?. 2020 - What is in dairy processing wastewater sludge (DPS)? - Teagasc | Agriculture and Food Development Authority. Accessed on 25 May 2025.
[53] Rackliffe, J, Ni, JQ, Mosier, N. 2022. Anaerobic Co-digestion of agro-industrial feedstocks to supplement biogas produced from livestock manure. Anaerobic Co-digestion of Agro-industrial Feedstocks to Supplement Biogas Produced from Livestock Manure – Livestock and Poultry Environmental Learning Community. Accessed on 30 May 2025.

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where the DPS can be anaerobically treated to generate biomethane for thermal or power use, reducing reliance on natural gas[54].

B. Supply Chain of Local Feedstock for Anaerobic Digestion in County Tipperary

County Tipperary offers a well-integrated and diverse supply chain potential for anaerobic digestion feedstock, underpinned by its extensive agricultural and agri-industrial base. The supply chain can be grouped into four primary feedstock streams:

1. LIVESTOCK MANURE AND SLURRY

This feedstock stream can be obtained from local dairy farms, beef cattle farms, pig farms, and poultry farms.

- Dairy and cattle slurry is the single largest year-round feedstock stream, given the county's high dairy and beef cattle densities.
- Pig slurry contributes significantly from several large EPA (Environmental Protection Agency)-licensed pig units in South and North Tipperary.
- Poultry manure (broiler and layer) is an increasingly relevant high-energy feedstock that is available in the county.

The supply model for this feedstock stream requires a collection procedure using sealed tankers from local farms on a regular schedule (weekly/biweekly) prior to delivery to central or on-farm AD plants and finally the digestate will be returned to farms as biofertilizer.

2. LIVESTOCK MANURE AND GRASS SILAGE

This feedstock stream can be obtained from livestock farms and industries.

- Livestock manure can be based on cattle or pig, used to balance the nitrogen and solids content in feedstock for anaerobic digestion.
- Grass silage, wholecrop silage, and surplus grass from pastureland are important feedstock rich in carbon content to balance the nutrients in anaerobic digestion.

[54] Pattenden, A, Hehihan, A M, Fitzgibbon, P, Burke, N, Kelly, O, Piterina, A. 2024. Stakeholder Landscape Analysis. Stakeholder Landscape Analysis. Accessed on 30 May 2025.

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The supply model for this feedstock stream requires harvesting time and storage at the farms. Delivery or transportation is needed to the AD facility plants before co-fed into digesters.

3. AGRI-INDUSTRIAL WASTE

This feedstock stream can be obtained from dairy industries, food and beverage manufacturers, and vegetable processors.

- Dairy-processing sludge (DPS), fats/oils/grease, and food waste are high-energy supplementary feedstocks.
- Vegetable-processing residues and rejected products from packhouse contribute additional feedstocks volume.

The supply model for this feedstock stream requires contracts with the industries, pre-processing (if required), transport in sealed tankers to AD facilities, then the residues treated safely and digestate can be returned for land spreading.

C. Deployment Scenarios for Biomethane in Ireland

As Ireland aims to decarbonise its gas system and achieve its climate and renewable energy targets, the National Biomethane Strategy outlines several pathways for the deployment of biomethane production facilities. These scenarios differ in terms of plant size, policy support, infrastructure needs, and overall feasibility. Table 2 illustrates three scenarios: Widespread Deployment (Scenario 1), Current Policies Only (Scenario 2), and Economic Deployment (Scenario 3)[55].

[55] national-biomethane-strategy.pdf. Accessed on 24 June 2025.

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Table 2: Biomethane Deployment Scenarios set out in the National Biomethane Strategy

	Widespread Deployment Scenario 1	Current Policies Only Scenario 2	Economic Deployment Scenario 3
Overview	A strategy encompassing a larger number of smaller-geographically dispersed plants	No further policy intervention outside of any existing policies	A strategy which allows flexibility, encourages a smaller number of larger, more economic community-scale facilities
Scale of plants developed	10 - 20 GWh plants	40 - 60 GWh plants	Broad mix but mainly 40 GWh
Feedstock required	25,000 tonnes	40,000 – 60,000 tonnes	25,000 to 60,000 tonnes
Number of plants built by 2030	c. 250	c. 90	c. 140
Policy enablers	All policy enablers deployed including capital grants	RHO & RTFO	All policy enablers deployed including capital grants
Injection	Truck and trailer for small plants	Direct	Direct connection with small % of truck and trailer
Cost to exchequer	Highest	Lowest	Medium
Target Met	Unlikely	Unlikely	Possible

1. Scenario 1: Widespread Deployment

This scenario outlines a densely distributed network of small-scale plants, each producing between 10 to 20 GWh of biomethane. To meet national biomethane targets by 2030, approximately 250 such plants will be required. Each plant will need around 25,000 tonnes of feedstock annually, primarily consisting of slurry and silage from local farms.

For this scenario to be feasible, all available policy mechanisms should be activated. These include capital grants, the Renewable Heat Obligation (RHO), the Renewable Transport Fuel Obligation (RTFO), and long-term purchase agreements. Without this support, small-scale operations would face significant economic and logistical challenges.

Given their dispersed nature, these plants would largely depend on truck-and-trailer transport, creating virtual pipelines, to deliver compressed biomethane to central injection points. This method would

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increase operational costs and emissions. This scenario would result in the highest public expenditure, due to the large number of facilities and the need for substantial financial support. While the scenario is technically feasible and has the potential to benefit rural economies, it is unlikely to meet national targets unless comprehensive policy deployment is achieved and sustained. Additionally, ensuring economic returns for small producers is crucial.

2. Scenario 2: Current Policies Only

Under this scenario, Ireland maintains its current policy framework without introducing any new incentives beyond the RHO and RTFO. As a result, the market is likely to favour fewer, large-scale plants, each with a capacity of 40 to 60 GWh, with only about 90 plants projected to be operational by 2030. These facilities will require significant volumes of feedstock, between 40,000 to 60,000 tonnes annually, making them more suitable for regions with concentrated agricultural or industrial biomass sources. However, larger plants would typically connect directly to the natural gas grid, thus avoiding the costs and complexities associated with transporting biomethane via road. Since no additional grants or incentives are provided, this approach results in the lowest cost to the state. However, it shifts the financial burden entirely onto the private sector, which may slow down deployment. Without further intervention, this scenario is also unlikely to meet national biomethane targets, as the associated investment risks may deter adequate industry participation.

3. Scenario 3: Economic Deployment

This middle-ground scenario emphasizes economic efficiency and flexible plant sizing, primarily focusing on 40 GWh plants while allowing for a mix of smaller and larger facilities. By 2030, approximately 140 plants are envisioned, striking a balance between geographic distribution, economies of scale, and logistical feasibility. Plants in this scenario would use between 25,000 and 60,000 tonnes of feedstock annually. Most of these plants would be directly connected to the gas grid, although a small percentage would rely on truck-and-trailer systems for remote injection. Similar to Scenario 1, this approach assumes the implementation of comprehensive policy measures, including grants and regulatory support, which would reduce risks and attract investment. The financial impact on the state is moderate, allowing for a more efficient use of public funds while enabling industry participation. Of the three pathways, Economic Deployment is the only scenario deemed likely to meet national targets. It represents the best balance between cost-effectiveness, logistical practicality, and scalability.

In summary, each scenario offers a unique path forward, but the Economic Deployment strategy stands out as the most practical and effective option. It avoids the excessive costs associated with widespread small plants and the stagnation of the market that comes with minimal intervention. Instead, it provides a plan that aligns with Ireland's infrastructure, feedstock resources, and climate commitments.

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If the government can successfully implement the Renewable Heat Obligation, establish strong Gas Purchase Agreements, and continue to provide capital grant schemes, this strategy has the best chance of achieving Ireland's ambitious biomethane goals for 2030.

D. Integration of Local Feedstocks into Sustainable Farm-Scale AD Systems

The integration of sustainable farming practices is a critical enabler for the successful implementation of farm-scale anaerobic digestion (AD) systems within the Irish agricultural context. Ireland's predominantly grass-based livestock sector generates significant quantities of slurry and organic residues, which represent both an environmental challenge and a valuable resource for renewable energy production. Embedding AD within existing farm operations and applying circular farming principles enhances system performance, reduces implementation risk, and improves long-term viability. The proposed approach aligns with national priorities under the Climate Action Plan, the National Biomethane Strategy, and the Nitrates Action Programme.

1. Environmental and Technical Feasibility

From an environmental and technical perspective, sustainable farming practices directly improve the feasibility of farm-scale AD by stabilising feedstock supply, reducing emissions, and enhancing nutrient management. The use of on-farm slurry and grass silage as primary feedstocks ensures consistent availability and minimises transport requirements, while controlled anaerobic digestion captures methane emissions that would otherwise occur during slurry storage. This contributes to measurable reductions in greenhouse gas and ammonia emissions, strengthening environmental compliance and public acceptability.

Digestate management is a central component of sustainability and feasibility. When applied in accordance with nutrient management plans and low-emission spreading techniques, digestate provides a predictable and plant-available nutrient source, improving nitrogen-use efficiency and reducing reliance on synthetic fertilisers. This improves soil structure and organic matter content while reducing risks of nutrient runoff and leaching. These benefits are particularly important in the Irish regulatory environment, where water quality and ammonia emissions represent major compliance challenges for livestock farms.

2. Economic Feasibility and Resource Efficiency

Economically, the integration of sustainable farming practices enhances the feasibility of farm-scale AD by improving resource efficiency and reducing operating costs. The utilisation of farm-derived feedstocks avoids exposure to volatile external feedstock markets and lowers input costs. Digestate use

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reduces expenditure on chemical fertilisers, which are subject to price volatility and import dependency. Energy produced through biogas or biomethane can be used on-farm to offset heat and electricity demand or supplied to local energy networks, contributing to revenue diversification and improved energy security.

The circular nature of the system, where nutrients, energy, and organic matter are recycled within the farm, improves overall economic resilience. While capital investment remains significant, the integration of AD into sustainable farming systems improves cost recovery potential by combining multiple value streams and reducing dependency on a single revenue source. This diversification is particularly important for Irish farms operating under fluctuating commodity prices and increasing environmental compliance costs.

3. Operational Feasibility and Farm Integration

Operational feasibility is strengthened when AD is implemented as an extension of existing farm activities rather than as a standalone industrial process. Sustainable farming practices such as slurry management, nutrient planning, and energy efficiency are already familiar to Irish farmers, reducing the learning curve associated with AD adoption. Integrating digestate application into existing fertiliser schedules and aligning feedstock supply with routine farm operations minimises additional labour requirements and operational disruption.

Farm-scale AD systems designed around sustainable practices are generally smaller, simpler, and more adaptable than centralised facilities, making them better suited to Irish farm structures. This reduces operational risk and improves system reliability, especially in terms of feedstock logistics and maintenance. Demonstration-led approaches further enhance operational feasibility by allowing systems to be optimised under real farm conditions before wider replication.

4. Regulatory and Policy Feasibility

From a regulatory perspective, sustainable farming practices enhance feasibility by aligning AD systems with existing environmental and agricultural policy frameworks. Proper digestate management supports compliance with the Nitrates Directive, while methane capture and renewable gas production contribute to climate mitigation targets. Aligning AD operations with recognised best practice reduces the likelihood of regulatory challenges and planning delays.

However, regulatory clarity remains essential, particularly regarding digestate classification, nutrient limits, and permitting requirements. Demonstration projects play a key role in generating evidence that can inform regulatory development and support the creation of clear, consistent guidance for future farm-scale AD deployment.

5. Social Feasibility and Farmer Acceptance

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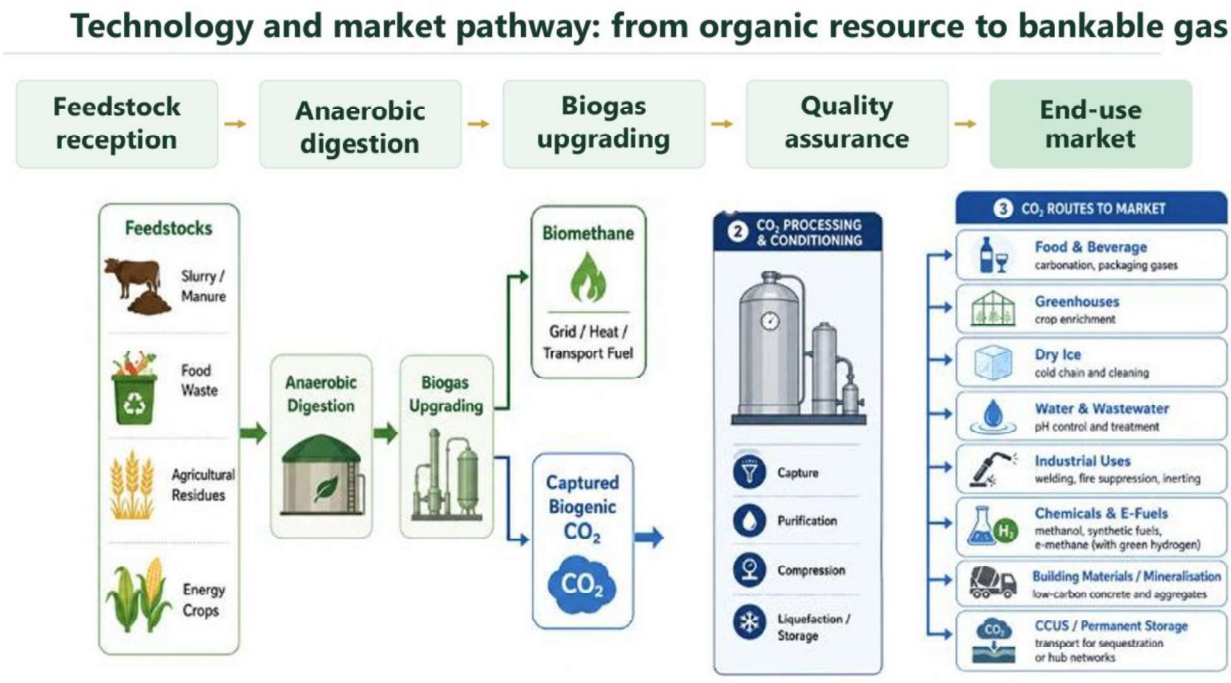
Social feasibility is a decisive factor for farm-scale AD implementation in Ireland. Sustainable farming practices increase farmer acceptance by ensuring that AD systems complement rather than disrupt existing farming models. By delivering tangible benefits, such as reduced fertiliser costs, improved nutrient management, and enhanced environmental performance, AD becomes a practical tool rather than an additional burden.

Community acceptance is also improved when AD systems are clearly linked to environmental protection, renewable energy production, and local economic benefits. Transparent operation, odour management, and traffic minimisation further reduce social risk. Demonstration facilities and knowledge-transfer programmes are critical for building trust, increasing understanding, and supporting informed decision-making among farmers and rural communities.

In conclusion, the integration of sustainable farming practices substantially strengthens the overall feasibility of farm-scale anaerobic digestion in Ireland. By enhancing environmental performance, improving economic resilience, supporting operational integration, facilitating regulatory compliance, and increasing social acceptance, sustainable farming practices reduce risk and improve the likelihood of successful implementation. These findings indicate that farm-scale AD, when embedded within a circular farming framework, represents a viable and scalable pathway for delivering renewable energy, nutrient efficiency, and climate mitigation within the Irish agricultural system.

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ANALYSIS OF POTENTIAL MARKETS FOR BIOMETHANE, INCLUDING GRID INJECTION, TRANSPORT FUEL, AND LOCAL ENERGY USE



As Ireland seeks to achieve its ambitious decarbonization objectives in alignment with EU climate policy, biomethane presents a promising, yet underutilized energy resource that could play a significant role in addressing some of the more challenging sectors to decarbonise. Produced through the anaerobic digestion of organic materials such as agricultural residues, food waste, and manure, biomethane is chemically indistinguishable from fossil natural gas, while also being renewable and climate-neutral when produced sustainably. Its versatility offers opportunities for a variety of applications, including integration into the national gas grid, fuelling heavy goods vehicles, supporting industrial heating processes, and potentially contributing to district heating schemes[56].

Despite its significant potential, the biomethane market in Ireland is still in its early stages and faces structural, financial, and policy-related challenges. Without strong incentives or stable revenue models, biomethane is considerably more expensive than fossil gas, which hampers its widespread adoption. However, there are signs of progress. Recent developments, including the government's National Biomethane Strategy, the planned introduction of a Renewable Heat Obligation (RHO), and the

[56] Biomethane Energy Report. Accessed on 26 June 2025.

expansion of Central Grid Injection (CGI) facilities, indicate a major policy shift aimed at promoting large-scale biomethane production.

Ireland's evolving energy landscape offers an excellent opportunity to explore the multifaceted role of biomethane across various markets. While grid injection emerges as a promising pathway due to its scalability, we also recognize the potential benefits of direct supply agreements with large corporations, as well as its applications in transport and industrial heat. With a focus on long-term sustainability, this study aims to collaboratively assess the commercial and technical viability of these markets, identifying where biomethane can provide the most significant climate and economic benefits in Ireland's clean energy transition.

A. Electric Power & Industrial Heat[57]

Biomethane presents an opportunity for combustion in electricity generation, typically through CHP systems. However, practical economic considerations can sometimes make its use less favourable compared to direct grid injection or applications for heating. While electricity generated from biogas may not be as efficient and faces competition from more affordable renewable electricity sources, utilizing biomethane directly for industrial heating stands out as a valuable option. This is mainly important for hard-to-decarbonise sectors such as food processing, distillation, and manufacturing.

The National Biomethane Strategy highlights this application, recognising that decarbonising industrial heating can deliver significant emissions reductions relative to other uses. In addition, mechanisms, such as Gas Purchase Agreements (GPAs) and Guarantees of Origin (GOs) facilitate access to certified renewable gas. This aspect is particularly attractive to large multinational corporations, such as Google, Meta, and Amazon, that are willing to invest in the "green premium" associated with biomethane as part of their commitment to achieve net-zero targets.

B. Gas Grid Injection for Biomethane[58]

Grid injection is a central component of Ireland's strategy to integrate biomethane into its national energy system. It serves not only as a technical mechanism but also as a vital tool that can transform biomethane from a local, small-scale energy source into a national decarbonisation asset. As Ireland aims to achieve its ambitious renewable energy targets and emissions reduction goals, the development of CGI infrastructure has emerged as a key focus.

A significant milestone is on the horizon. Gas Networks Ireland (GNI) is gearing up to begin construction of its Central Grid Injection facility in Mitchelstown, County Cork. This facility is designed to inject up to 700 GWh of biomethane annually into the national gas network, which is enough to supply energy to tens of thousands of homes or power numerous industrial operations. The Mitchelstown CGI facility is

[57] Biomethane Energy Report. Accessed on 26 June 2025.
[58] Biomethane Energy Report. Accessed on 26 June 2025.

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not only technically important; it also marks a pivotal moment in the government's commitment to facilitating access for biomethane producers, especially those located far from the traditional fossil gas grid.

Geographical limitations present a significant barrier to development. In areas like the Mid-Tipperary Decarbonising Zone, there is no local connection to the gas grid, making the construction of new pipelines prohibitively expensive. For example, the Irish Bioeconomy Foundation's campus in Lisheen is over 23 kilometers from the nearest natural gas grid point in Ballyragget. Extending the gas infrastructure across such distances involves substantial costs, legal challenges, and lengthy planning processes. For many rural developers, accessing the grid is not a straightforward extension; it represents a systemic barrier that threatens the viability of their projects.

To tackle this challenge, Gas Networks Ireland (GNI) requires developers to cover 30% of the capital costs for grid connections. This self-funding requirement, combined with an economic feasibility test, helps filter out underdeveloped or speculative proposals, ensuring that only financially viable and well-planned projects move forward. While this model promotes fiscal responsibility and risk-sharing, it may discourage smaller developers or community-scale projects, particularly in regions with low population density or limited energy demand.

The success story of Cush, County Kildare, demonstrates that connections at the farm or small industrial level are indeed possible. This facility injects biomethane into the low-pressure distribution network, utilizing local compression and control equipment to ensure compliance with grid standards. This case has become a model for similar projects, showing that with careful planning, regulatory support, and an appropriate location, biomethane can be successfully integrated into the grid without requiring significant infrastructure investments.

In Ireland, most biomethane injection is expected to take place through the low-pressure gas distribution network, which services homes and businesses rather than large industrial consumers. For these connections, biomethane must be upgraded to meet strict quality standards, and then compressed and injected using specialized reversion compression units. In contrast, while high-pressure transmission connections are technically feasible, they tend to be expensive and are typically reserved for very large production sites located near the national gas pipeline.

For facilities located more than 10 km from existing gas infrastructure, "virtual pipelines" are emerging as a practical alternative. These systems involve compressing biomethane to about 250 bar and transporting it using high-pressure trailers to a CGI hub, such as the one being developed in Mitchelstown. This approach eliminates the need for expensive pipeline networks while still providing access to national distribution. However, it introduces new complexities, including logistics for the trailers, vehicle routing, safety regulations, and the carbon footprint associated with transporting gas. Despite these challenges, virtual pipelines offer a flexible and scalable solution, particularly for remote farms and rural biogas plants.

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For producers in Tipperary, the Mitchelstown facility is likely to become a central hub. Although it is around 80 km away from some sites, virtual pipelines can effectively bridge this distance if supported by appropriate planning and incentives. This model also enables the aggregation of smaller volumes of biomethane from multiple sources, enhancing the efficiency and commercial attractiveness of the system.

Looking ahead, the expansion of grid injection infrastructure and policies like the Renewable Heat Obligation (RHO) will be crucial. If implemented with clear targets and long-term revenue support mechanisms, the RHO could help address the weak demand currently faced by biomethane due to its price premium over fossil gas. In this context, grid injection is not just a technical feasibility issue; it is a key component of market development.

In conclusion, Ireland's progress in facilitating biomethane grid injection reflects a combination of infrastructure planning, policy innovation, and market anticipation. With the Mitchelstown facility leading the way and virtual pipelines enabling broader participation, a solid foundation is being established for a truly national renewable gas network. However, sustained progress will depend on overcoming regional access barriers, reducing cost burdens, and aligning infrastructure with long-term energy strategy goals. Grid injection is not the end of the pipeline; it is the beginning of a cleaner, decentralised energy future.

C. Transport Fuel: Opportunities & Challenges in Bio-CNG[59]

Biomethane presents a significant opportunity to decarbonize the heavy-duty transport sector in Ireland. This sector is particularly challenging to electrify due to its high energy demands and long-range requirements. Unlike passenger cars, heavy goods vehicles (HGVs) are better suited to gaseous fuels like compressed biomethane (bioCNG) or liquefied biomethane (bioLNG) because they offer faster refuelling times and a higher energy density. In this context, biomethane serves as a low-emissions alternative that can easily replace fossil-derived natural gas without necessitating major changes to vehicle technology or fuelling infrastructure.

A practical example in Ireland is Green Generation's biomethane production facility, which supplies renewable gas to the Junction 14 Mayfield service station. This initiative allows HGVs to refuel with Irish-produced bioCNG, demonstrating the feasibility of localised, circular energy systems. It also highlights the potential for biogas producers to form partnerships with logistics companies and service stations to decarbonise freight transport on key national routes.

Internationally, the UK serves as a compelling proof of concept for sustainable transportation. Retail giant Waitrose, in collaboration with CNG Fuels, has successfully transitioned its delivery fleet to

[59] GIF-Development-Bio-CNG-SE-Ireland.pdf. Accessed on 26 June 2025.

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bioCNG, achieving significant emissions reductions. This model can be scaled to Ireland, particularly with policies like the Renewable Transport Fuel Obligation (RTFO), which currently requires that 25% of transport fuels be renewable, this figure will rise to 49% by 2030.

While the Irish RTFO market is presently dominated by lower-cost biofuels, such as imported hydrotreated vegetable oil (HVO), some of which raise questions about sustainability, the tightening of sustainability standards could create opportunities for domestically produced biomethane to capture more market share. This is especially relevant as the infrastructure for bioCNG expands.

However, there are challenges to this opportunity. The relatively high cost of biomethane production in Ireland, the lack of widespread bioCNG fuelling stations, and limited support through the RTFO system have hindered adoption. To fully unlock this market, dedicated incentives or bioCNG fleet transition programs could be crucial in stimulating investment and achieving scale.

Transport, especially heavy goods vehicles (HGVs), has significant potential for emissions reduction using bio-compressed natural gas (bio-CNG), which can achieve up to 90% carbon savings compared to diesel. Ireland's first dedicated public bio-CNG station opened in North Dublin in April 2024, with additional stations planned at Circle K outlets in Cashel, Limerick, Clonshaugh, and Dublin Port. These locations can support fleets of up to 50 HGVs daily, contributing to meaningful emissions reduction in a sector that comprises just 3% of vehicles but accounts for nearly 20% of transport emissions. However, the RTFO primarily favours cheaper biodiesel and HVO, which diminishes the competitiveness of biomethane. There is, however, increasing scrutiny around fraudulent HVO, which may shift more RTFO demand toward biomethane.

D. Gas Grid Access, District Heating & Local Supply

Biomethane has the potential to enhance district heating systems, which can help decarbonise local heating infrastructure. Although district heating currently accounts for less than 1% of national consumption, the introduction of the Support Scheme for Renewable Heat and the establishment of district heating policy frameworks indicate a growing interest in this area[60]. However, community-scale supply of biomethane is unlikely to succeed without access to the grid due to its high costs. Instead, a more feasible approach is to use trailer-based local delivery, where biomethane is compressed and distributed to industrial clusters or large heat users, especially when nearby injection points are available.

In regions without direct access to the national gas network, such as parts of County Tipperary, including the Lisheen Bioeconomy Campus, localised energy use models present a compelling alternative. Grid injection is often economically unviable because of the distance from pipeline infrastructure. For

[60] seai.ie/sites/default/files/publications/2016_RDD_79._Guide_District_Heating_Irl_-_CODEMA.pdf. Accessed on 26 June 2025.

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example, Lisheen is 23 km away from Ballyragget. This distance increases pipeline construction costs and introduces additional technical challenges, such as the need for compression.

To address this issue, local injection methods utilising trailering and virtual pipelines have emerged as viable solutions. Biomethane can be compressed and transported in high-pressure containers to a nearby CGI facility, like the one being developed in Mitchelstown, County Cork, which is approximately 80 km from Lisheen. This approach maintains access to the national grid and allows participation in markets such as GO schemes and GPAs with energy utilities or industrial customers, albeit with higher transportation costs.

Another option involves local businesses directly using biomethane, which can be procured through off-grid GPAs. High-heat demand industries, such as agri-food and pharmaceuticals, can use bioCNG as a drop-in replacement for fossil gas in their thermal processes. Additionally, while still underdeveloped in Ireland, district heating networks represent a promising long-term application for biomethane, particularly in decarbonising residential and municipal heating in urban areas.

In these scenarios, biomethane can enhance energy autonomy in rural communities, reduce fuel transportation emissions, and align with circular economy principles by sourcing feedstocks locally and recycling nutrients through digestate application. However, achieving these opportunities will require clear policies, infrastructure investment, and support for decentralised energy models.



Figure 3: A note on scale

E. Contracting Instruments: GPAs & GOs

Gas Purchase Agreements (GPAs), typically supported by Guarantees of Origin (GOs), play a crucial role in monetizing biomethane. These contracts enable utilities and large corporations to secure carbon credentials. The increasing focus on corporate sustainability commitments, alongside renewable obligations (such as Renewable Heat Obligations), can further boost the demand for formal GOs.[61]

While biomethane can be used for anything natural gas is used for (industrial or domestic heating, as a transport fuel or for electricity generation), the National Biomethane Strategy indicates that use in heating is preferred based on its value in a hard to decarbonise industry. The market for biomethane is currently weak due to its high-cost relative to natural gas in the absence of any market incentives. A

[61] Irish Energy Sector Update: Ireland's National Biomethane Strategy 2024 | Addleshaw Goddard LLP. Accessed on 26 June 2025.

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RHO[62] has been promised from the Irish government in the National Biomethane Strategy. However, this was expected in quarter 3 of 2024 and details are yet to be announced. At the Biomethane Day Ireland conference 2025 on 25th June 2025, Minister of State at the Department of Climate, Energy and the Environment, Alan Dillon said that the RHO in progress and reinforced the government's commitment to the National Biomethane Strategy. The RHO is expected to create a market for biomethane by requiring gas suppliers to include a minimum share of renewable gas in its supply. This share is expected to increase incrementally in the years up to 2030. Though a RTFO is in place in Ireland, the certificates for this are dominated by cheaper biofuel imports, outcompeting biomethane on price. In some cases, HVO is being imported and fulfilling some of these RTFO certificates, despite a growing acceptance that a portion of this is fraudulently labelled virgin oil. In the case that this portion of the HVO is removed from the market, some biomethane may be able to gain a small share of the market.

To encourage the construction of biomethane production facilities, the Irish government ran a Capital Grants Scheme in 2024, offering grants which could cover up to 20% of the capital costs of biomethane plants built and operational by 31st December 2025. Eighteen projects were successful in this scheme. However, Seán Finan of the Irish Bioenergy Agency reported at the Biomethane Day Ireland conference 2025 on 25th June that only three of the eighteen grants' awardees are proceeding with their biomethane projects.

[62] Renewable Heat Obligation. Accessed on 26 June 2025.

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OVERVIEW OF THE REGULATORY, POLICY, AND INCENTIVE LANDSCAPE IN IRELAND



Ireland is making impressive progress in its renewable gas initiatives through an evolving policy framework. The Climate Action Plan 2023 aims to achieve an ambitious target of producing 5.7 TWh of biomethane annually by 2030, significantly enhancing previous goals[63]. This forward-thinking approach is closely aligned with the EU's REPowerEU plan[64], which encourages member states to accelerate the adoption of renewable gas and reduce their dependence on fossil fuels. This concerted effort not only supports sustainable energy development but also contributes to a greener future for all.

In May 2024, the Irish government revealed its National Biomethane Strategy[65], a forward-looking initiative led by the Department of the Environment, Climate and Communications (DECC) in partnership with the Department of Agriculture, Food and the Marine (DAFM). This comprehensive strategy presents 25 strategic actions designed to enhance sustainability, promote a circular economy, stimulate demand, create enabling frameworks, and drive economic development.

[63] Climate Action Plan. 2023. Climate Action Plan 2023. Accessed on 7 June 2025.
[64] REPowerEU. REPowerEU. Accessed on 7 June 2025.
[65] National Biomethane Strategy. 2024. National Biomethane Strategy. Accessed on 7 June 2025.

A key aspect of this approach is the formation of a Biomethane Implementation Group, which will facilitate smoother processes for planning, permitting, and grid access while ensuring that all activities align with EU environmental directives. Furthermore, the development of a Sustainability Charter will set clear and binding criteria on important issues such as feedstock sourcing, land use, biodiversity, and greenhouse gas emissions. This integrated strategy not only aims to advance the biomethane sector but also strengthens Ireland's commitment to environmental stewardship and sustainable growth.

To promote growth in the industry, the government has introduced an exciting €40 million capital grant scheme[66]. This initiative aims to support the establishment of approximately 10 medium-scale biomethane facilities, each producing around 40 GWh of energy annually, in its initial phase. The Sustainable Energy Authority of Ireland (SEAI) will oversee the administration of this scheme, which is designed to mitigate capital risks for project developers. Backed by the EU's RePowerEU initiative, this funding presents a valuable opportunity and will expand based on the early uptake and the readiness of the sector.

Alongside the capital grants, the upcoming introduction of a Renewable Heat Obligation (RHO)[67] by 2025 offers an exciting opportunity for the renewable energy sector. The RHO will require heat suppliers to blend a designated percentage of renewable heat, particularly from biomethane, into their supply chains. While the rollout has faced delays due to the need for EU State Aid approval, this initiative is hovered to create a sustainable demand for biomethane, benefiting both the commercial and industrial sectors in the long run.

In 2022, the introduction of GOs[68] for renewable gas marked a significant advancement in certification and traceability. Managed by Gas Networks Ireland (GNI), these GOOs empower consumers and businesses to confidently verify the renewable source of their gas. This initiative not only facilitates participation in carbon offsetting but also enhances engagement in the growing green gas purchasing markets.

Ireland's emerging grid infrastructure is actively facilitating biomethane production and injection. Notably, the first injection facility in the country, located in Cush, County Kildare, has been operational since 2020. In addition, the CGI Hub, which is currently under construction in County Cork, will enhance this effort by enabling the injection of up to 700 GWh of biomethane per year into the national gas grid. These hubs play a vital role in fostering access for multiple small to medium-sized producers, allowing them to connect to the gas network without requiring the construction of individual injection pipelines.

[66] Minister McConalogue announces opening of applications for €40 million Biomethane Capital Grant. Accessed on 7 June 2025
[67] Renewable Heat Obligation. Accessed on 7 June 2025
[68] Renewable gas certification. Accessed on 7 June 2025.

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This strategic development supports Ireland's commitment to increasing renewable energy sources and strengthening its energy security[69].

The developing regulatory landscape is being enhanced by proactive environmental safeguards. The upcoming Sustainability Charter, an essential component of the National Strategy, aims to establish robust standards that promote the development of biomethane while ensuring factual climate benefits. This charter will outline criteria focused on lifecycle GHG savings, the protection of soil health, the preservation of biodiversity, and guidelines to manage land-use changes and prevent excessive dependence on specific feedstocks like maize or energy crops[70].

Industry engagement has shown great promise, with Gas Networks Ireland receiving over 170 expressions of interest in biomethane production projects, highlighting significant development potential. To further enhance this progress, stakeholders, including the Irish Bioenergy Association (IrBEA) and the Renewable Gas Forum Ireland (RGFI), suggest focusing on long-term clarity regarding RHO design, streamlining permits, establishing clear regulations for digestate use, and ensuring consistent grant funding[71]. These steps could help reduce risks associated with early-stage projects and support the growth of the biomethane sector.

A. Regulatory Framework and Policy Environment

The regulatory framework and policy environment related to biomethane development in Ireland will include this following policy:

1. Renewable Heat Obligation
2. Capital Grants
3. National Biomethane Strategy
4. Policy Enablers and Grid Integration
5. Licensing required for AD Plants
6. Planning Permission
7. Grid Connection and Energy Regulatory approvals
8. Water and Discharge Licensing
9. Health and Safety Compliance

[69] Renewable gas (biomethane). Accessed on 7 June 2025.
[70] Climate Change Policy – Tuesday, 29 Apr 2025 – Parliamentary Questions (34th Dáil) – Houses of the Oireachtas. Accessed on 7 June 2025.
[71] Irish Energy Sector Update: Ireland's National Biomethane Strategy 2024 | Addleshaw Goddard LLP. Accessed on 10 June 2025.

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10. Feedstocks and Digestate management plans

B. Renewable heat obligations (RHO) – Launch expected in 2027

The upcoming RHO[72], expected to be officially launched in 2025. It presents a compelling opportunity to advance Ireland's decarbonization strategy, especially within the heating sector. This initiative will require suppliers of fossil-based heating fuels, such as, natural gas, LPG, and heating oil, to ensure a designated percentage of the heat they provide comes from renewable sources, including biomethane. This legislation is set to create a long-term market demand for renewable heat, providing vital support for hard-to-decarbonize sectors like commercial and industrial heating. By adopting this change, Ireland can make significant strides toward a more sustainable energy future.

The RHO is important because it provides market certainty for biomethane producers and AD project developers. The RHO creates a stable, policy-supported pathway for the offtake of biomethane, which addresses one of the most critical challenges in the sector: securing long-term purchase agreements and ensuring revenue visibility. By directing fossil heat suppliers to incorporate renewable gas into their supply chains, the RHO guarantees a growing market for biomethane produced from AD plants. This reduces dependence on unstable short-term energy contracts.

For investors and financial institutions, the RHO significantly enhances the attractiveness of biomethane projects. With clear policy support and predictable revenue streams from obligated buyers, investing in AD infrastructure becomes more appealing. This could lead to increased capital flows into rural energy projects and help scale up biomethane production across Ireland, especially in high-potential agricultural areas like County Tipperary.

Successful implementation of the RHO will require careful design. The government must ensure that the mechanism is transparent, enforceable, and provides fair pricing signals to producers. The anticipated introduction of tradable RHO certificates, awarded for each unit of renewable heat supplied, will be essential for allowing compliance flexibility and creating liquidity in the renewable heat market. Besides, establishing clear rules regarding eligibility, sustainability criteria, and administrative processes will be crucial for building stakeholder confidence.

Ireland's Renewable Heat Obligation is intended to require suppliers of fossil fuels used for heating to demonstrate that a proportion of their energy supply comes from renewable sources. The General Scheme proposes opening obligation rates of 1.5% in year one and 3% in year two, with later rates to be reviewed as the market develops. The National Oil Reserves Agency (NORA) has been designated as

[72] Renewable Heat Obligation. Accessed on 7 June 2025

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scheme administrator, while primary legislation and detailed operating rules remain under development.

A proposed incentive would have awarded an additional 0.5 certificate for each unit of biomethane produced in Ireland, allowing one domestic unit to count as 1.5 units for compliance. Following notification under the EU Technical Regulations Information System, the European Commission issued a Detailed Opinion in March 2026 indicating that the domestic-only multiplier was incompatible with EU internal-market rules in its proposed form. The measure therefore cannot be relied upon as an approved support mechanism.

In summary, the RHO is set to be a foundational policy for Ireland's biomethane industry. It will encourage investment, support the development of new projects, and align the decarbonization of the heat sector with goals for agricultural and rural development. For producers, developers, and entrepreneurs, the launch of the RHO in 2025 could signify the start of a stable and scalable renewable heat economy.

C. Planning Permission from Local Authority

Securing planning permission from the local authority is a crucial and time-sensitive step in the successful development of a biomethane production facility in Ireland[73]. The planning process plays an important role in shaping all key components of the site, such as the AD plant, feedstock reception and storage areas, biogas storage tanks, flare systems, and digestate storage or processing units. It is important to provide detailed descriptions of each element in the planning application, along with supporting technical drawings, environmental controls, and comprehensive site layout plans. This well-prepared approach not only helps streamline the approval process but also demonstrates a commitment to responsible and effective facility development.

A key component of the application process is the Environmental Impact Assessment (EIA) screening. This screening evaluates whether a full EIA report is necessary, taking into account the project's scale, location, and the sensitivity of the site. Even if a full EIA is not required, a comprehensive EIA screening report must still be submitted. This report should detail the project's potential effects on water quality, air quality, biodiversity, landscape, and human health.[74]

[73] Irish Farmer Association. Microsoft Word - Response to Draft Biomethane Strategy submission. Accessed on 10 June 2025.
[74] Environmental Impact Assessment (Agriculture) Regulations. Accessed on 10 June 2025

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Public engagement is required through public consultation, allowing local stakeholders—such as residents, landowners, and community groups—to review the proposed project and share their feedback or objections. It is highly recommended to maintain transparency and engage with the local community early on in the process to foster support and address any potential concerns during this phase.

In addition to addressing environmental concerns, the planning submission must also include technical assessments on:

- **Traffic Impact:** A traffic study is required to evaluate the volume and frequency of vehicle movements associated with feedstock delivery, digestate removal, and staff operations. This study will ensure that the existing road infrastructure can support the project without negatively impacting road safety or causing congestion.
- **Odour Management:** An odour impact assessment must be conducted to assess the potential emissions from feedstock storage and digestate handling. This assessment will include modelling prevailing wind directions and determining distances to sensitive receptors, such as homes, schools, and public buildings.
- **Visual Impact:** A visual impact study is important to understand how the proposed facility will blend into the surrounding landscape. This study will include photomontages and simulations of the site as seen from nearby roads, residences, and scenic viewpoints, as well as proposed landscaping or screening measures to mitigate visual effects.

Depending on the local authority, such as Tipperary County Council, you may need to provide additional documentation. This can include surface water management plans, noise assessments, and site-specific flood risk analyses. It is advisable to have early pre-application meetings with the planning department to clarify requirements and streamline the process.

The planning permission stage is not just a regulatory requirement; it is also a crucial milestone for showcasing environmental responsibility, aligning with community needs, and ensuring technical readiness. Effectively navigating this process can greatly impact the timeline, costs, and overall success of a biomethane project.

D. Grid Connection & Energy Regulatory Approvals

Developing a biomethane facility in Ireland involves not just building anaerobic digestion (AD) infrastructure but also managing the grid connection and regulatory approval processes necessary for injecting biomethane into the national gas grid. Two key institutions are involved in this process: Gas Networks Ireland (GNI) and the Commission for Regulation of Utilities (CRU). Both organizations play

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important roles in ensuring that biomethane production meets national energy standards, safety protocols, and market regulations.

(a) Gas Networks Ireland (GNI) – Grid Connection Requirements

To inject biomethane into the national gas grid, a connection application must be submitted to GNI[75]. GNI is responsible for the operation and maintenance of Ireland's gas transmission and distribution networks. The connection process includes several assessments related to technical specifications, safety, and contractual obligations, ensuring that the injected gas complies with strict national and EU standards.

Key requirements include:

- Gas Quality Testing: Biomethane must meet specifications for methane content, calorific value, water content, and contaminant levels. GNI conducts thorough sampling and laboratory verification to ensure compliance with I.S. EN 16723 gas quality standards.
- Odourisation Systems: Since raw biomethane does not have the distinctive smell of natural gas, GNI mandates the installation of odourisation units that inject trace odorants, such as tetrahydrothiophene, to comply with safety detection protocols.
- Pressurization and Grid Injection Systems: Biomethane needs to be compressed to the appropriate pressure levels suitable for the target grid entry point. This process usually requires the installation of booster compressors, buffer tanks, and metering systems to manage the flow, ensure traceability, and facilitate integration with the SCADA monitoring system.
- Injection Agreements: Once technical approval is granted, GNI formalizes biomethane injection agreements with the producer. These agreements cover grid access terms, volume limits, maintenance responsibilities, and emergency shutoff protocols.

The connection process may take between 12 and 24 months and could require Environmental Impact Assessment (EIA) screening and planning permission for grid injection infrastructure, depending on the location and scale.

(b) Commission for Regulation of Utilities (CRU) – Market Oversight and Incentives

The CRU is Ireland's independent energy regulator, responsible for overseeing the operation, fairness, and sustainability of the energy and gas markets[76]. For developers of biomethane, the CRU acts as a key authority that governs:

- The CRU is responsible for approving network tariffs and connection fees, which significantly impact the financial viability of biomethane-to-grid projects.

[75] Gas Network Ireland. Renewable gas (biomethane). Accessed on 10 June 2025.
[76] Commission for Regulation of Utilities. what we do | CRU.ie. Accessed on 11 June 2025.

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- Biomethane producers must adhere to the regulations set by the CRU regarding energy supply licensing, gas balancing rules, and network codes. Depending on their business model, they may need to obtain either a Natural Gas Licence exemption or a simplified registration to participate in the market.
- The CRU offers guidance on support schemes, including the upcoming Renewable Heat Obligation (RHO). This initiative will encourage the use of renewable gases by requiring fossil fuel heat suppliers to blend a specific percentage of renewable gas, such as biomethane, into their offerings.

The CRU is set to play a crucial role in establishing rules and monitoring compliance once the RHO is implemented, ensuring transparency, sustainability, and accountability among producers, suppliers, and consumers.

To successfully connect a biomethane facility to Ireland's gas grid, coordinated efforts with Gas Networks Ireland are critical for technical integration, while working with the Commission for Regulation of Utilities is necessary for market participation and regulatory compliance. This process involves multiple layers, including gas quality testing, odorization, price approvals, and injection contracts. These steps are required for the commercial delivery of renewable gas to the Irish energy system.

E. Health & Safety Authority (HSA) Compliance

The safe operation of anaerobic digestion (AD) plants in Ireland is subject to strict regulatory oversight from the HSA. All facilities that handle large amounts of biogas must comply with both national and European safety legislation. This includes key regulations such as the Control of Major Accident Hazards (COMAH) Regulations, the ATEX (Atmosphères Explosibles) directives, and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)[77].

A. Control of Major Accident Hazards (COMAH)

Under Irish law, AD plants that store or process large volumes of biogas or related materials may be subject to the COMAH Regulations, which are designed to implement the EU Seveso III Directive[78]. These regulations aim to prevent major industrial accidents and mitigate their impact on people and the environment.

[77] SEAI. Anaerobic Digestion - Operations and Maintenance Guide.pdf. Accessed on 13 June 2025.
[78] https://www.hse.ie/eng/services/list/5/publichealth/publichealthdepts/env/comah-seveso.pdf. Accessed on 13 June 2025.

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Operators must evaluate their site's capacity against COMAH thresholds for hazardous substances, specifically methane, ammonia, and pressurized gases. If any thresholds are surpassed, developers are obligated to:

- Prepare a Major Accident Prevention Policy (MAPP),
- Submit a Safety Report to the HSA, and
- Develop detailed emergency response plans in coordination with local fire and rescue services.

It is advisable to engage early with the HSA during the design phase to assess whether a plant qualifies as a lower-tier or upper-tier COMAH site.

B. Hazardous Zones and Flare Stack Design

Biogas production, storage, and upgrading involve hazardous zones where explosive atmospheres can develop due to methane leaks or gas handling activities. It is important to classify and map these zones according to the ATEX Directives. In Ireland, these directives are enforced under the Safety, Health and Welfare at Work (General Application) Regulations 2007[79].

- Flare Stack Design must account for safe gas combustion, minimum separation distances, wind loading, and maintenance access.
- Flare systems should be fail-safe, include automatic ignition, and meet EPA emission limits if operated regularly.
- Zone 0, Zone 1, and Zone 2 hazardous area classifications must be applied, influencing equipment selection, ventilation design, and cable routing.

All electrical and mechanical systems installed within these zones must be ATEX-certified, and periodic inspections are mandated to verify compliance.

C. Pressure Vessels and Safety Measures – DSEAR Compliance

The DSEAR Regulations, which have been incorporated into Irish law, supplement ATEX by requiring operators to identify and manage risks associated with flammable gases, vapours, and pressure systems. In AD plants, this includes:

- Gas-tight digesters and pressurised biomethane vessels,
- Emergency venting systems and overpressure protection,
- Gas detection systems and automatic shutdown protocols

[79] Guidelines for Anaerobic Report 2018.indd. Accessed on 14 June 2025.

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Operators are required to conduct risk assessments, create explosion protection documents, and train staff in emergency procedures. Moreover, regular inspection and maintenance of pressure vessels are mandated under the Pressure Systems Safety Regulations (PSSR).

Compliance with HSA regulations is crucial for AD plants in Ireland. Whether a facility falls under the COMAH regulations due to gas volumes or is guided by ATEX and DSEAR due to hazardous area risks, project developers must integrate safety engineering from the earliest stages of design. Failing to do so can lead to significant project delays, enforcement actions, or operational shutdowns.

By proactively addressing HSA compliance, biomethane facilities can ensure safe, legal, and sustainable operations in the long term while protecting workers, the community, and the environment.

F. Feedstock & Digestate Management Rules

The use of agricultural, food, and animal-derived feedstocks in AD projects is strictly regulated by a combination of EU and Irish laws designed to protect soil, water, and public health. Moreover, the management of digestate, the nutrient-rich by-product of the AD process, must adhere to environmental and agricultural best practices to ensure sustainable use and compliance with legal standards[80].

1. Nitrates Directive & Good Agricultural Practice (GAP) Regulations

All feedstock applications and digestate spreading activities must adhere to the EU Nitrates Directive (91/676/EEC), which has been incorporated into Irish law through the Good Agricultural Practice (GAP) Regulations[81]. These regulations aim to safeguard water bodies from nutrient pollution, specifically nitrate leaching and phosphorus runoff. Operators and landowners are required to prepare and implement a Nutrient Management Plan (NMP), which includes:

- Soil sampling across all receiving lands (minimum every 4 years),
- Mapping of land parcels, slopes, distances to watercourses, and buffer zones,
- Nutrient budgets to match digestate application rates with crop needs,
- Prohibited spreading periods and setback distances (e.g., no spreading near wells, rivers, or on waterlogged land).

[80] Gas Network Ireland. biomethane-sustainability-report-2021.pdf. Accessed on 14 June 2025.
[81] Nitrates Directive. Accessed on 14 June 2025.

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Digestate should be applied only in accordance with the nutrient limits established by the Department of Agriculture, Food and the Marine (DAFM), ensuring that it replaces chemical fertilizers rather than adding to them.

2. Animal By-Products (ABP) Regulations

When using animal manure, slurry, food waste, or slaughterhouse residues as feedstock, the facility must comply with the EU Animal By-Products Regulation (EC) No. 1069/2009 and its implementing regulation (EU) No. 142/2011[82]. These regulations apply to both the transportation and treatment of animal by-product (ABP) materials.

Key requirements include:

- Registration and approval by DAFM as an ABP processing facility,
- Installation of dedicated hygienisation systems, particularly for Category 2 and Category 3 materials (e.g., catering waste, certain manures, and abattoir waste),
- Strict traceability and record-keeping for feedstock reception and digestion,
- Separate storage and handling systems to avoid cross-contamination.

High-risk ABP inputs should not be co-digested with non-ABP materials unless full hygienisation is achieved, generally at 70°C for 1 hour or via an equivalent validated process.

3. Digestate: End-of-Waste Criteria and Land Use

In order for digestate to be legally used on land without being classified as waste, it must meet End-of-Waste (EoW) criteria. While Ireland has not yet established a formal EoW position for digestate, guidance is developing based on principles from the EPA and examples from other EU Member States.

If digestate is classified as waste, it will be subject to waste licensing and permitting regulations. Applying digestate to land may require a waste facility permit or an EPA license, depending on the volume and treatment of the digestate[83].

To achieve End-of-Waste status, digestate must meet specific criteria, including:

- Derived from approved feedstocks (e.g., crops, slurries, food waste),
- Processed in a way that ensures safety and environmental protection,
- Of consistent quality and suitable for use as a fertiliser or soil conditioner,
- Distributed and used in a defined market, replacing virgin inputs.

[82] Animal By-products - Legislation. Accessed on 15 June 2025.
[83] https://www.epa.ie/publications/research/waste/Research_Report_375.pdf. Accessed on 15 June 2025.

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The National Standards Authority of Ireland (NSAI) plans to create a quality assurance framework for digestate, aiming to support End-of-Waste applications in the future.

Successful anaerobic digestion projects in Ireland must adhere to a complex framework of environmental and agricultural regulations that govern both feedstock acceptance and the use of digestate. Compliance with the Nitrates Directive, ABP Regulations, and End-of-Waste protocols ensures that the facility operates legally, safely, and sustainably. Effective management of feedstock inputs and nutrient outputs not only protects the environment but also supports the circular economy goals that are central to biomethane development.

Requirement	Farm-Scale AD (≤10kt/year)	Medium AD (10–100kt)	Large/Commercial AD (>100kt)
Planning Permission	Yes	Yes	Yes
Waste Permit/COR	More than likely	No	No
EPA Licence	No	Maybe	Yes
ABP Approval	Yes	Maybe	Yes
Grid Connection	Maybe	Maybe	Maybe
Water Discharge Licence	Maybe	Maybe	Yes
CRU Engagement	No	Maybe	Yes
HSA/COMAH	No	Maybe	Yes

Table No. 2 Regulatory and licencing requirements for anaerobic digestion plants in Ireland

4. ReNure Directive in the Irish Context

A further regulatory development with direct relevance to digestate value is the EU's proposed RENURE framework (Recovered Nitrogen from Manure), which would allow processed manure-based nutrient products meeting defined quality criteria to be classified separately from raw livestock manure under the Nitrates Directive, potentially easing nitrogen-loading restrictions on their use. For Irish biomethane developers, ReNure recognition could materially increase the commercial value of digestate by opening it to markets and application limits currently unavailable to unprocessed manure, while also strengthening farm-level nutrient-use efficiency and reducing reliance on imported synthetic fertiliser. However, Ireland has not yet finalised national end-of-waste or biofertilizer classification criteria for digestate, and the Nitrates Action Programme (NAP) has yet to be amended to incorporate ReNure-

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aligned provisions. In the interim, digestate continues to be regulated as waste once placed on the market, unless an individual EPA end-of-waste determination is secured on a case-by-case basis. This regulatory gap is more than a compliance issue: it is a commercial constraint, since the absence of defined processing routes and classification pathways for digestate weakens revenue certainty for biomethane developers and reduces project bankability for investors and financers. Progress is expected through coordinated input from the EPA, which has signalled support for statutory standards research, and the NSAI, which is positioned to develop the national quality assurance framework needed to operationalise these routes. Until this clarity is achieved, Co. Tipperary developers should treat RENURE-derived revenue as a future upside rather than a bankable assumption at current stages planning.

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ENVIRONMENTAL ASSESSMENT, FOCUSING ON EMISSIONS REDUCTION



A. Environmental Assessment and Emissions Reduction

1. Greenhouse Gas Emissions Mitigation through Methane Capture

The production of biomethane through AD significantly reduces greenhouse gas (GHG) emissions, particularly methane (CH_4). Methane has a global warming potential (GWP) that is 28 times greater than that of carbon dioxide (CO_2) over a 100-year period. In Ireland, agriculture is the leading source of GHG emissions, accounting for about 39% of the country's total emissions. Among these, livestock-related emissions, such as those from manure management and enteric fermentation, constitute the largest portion[84].

By diverting animal slurry and food or agricultural waste into sealed anaerobic digesters, methane that would otherwise escape into the atmosphere from open slurry tanks or landfills is captured and converted into energy. This process not only displaces the use of fossil fuels but also helps to prevent the uncontrolled release of methane.

A study conducted in 2022 by the Sustainable Energy Authority of Ireland (SEAI) found that biomethane produced from grass silage and slurry can achieve GHG emission savings of 70–90% over its life cycle. The extent of these savings varies based on the methods used for upgrading and distribution. These

[84] Teagasc. Environment - Reduction in agriculture emissions in 2023 - Teagasc | Agriculture and Food Development Authority. Accessed on 18 June 2025.

reductions are primarily due to the prevention of methane leaks, the decreased nitrous oxide emissions resulting from the land application of untreated slurry, and the replacement of fossil-derived natural gas[85].

2. Lifecycle Assessment and CO_2e Offset

Lifecycle Assessment (LCA) models used in both EU and Irish contexts indicate that biomethane systems can achieve net-negative emissions under specific configurations. For example, if the digestate (the by-product after digestion) is properly managed and utilized as a biofertilizer, it can help avoid emissions associated with the production and application of synthetic fertilizers. A report funded by the EPA, titled Research 431: Advanced Gaseous Biofuels (AGB), suggests that by integrating biomethane production with biochar production and power-to-gas technologies, Ireland could potentially offset 2.6 million tons of CO_2 equivalent (CO_2e) each year. This amount corresponds to approximately 6.5% of Ireland's total greenhouse gas emissions in 2021[86].

Moreover, when biomethane is injected into the gas grid or used as bio-CNG for transportation, it can effectively replace fossil fuels like diesel and natural gas. This substitution can lead to carbon intensity reductions of up to 95%, particularly in challenging sectors that are hard to decarbonise, such as heavy goods transport and industry.

3. Role in National and EU Climate Targets

The development of biomethane is vital for Ireland to meet its legally binding carbon budgets, as outlined in the Climate Action and Low Carbon Development Act (2021), as well as the EU targets established under the Effort Sharing Regulation (ESR)[87]. The Government's Climate Action Plan 2024 sets a target of producing 5.7 terawatt-hours (TWh) of biomethane by 2030, primarily aimed at decarbonizing the heating and industrial sectors. Achieving this target would result in a reduction of approximately 1.5 million tonnes of CO_2 equivalent (CO_2e) per year, according to Gas Networks Ireland (2023).

Moreover, the European Commission's REPowerEU plan, created in response to the energy crisis, establishes a wider target of producing 35 billion cubic meters (bcm) of biomethane by 2030. This plan highlights the strategic importance of biomethane in reducing EU gas imports and lowering emissions.

[85] https://www.gasnetworks.ie/sites/default/files/biomethane-sustainability-report-2021.pdf. Accessed on 18 June 2025.
[86] Research 431: Production of Advanced Gaseous Biomethane Transport Fuel in an Integrated Circular Bioenergy System | Environmental Protection Agency. Accessed on 18 June 2025.
[87] EPA-GHG-Projections-2022-2040_Finalv2.pdf. Accessed on 18 June 2025.

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Ireland's portion of this production will not only enhance national energy security but also help fulfil climate commitments.

4. Managing Fugitive Emissions and Leakage

AD plants have significant potential for reducing emissions, but their environmental effectiveness relies heavily on managing fugitive methane emissions during various processes, including feedstock handling, digestion, upgrading, and injection. If methane leakage exceeds 1–2% of the total methane output, the overall climate benefits can be greatly diminished[88]. Therefore, implementing best practices is critical. These include leak detection and repair (LDAR) programs, gas-tight feedstock systems, pressure relief valves, and enclosed digestate storage.

The UK's Environment Agency and the Irish Environmental Protection Agency (EPA) have emphasized the importance of stringent monitoring and reporting of fugitive emissions. Technologies such as infrared gas imaging (OGI), fixed gas monitors, and drone surveys for quantification are increasingly being utilized. Also, Irish policy under the emerging Renewable Heat Obligation (RHO) is expected to incorporate reporting standards for emissions performance as part of sustainability certification.

5. Co-benefits of Emission Reduction in a Circular Framework

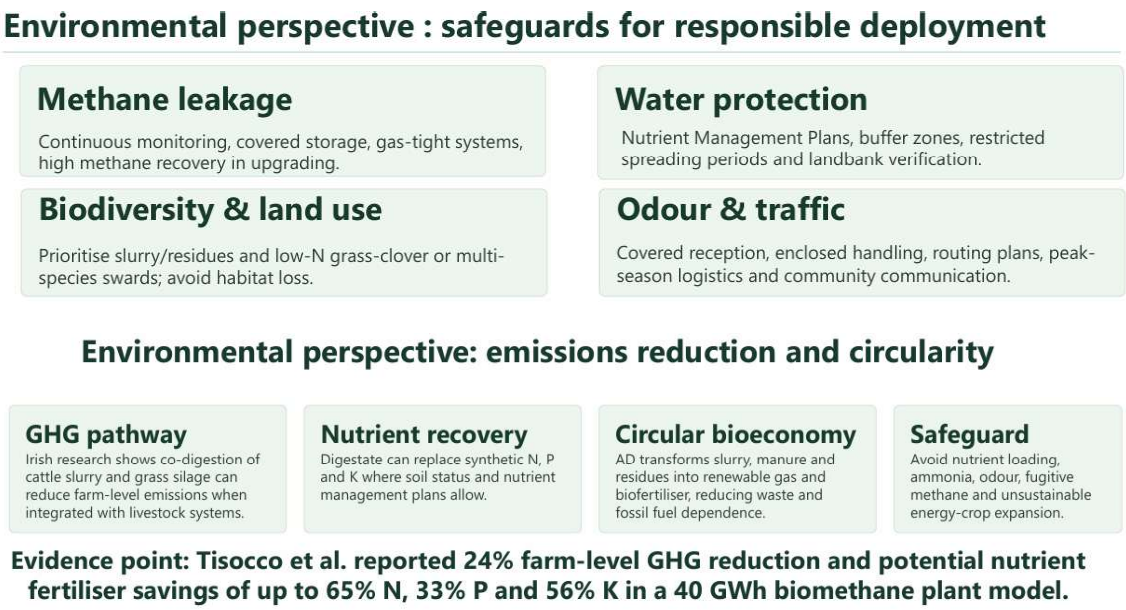
The environmental benefits of biomethane extend beyond just climate metrics. The use of digestate can replace synthetic fertilizers, which in turn reduces the energy-intensive production of nitrogen and the consequent emissions of nitrous oxide. In addition, diverting organic waste from landfills helps to minimise issues related to leachate and methane emissions. According to SEAI (2023), an integrated biomethane system, especially one that combines food waste, slurry, and crop residues, provides multiple environmental advantages. These include a reduction in air pollutants like ammonia, better odour control, and improved water quality.[89]

Biomethane presents Ireland with a powerful and scalable solution for reducing greenhouse gas (GHG) emissions in the agriculture, energy, and waste sectors. When developed using best-practice operational standards and integrated with nutrient and waste reuse, biomethane systems can become net climate-positive infrastructures. This approach aligns national development goals with the European Union's decarbonisation objectives. To maximize the environmental benefits of this transition to renewable gas, it is essential to continue incorporating life cycle assessment (LCA) planning, emissions monitoring, and policy alignment, such as renewable heat obligations (RHO) and grid injection incentives.

[88] Methane Emissions make Gas dirtier than Coal. Accessed on 18 June 2025.
[89] Gas Network Ireland. https://www.gasnetworks.ie/sites/default/files/docs/business/renewable-gas/GIF-Development-Bio-CNG-SE-Ireland.pdf. Accessed on 18 June 2025.

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B. Benefits related to Circular Economy

1. Digestate as Circular Biofertiliser

One of the most significant contributions of biomethane to the circular economy is its ability to return nutrients to the soil through the production and application of digestate. Digestate is the organic by-product of anaerobic digestion and is rich in nitrogen (N), phosphorus (P), and potassium (K), essential elements for plant growth. Compared to raw manure, digestate offers improved nutrient availability (especially ammonium nitrogen) and has fewer pathogens, making it more effective and safer for land application[90].

In Ireland, where the use of synthetic fertilizers contributes to greenhouse gas emissions, soil acidification, and water pollution, digestate serves as a renewable, locally sourced alternative. Its application directly supports compliance with the EU Nitrates Directive and the Good Agricultural Practice (GAP) Regulations, particularly in Nitrate Vulnerable Zones (NVZs). Additionally, by replacing synthetic fertilizers, biomethane systems reduce the energy and fossil fuel inputs required to produce ammonia-based products, further enhancing climate performance and resource efficiency[91].

2. Waste Valorisation and Resource Recovery

[90] https://www.seai.ie/sites/default/files/renewable-energy/bioenergy/biogas-boilers/Anaerobic-Digestion-Overview-Guide.pdf. Accessed on 19 June 2025.
[91] https://www.seai.ie/sites/default/files/renewable-energy/bioenergy/biogas-boilers/Anaerobic-Digestion-Overview-Guide.pdf. Accessed on 19 June 2025.

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Biomethane development plays a vital role in supporting the circular economy by converting waste into valuable resources. Key feedstocks such as animal manure, grass silage, food waste, and industrial by-products (for example, those from dairies and slaughterhouses) are repurposed as renewable energy sources instead of being treated as liabilities. This approach helps reduce landfill usage, lower methane emissions from unmanaged decomposition, and alleviate the pressure on waste management systems.

In Ireland, over 1 million tonnes of food waste is generated annually, with a significant portion being biodegradable and suitable for AD[92]. Instead of resorting to incineration or landfilling, channelling this waste into biomethane production allows for the recovery of both energy and nutrients. By doing so, this sector contributes to the European Union's circular economy objectives outlined in the Circular Economy Action Plan, which aims to promote resource recovery and minimize waste across various sectors.

3. Supporting Local Agricultural Circularity

Biomethane projects naturally connect local farming systems, energy consumers, and nutrient cycles. Feedstocks like slurry and silage are sourced from farms within a 10–20 km radius of the AD plant. The resulting digestate is then returned to these farms or neighbouring lands. This approach minimises transportation emissions and creates a closed-loop nutrient cycle. Additionally, it allows farmers to diversify their income streams through feedstock contracts and services related to digestate management[93].

In County Tipperary and other similar agricultural regions where intensive livestock farming is common, biomethane fosters a decentralized and mutually beneficial relationship between energy production and sustainable land management. Furthermore, facilities that utilize local cooperatives or community energy ownership models enhance economic resilience and promote rural regeneration, which are key principles of circular economy design.

4. Industrial Symbiosis and Biorefinery Models

Advanced biomethane projects in Europe are increasingly adopting the concept of industrial symbiosis. This approach involves integrating bioenergy facilities with waste producers, carbon dioxide (CO_2) users, and heat consumers in configurations similar to biorefineries. In Ireland, this model could be effectively replicated by locating biomethane plants near food processors, dairies, or municipal treatment facilities. The CO_2 captured during the process of upgrading biogas could be reused in horticulture, food preservation, or the production of green methanol[94].

This integration not only enhances circularity among various industries but also generates economic efficiencies and reduces the environmental impact across multiple sectors simultaneously. Such systems

[92] A study of consumer behaviour towards food-waste in Ireland: Attitudes, quantities and global warming potentials - ScienceDirect. Accessed on 19 June 2025.
[93] Biomethane: A sustainable industry of scale – Energy Ireland. Accessed on 19 June 2025.
[94] Microsoft PowerPoint - 821 - Ringsend Report - B (21-06-22). Accessed on 19 June 2025.

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are already being tested in Germany, Denmark, and the Netherlands, providing a potential pathway for Ireland to advance circular innovation as part of the energy transition.

Co. Tipperary is already moving from this conceptual model toward practical demonstration. The National Biorefinery Pilot Plant (NBPP), located within the National Bioeconomy Campus at the former Lisheen mine site, Thurles, hosts a suite of technologies designed to advance Irish bio-innovations from Technology Readiness Level (TRL) 4 to TRL 7, using regional feedstocks including dairy residues, forestry side-streams, and organic waste. Developed through the BioScaleUp project and co-funded by the Government of Ireland and the European Union under the EU Just Transition Fund Programme 2021–2027, the NBPP is delivered in partnership with BiOrbic Research Ireland Centre for Bioeconomy, linking academic institutions, industry, and farmer co-operatives to translate research into market-ready solutions. As a working scale-up facility rather than a conceptual proposal, the NBPP gives Co. Tipperary direct, de-risking access to technology trialling that most other Irish regions currently lack.

This pilot capacity builds on technical groundwork already proven by Teagasc-led research. Biorefinery Glas, a 2018–2021 European Innovation Partnership project coordinated by Teagasc, demonstrated the technical feasibility of green biorefining under Irish farming conditions, using a mobile screw-press system to fractionate freshly harvested grass into a protein-rich juice and a fibrous press-cake on-farm. A subsequent Teagasc life-cycle assessment of co-digesting this grass press-cake with cattle slurry reported greenhouse gas savings of approximately 94% relative to the RED III fossil natural gas comparator, comfortably exceeding the 80% threshold required from 2026, while farm-gate nutrient audits from the same pilot showed a 40% improvement in nitrogen-use efficiency compared to conventional grass-silage systems. Together, the NBPP and Teagasc's research pipeline give the Mid-Tipperary Decarbonising Zone a credible, evidence-based route from pilot demonstration to commercial-scale industrial symbiosis and biorefinery deployment.

5. Reducing Dependency on Linear Inputs

Biomethane plays an important role in reducing reliance on imported fossil fuels, chemical fertilizers, and centralized power sources by converting residual and waste materials into renewable gas. This shift from a linear "take-make-dispose" model to a regenerative system aligns with Ireland's National Bioeconomy Action Plan and the Circular Bioeconomy objectives outlined in the European Green Deal.

By decarbonising heat, power, and transport while enhancing soil health and utilizing waste, biomethane serves as a key tool in developing a low-carbon, circular bioeconomy.

The development of biomethane in Ireland offers a significant opportunity to implement the principles of the circular economy by regenerating natural systems, maintaining resource use, and minimizing waste and pollution. By capturing energy from agricultural residues, food waste, and other biodegradable materials, biomethane production not only reduces greenhouse gas emissions but also generates value from waste that would otherwise harm the environment.

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At the core of biomethane production is the AD process, which supports closed-loop nutrient recycling. This process produces organic biofertiliser (known as digestate) that can replace synthetic fertilisers, promoting more sustainable and resilient agricultural practices. Furthermore, integrating biomethane with local supply chains encourages regional industrial symbiosis and reinforces Ireland's objectives related to rural development, energy security, and climate action.

Biomethane plays a vital role in supporting several EU and Irish policy frameworks, including the Circular Economy Action Plan, the Climate Action Plan 2024, and the National Bioeconomy Strategy. It integrates waste management, renewable energy, and sustainable farming into a single regenerative system.

As Ireland aims to achieve its 2030 climate targets and decarbonize hard-to-abate sectors, biomethane not only provides a technical solution but also offers a comprehensive circular pathway towards a low-carbon and resource-efficient future.

SOCIAL ACCEPTANCE AND COMMUNITY TRUST CONCERNING BIOMETHANE DEVELOPMENTS

The persistent cause of the Irish government, via CAP (Climate Action Plan) 2030 concerning biomethane developments has been the 5.7 TWh of indigenous biomethane generation. This goal will be realised if Planning permissions and their implementers understand that primary source of rejection of planning permissions is due to a lack of social licence to operate (SLO). SLO gauge public perception, acceptance, social aspects of biomethane project that involve local communities, rural enterprises, and custodians of the land. For Co. Tipperary, an agricultural and feedstock potent region, delineating this social aspect will set the cadence of shape and size of a Just Transition for the county and its inhabitants.

A. Perspectives of Primary producers and processors

The direction of farmers, primary producers and processors in the biomethane context can be currently linked to being feedstock contractors, and not energy producers themselves. The risk is imminent until cooperative or community ownership models are considered as the norm. Previous project RuralBioUp, demonstrated that the bottom-up, co-adaptive approaches are the most advantageous in terms of facilitating primary producer engagement.

Land use competition is another aspect that demands critical analysis considering the utility of purpose grown cover crops, slurry, organic waste over dedicated energy-crops. Current regulatory tension here is based on the EU Renewable Energy Directive III (RED III) sustainability criteria for biomethane restrict the use of land converted from high-carbon stock land, but enforcement at the county level is much

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ambiguous. Co. Tipperary biomethane feasibility planning must order a feedstock sustainability hierarchy from the outset.

Digestate as a nutrient-rich by-product could help reduce the dependency on imported synthetic nitrogen given fertiliser prices volatility. However, the uncertainty over digestate consistency, pathogen safety, planning constraints in storage and spreading and lack of certified Irish quality frameworks similar to the UKs PAS 110 standard. Clarity with respect to the implementation of the proposed EU Fertilising Products Regulation (FPR) for digestate market development in Ireland must be elucidated to fully understand how such a decision impacts the viability of biomethane projects in Co. Tipperary.

Tipperary lies within a dense agri-food processing landscape populated with dairy co-ops, meat and mushroom processors, each generating organic side-streams with significant biomethane potential. The social dimension of processor engagement must be sufficiently uncovered. Key questions concerning ownership and operations of biomethane plants, value distribution and financial incentivization for primary producers must be clearly outlined. Co-op models are deeply embedded into the Tipperary's agricultural landscape and must be aligned with on-going co-op led biomethane plants such as Carbery group and Drinagh Co-op, West Cork to fully understand the critical control points for successful implementation.

Finally, generational renewal can also play a role in the implementation of biomethane plants in Co. Tipperary. Long-term feedstock supply contracts can be critical points of tension between succeeding partners, difference in risk appetite and environmental consciousness may nudge younger farmers to divest from such long-term contracts or fall short on agreeing to contract terms.

B. Social Acceptance and Trust in Local Communities

The social licence to operate (SLO) in the Irish context, widely used in the industrial contexts currently being applied to renewable energy industries. This SLO allows ongoing acceptance by local communities of largeoscale biomethane projects presence, operations and impacts. The three levels of SLO in Co. Tipperary are: acceptance (passive tolerance) allowing projects to operate and function within the local space, approval (active support) facilitating the smooth operation and function of the plants in the local space, and psychological identification (community ownership and pride) with the biomethane plant as a source of community pride and ownership. Irish policy in this context has only focused on regulatory licencing and financial support with insufficient investment in much needed social licence dimension. Nevertheless, previous reports converge on a similar narrative that trust and social acceptance lead to reduced planning risk, faster consents, which in turn improve the bankability and investment potential of the projects. This ultimately leads the ability to hit national biomethane targets. This has been viably

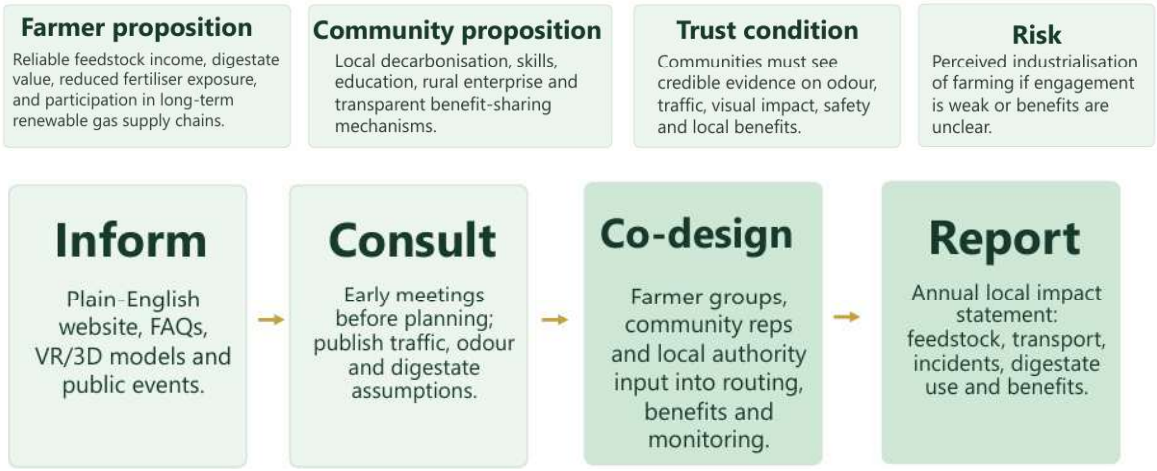
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demonstrated in two case studies of the Tully and Den Edler Farm, where social impact mitigation led to no problems in acceptance reported.

Proximity impacts (odour, noise, traffic near site) are another critical control point that impact feasibility. The main point of contention for Co. Tipperary is that while most of the impacts are viewed through high appeal rates against planning permissions. These friction points are mostly mitigable and procedural in nature. Early and robust community trust building actions and rigorous evidence at site-selection stage can be a suitable prescription for managing this critical control point.

Misinformation and lack of clear messaging is another line of risk identified by previous reports. The novelty of biomethane and limited public understanding create a vacuum that misinformation or inconsistent messaging can fill, with real feasibility consequences (delay, opposition, contested planning outcomes). The consistent prescription is transparent, sustained and locally delivered communication following via a national messaging body (County level communications hub) coupled with local trusted agents (Liaison Officers), small format engagements and farmer centric framing are key.



C. Biomethane facilitating a Just Transition

The Tipperary Decarbonizing Zone sits entirely within EU Just Transition Fun (JTF) Territory, a status that directly ties into the region history of job losses following the closure of industrial peat extraction and mining operations. The National Bioeconomy Campus at Lisheen is explicitly positioned as a 'flagship example of just transition in practise'. The BCC project is directly funded by the JTF, indicating that the outcomes such as planning guidance, engagement infrastructure and efficient reports are a direct output of just-transition financing. On jobs, the evidence sits at three levels of certainty; national-scale modelling using European Biogas Association multiplier projects 1800 direct and 4400 indirect jobs against 5.7 TWh 2030 target (this is a scenario-based estimate and not a precise forecast), with a parallel

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skills pipeline (Bioeconomy Action Plan Pillar 7) built to address an anticipated technician and operator shortfall against 6000+ job target. Sector-specific confirmed evidence from the Tully Biogas case study shows 12 full-time operational roles, up to 50 workers during peak construction and indirect support sustaining over 100 local poultry farms. In unison, the Just transition jobs direction is credible and explicitly links biomethane deployment to economic renewal in regions disadvantaged by prior energy transitions. However, scales of benefit is uncertain and based on continued public funding and skills investment.

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EVALUATION OF FINANCIAL VIABILITY, INVESTMENT REQUIREMENTS, AND ASSOCIATED RISK-FACTORS



The financial viability of biomethane production in Ireland is a complex issue influenced by the capital-intensive nature of anaerobic digestion (AD) infrastructure and the changing policy environment. Studies carried out in recent years indicated that the upfront capital expenditure (CAPEX) for mid-sized AD facilities, especially those that include biogas upgrading systems for biomethane injection, could range from €5 million to €12 million. This cost varied based on factors such as feedstock type, plant capacity, and the presence of additional systems like grid injection points, digestate management, and odour control[95]. However, these figures no longer appear realistic. Ongoing commercial biomethane plant developments in Ireland are tending towards 40-100 GWh per annum in scale and with capital investment cost estimates of 0.35-1.00 million € per GWh, depending on proposed feedstocks (among other factors). Biomethane plants which will process waste feedstocks such as municipal and garden waste tend to involve larger scale facilities and larger CAPEX, justifying this investment as they can generate revenue via a gate fee for the feedstocks they take in.

[95] RGFI-Regatrace_Final-Ireland-Roadmap-20-April-2022-1.pdf. Accessed on 20 June 2025.

Operational expenditure (OPEX), which is often related to the costs of feedstock transport, labour, maintenance, and energy use, can cumulatively cause financial strain without wise management. This is especially true when the feedstock is sourced externally rather than being produced internally through integrated farm-based models[96].

Revenue generation continues to be a significant challenge for investors, primarily due to the lack of a guaranteed biomethane tariff and long-term Power Purchase Agreements (PPAs). Currently, revenue streams largely depend on the market sales of biomethane, gate fees for waste processing, and the sale or reuse of digestate. However, as highlighted in reports by the Sustainable Energy Authority of Ireland (SEAI) in 2021, these markets are still in the early stages of development.



The long-awaited Renewable Heat Obligation (RHO), previously expected to be implemented in 2025, is viewed as a potential game-changer, though it was set back due to the failed inclusion of a 50% multiplier for certificates awarded to Irish-produced renewable heating fuels. The solution to promoting indigenous biomethane production over imports so that the industry can develop here remains unclear. This obligation will require fossil heating fuel suppliers to include renewable heating fuel including, but not limited to biomethane in their offerings, which will create a more stable, predictable and gradually increasing demand (market pull). This shift is likely to enhance the bankability of new AD projects, according to the Department of the Environment, Climate and Communications (2024)[97].

Biomethane development in Ireland has great potential but faces significant investment challenges. A 2023 policy paper by the European Biogas Association (EBA) highlights that financing issues primarily arise from uncertainties regarding returns, a lack of structured incentives, and the limited history of successful large-scale biomethane projects in the country. In contrast, countries like France, Germany, and Denmark have mitigated investment risks by implementing guaranteed feed-in tariffs, providing upfront capital grants, and offering producer subsidies[98]. Unfortunately, Ireland has not yet adopted similar mechanisms, leaving investors and developers vulnerable to price volatility and demand insecurity.

Feedstock security is a recurring risk factor highlighted in the literature. Studies emphasize that access to consistent and affordable feedstocks, such as grass silage, animal slurry, and food waste, is essential for operational viability[99]. Competition for agricultural feedstocks, along with the need for logistics planning, increases cost pressures and contributes to the project's risk profile. In addition, handling

[96] Least cost energy system pathways towards 100% renewable energy in Ireland by 2050 - ScienceDirect. Accessed on 20 June 2025.
[97] Renewable Heat. Accessed on 20 June 2025.
[98] 1st EBA Biomethane Investment Outlook | European Biogas Association. Accessed on 20 June 2025.
[99] BioenergySupplyCurvesForIreland2010-2030.pdf. Accessed on 20 June 2025.

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digestate and complying with nitrate regulations, as outlined in the Nitrates Directive and the ABP Regulation, introduce regulatory complexities that must be considered in financial planning[100].

Other identified risk factors include delays in permitting and planning, which often necessitate detailed Environmental Impact Assessments (EIAs), public consultation processes, and studies on visual and traffic impacts. These requirements can lead to project hold-ups that last several years. In addition, technical risks, such as methane slip, failures in biogas upgrading, and inadequate valorisation of digestate—contribute to operational uncertainty, as highlighted in analyses conducted across Europe[101].

To address these issues, academic and policy literature suggest that Ireland implement a range of de-risking measures. These measures include blended finance models, the establishment of a national biomethane certification system that aligns with the sustainability criteria set out in RED II, and the development of aggregated or cooperative project models that facilitate shared feedstock and infrastructure[102]. In addition, co-location strategies with agri-food industries and regional waste processors can help reduce transport costs and enhance the reliability of feedstock.

Ireland's abundant resources of suitable biomethane feedstocks such as surplus grass silage and cattle slurry make biomethane generation quite attractive. However, Ireland's relatively small farm size and herd sizes add to the logistical input for feedstock collection and for digestate distribution. Furthermore, the use of mixed animal slurries and/or manures from multiple farms in the AD process will require digestate to be pasteurised before it may be returned for land spreading on farms. This will accrue significant additional CAPEX and OPEX at biomethane plants. Ireland's highly successful beef and dairy system typically involve cattle being outside for approximately half the year and spending the wetter winter months housed indoors. As a result, cattle slurry can only be practically collected for the winter months and securing summer supplies of cattle slurry is challenging. Though some technologies for preserving the methane content in cattle slurry are maturing, this seasonal supply variability is problematic for biomethane plants, relative to the year-round cattle housing systems and large farms more commonly found in Denmark, for example.

In summary, biomethane offers a promising solution for decarbonizing Ireland's gas grid and promoting circular economy principles. However, its financial viability depends on supportive policies, secure supply chains for feedstock, and the reduction of market, regulatory, and technical uncertainties. The expected launch of the RHO and related policy instruments will be crucial for attracting private capital and scaling up Ireland's biomethane sector.

[100] EPA_National_Waste_Stats_Summary_Report_2020.pdf. Accessed on 20 June 2025
[101] Biogas: Developments and perspectives in Europe - ScienceDirect. Accessed on 20 June 2025.
[102] IEA_T37_CountryReportSummary_2021_rev.pdf. Accessed on 20 June 2025.

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A. Capital and Operation Costs for long-term Feedstock supply

The use of sensors, machine learning and automated control and dosing systems in anaerobic digestors will help to maintain consistent and optimised biogas yields, prevent problems and will reduce staffing requirements at biomethane plants.

B. Financial Supports for Biomethane in Ireland

In 2024 and 2025, Ireland's Department of Agriculture, Food and the Marine, delivered a €40 million capital grants scheme for agri-led biomethane plants, in which up to €5 million or 20% of the project costs could be granted to successful projects, provided they were complete by 31st of December 2025. At the time of writing, the details of a similar subsequent capital grants scheme expected to provide €200 million in grant funding in the years up to 2030 are being finalised. This time, the funding is the responsibility of the Department of Climate, Energy and Environment.

The RHO is expected to create demand for biomethane among heating fuel suppliers and is due to come into effect later in 2026. The initial obligation rate for renewable heating fuels is expected to be 1.5% in 2026 (year 1), 3% in year 2 and 15% by 2030.

C. Offtake agreements for biomethane

Despite that the RHO has not yet been finalised, some offtake agreements for biomethane have been agreed between biomethane plant developers and companies.

D. Investment Risks and de-risking Installation of Biomethane plants, Feedstock competition between organic practises

Achieving secure, long-term feedstock agreements remains a leading risk for biomethane plant developers. Delays to policy supports have hindered certainty and biomethane demand growth. Achieving planning permission for biomethane plants can be challenging due to detailed requirements and at times due to community opposition related to poor community engagement and the nascence of the industry in Ireland. A fear of competition for feedstocks elevated feed and food costs as a result

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remain common. It must be ensured that biomethane feedstock supply does not compete with feed or food production. Grass silage derived from and cattle slurry have long been proposed to be the dominant feedstock sources used in Ireland's biomethane industry. Studies have indicated that additional silage can be produced from marginal and under-used land in Ireland to produce the extra supply without adverse impacts on competition for resources.

Recommended investment sequence

1. Resource proof → 2. Farmer LOIs → 3. Site/options → 4. Grid enquiry → 5. Pre-FEED → 6. Consent strategy → 7. Offtake heads of terms → 8. Financial model → 9. Planning → 10. Financial close

COUNTY TIPPERARY: A CREDIBLE REGION FOR BIOMETHANE

County Tipperary presents a coherent and well-evidenced case for biomethane development, supported by converging strengths across feedstock supply, technology readiness, policy alignment, and institutional capacity, alongside identifiable risks that are manageable rather than disqualifying. This conclusion draws on the full body of evidence assembled across this study and the wider BCC project research base, including the Biomethane and Bioeconomy Synergies Report, the Towards a Low-Carbon Future in the Tipperary DZ report, the Biomethane Planning, Permitting and Policy Guidelines, and the IEA Bioenergy case studies on small and mono-digestion AD systems.

The county's agricultural base is the foundation of this case. As Ireland's second-highest biomass producer after Co. Cork, Tipperary generates over 3 million tonnes of livestock manure and slurry annually, drawn from 180,352 dairy cows, 53,232 suckler cows, and supporting pig and poultry operations across 7,404 farms. This is complemented by 19,692 hectares of tillage and substantial grass silage production, enabling the co-digestion ratios (40% silage to 60% slurry) that research shows deliver optimal methane yield and net environmental benefit. A single 40 GWh biomethane plant is achievable from the feedstock base of roughly 130 local cattle farms, meaning the county can support multiple installations without exhausting supply, particularly once dairy-processing sludge and vegetable-processing residues are layered in as supplementary feedstock.

On technology, membrane separation emerges as the best-fit upgrading route for Tipperary's deployment model. It is modular, lower in complexity, and economically scalable to the 20 GWh plant size that matches the national strategy's preference for distributed, slurry-led facilities rather than a handful of mega-plants. International case studies, including the Den Eelder Farm in the Netherlands and the Tully Biogas Plant in Northern Ireland, confirm that gas-conditioning and treatment steps of this kind are well-proven at comparable scale, though these remain international comparators rather than Tipperary-specific evidence.

Institutionally, Tipperary holds an advantage few other counties can match. The National Bioeconomy Campus at Lisheen, anchored by the Biomethane Development Office, the National Biorefinery Pilot

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Plant, and Teagasc-proven biorefinery research showing up to 94% lifecycle GHG savings, gives the county a working de-risking and demonstration pathway, not just a theoretical one. The Synergies Report confirms this campus is already functioning as a convening hub linking DAFM, SEAI, EPA, Enterprise Ireland, and the Just Transition Fund, with the wider Thurles-Lisheen corridor designated a Decarbonising Zone committed to a 50% local emissions reduction by 2030. This is reinforced by an enabling planning framework: Tipperary County Development Plan Policies RE4 and RE5 explicitly support both farm-scale anaerobic digestion and mixed biomass processing, positioning the county ahead of many local authorities in regulatory readiness.

The market and policy environment, while still maturing nationally, is moving in Tipperary's favour, and recent regulatory developments materially strengthen this case beyond what earlier sections of this report capture. The Mitchelstown Central Grid Injection hub, virtual pipeline solutions for grid-distant sites such as Lisheen, and the anticipated Renewable Heat Obligation together offer multiple routes to market despite the county's distance from existing gas infrastructure. This is now reinforced by Reverse Grid Compression, approved by the CRU in early 2026, which can unlock up to 437 GWh of additional distribution-network injection capacity nationally, directly easing the grid-access constraint identified for sites like Lisheen. RED III's transposition into Irish law in August 2025 also now guarantees a statutory two-year planning permission timeline (one year in renewables acceleration areas), giving developers greater certainty than previously available. National capital support is similarly set to continue, with a second Biomethane Capital Grant Scheme expected from 2026 under the Sectoral Capital Plan, allocating up to €200 million in further funding.

Socially, the picture is more nuanced but increasingly well-evidenced. Tipperary's Just Transition Fund designation, the legacy of the Lisheen mine closure, and modelled projections of up to 1,800 direct and 4,400 indirect national jobs against the 2030 target build a strong rationale for community buy-in, with the Tully case study confirming comparable plants can sustain 12 full-time roles and over 100 supplying farms in practice. However, the report is candid that farmer engagement currently sits closer to feedstock supply than co-ownership, that planning risk linked to social licence remains real, and the sector's national appeal rate of approximately 44%, against a 7-10% average across all development types, confirms that contested planning outcomes are a defining feature developers must plan for, even though refusals are driven mainly by information gaps rather than opposition to biomethane itself.

Taken together, the evidence across feedstock, technology, infrastructure, policy, and institutional support is substantially stronger and more specific to Tipperary than to most other candidate regions in Ireland. The principal remaining risks are not feasibility risks but execution risks: securing long-term feedstock contracts, building social licence proactively, preparing planning applications to the standard the data demands, and timing investment to national policy delivery. On the balance of evidence presented across this study and its supporting research base, County Tipperary stands as one of Ireland's most credible regions for sustained biomethane industry development.

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