GreenGasCert
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Certification of Renewable Gas in Ireland

Final Project Report for WPs 1-3

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GreenGasCert Project

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Acronyms

Acronym	Meaning
AD	Anaerobic digestion
CO_2	Carbon Dioxide
DAFM	Department of Food, Agriculture & the Marine
DBFZ	Deutsches Biomasseforschungszentrum
DCCAE	Department of Communications, Climate Action & the Environment
DENA	Deutsche Energieagentur
EPA	Environmental Protection Agency
EU	European Union
EU-ETS	EU Emissions Trading Scheme
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNI	Gas Networks Ireland
GO	Guarantee of Origin
IERC	International Energy Research Centre
ILUC	Indirect land use change
LCA	Lifecycle Analysis
MaREI	Centre for Marine and Renewable Energy
MEP	Member of the European Parliament
Mt	Megatonnes
MWh	Megawatt hour
NSAI	National Standards Authority of Ireland
RED	EU Renewable Energy Directive
REFIT	Renewable Energy Feed-in Tariff
RES	Renewables or renewable energy
RESS	Renewable Energy Support Scheme
RES-E	Renewables in electricity (final energy consumption)
RES-H	Renewables in heat
RES-T	Renewables in transport
RGFI	Renewable Gas Forum of Ireland
RSER	Renewable and Sustainable Energy Reviews scientific journal
SEAI	Sustainable Energy Authority of Ireland
SHARES	Short Assessment of Renewable Energy Sources
SSRH	Support Scheme for Renewable Heat
UCC	University College Cork
WRI	World Resources Institute

Glossary

	Green gas	Green gas or renewable gas is defined within the scope of this project as gas which is either produced from anaerobic digestion of organic material (biogas) and upgraded to natural gas quality (biomethane that derives from a Power to Gas plant which uses a renewable energy source to produce Hydrogen.
PoO	Proof of Origin	A proof of Origin provides information about the origin of a specific amount of energy.
	Proof of Quality	A proof of Quality provides information about the properties of a specific amount of energy.
	Proof of Quantity	A proof of Quantity provides information about the quantity coming from a specific energy source.
GoO	Guarantee of origin	"Guarantee of origin' means an electronic document which has the sole function of providing proof to a final customer that a given share or quantity of energy was produced from renewable sources." (RED definition)
	Mass balance	Mass balancing is required in the RED (and RED II) for biofuels in order to change market actors' behavior and to enable a higher price for these fuels. It achieves a link between a physical consignment and its biogenic properties. The mass balancing method is applied to the whole trading chain. It can be found in different implementations in this document.
CHP	Combined heat and power plant	A power plant able also to use the produced lost heat in order to increase overall efficiency.
EF	Emission factor	The emission factor defines the amount of pollutant which is emitted by a certain process.
EU RED	EU Renewable Energy Directive	A European law which promotes the use of renewable energy in the European Union. See also https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive
LHV	Lower heating value	When subtracting the ->higher heating value from the heat of vaporization, one obtains the lower heating value.

HHV	Higher heating value	The Higher heating value is determined by bringing all the products of combustion back to the original pre-combustion temperature
	Registry statement	(also: Proof of cancellation) The registry statement is created when the final use of green gas is decided and the consumption of the green gas has to be approved.
	Sustainability Certificate	The sustainability certificate contains all relevant information regarding -> GHG emissions for a specific amount of biomethane.
	Registry certificate	The registry certificate represents the tradeable specific amount of green gas in the registry.
	Certification system/scheme	Certification schemes are based on a normative framework, e.g. a standard or a set of criteria and indicators. The most important characteristic of a certification scheme, as it is understood in this context, is that it includes a third party verification of the sustainability criteria, stipulated in the system documents. Also the whole certification process is usually based on accreditation standards (e.g. ISO 19011 or ISO 17065), in which the separation of evaluation and certification is to mention as important feature. As a result of the certification process, a label on a product shows compliance with the respective certification scheme. Certificate holders mostly participate voluntarily in a certification scheme. However, there are industries, in which only a certificate enables market access, which is for instance the case with liquid biofuels within the European Union.
	Certification company	In the context of this report, a certification company represents an independent entity which is responsible for the verification of the sustainability requirements and criteria of the certification system.

1 Introduction

Ireland strives to meet its targets in regard to the Renewable Energies Directive also by reducing greenhouse gas (GHG) emissions. Green gas, when replacing fossil fuels, can contribute to this overall goal. Furthermore, green gas can be used, equivalent to natural gas, as transportation fuel and for producing heat and electricity. Production and use of green gases can be stimulated by the European Union Emissions Trading System (EU ETS), the Biofuels Obligation scheme (BOS), or possible support schemes. Both, in the EU (via the Renewable Energies Directive, RED, and the RED II proposal) and in Ireland (in the future via support schemes and nowadays via the BOS) sustainability standards apply.

Sustainable production and utilisation of bio-based products and resources has become an important precondition for their overall acceptance and competitiveness with other renewable or fossil resources. One major aspect for renewable gases regarding sustainability is the overall GHG emission savings potential, which has to be as high as possible in order to decrease GHG emissions in the most effective way. Over the recent years several stakeholder or policy driven initiatives have been involved in the development of sustainability criteria, sustainability certification schemes and infrastructures to foster the trade of sustainable bio-based or renewable products. On European level, the EC has developed a set of mandatory sustainability criteria for the use of bioenergy as a transportation fuel. Furthermore, the expansion of these criteria to other sectors of biomass and bioenergy utilisation (e.g. heat and power) is envisaged in the recently published proposal for a new renewable energy directive (RED II).

In order to ensure both the fulfilment of the mandatory criteria on European level as well as stakeholder involvement to include country specific criteria on a national level, the GreenGasCert project developed a sustainability certification scheme proposal and a registry blueprint for green gas produced and/or used in Ireland.

The potential for biogas (which will probably be the first green gas market to emerge) in Ireland has been assessed to be between 5.3 and 35 PJ per year (SEAI 2017). This corresponds to 3% and 22% of the gas consumption in Ireland in 2015.

It is the aim of this project to develop a green gas certification scheme specifically for Ireland to support a growing renewable gas market and help Ireland achieve their carbon and heating targets for 2020.

Although the certification scheme and the registry are generally designed to be open to all kind of green gases, a special focus was set in this project on biomethane as a green gas.

What is green gas?

Green gas or renewable gas is defined within the scope of this project as gas, which is either produced from anaerobic digestion of organic material (biogas) and is upgraded to natural gas quality (biomethane) or that derives from a Power to Gas plant which uses a renewable energy source to produce Hydrogen.

1.1 Project description

The key objectives of this project were:

- The development of a robust methodology (that considers different feedstock/ processes and potentially end uses) for calculating and accounting for GHG emissions savings from renewable gas and to ensure its compatibility with international best practice and EU legislation.
- The determination of the relevant specifications required to independently quantify and certify the carbon savings associated with using renewable gas by having a traceable and auditable guarantee of origin and validation of greenhouse gas savings.
- The description of the structure for an accreditation / certifying body that will adopt and implement robust methodologies for registering and certifying renewable gas producers and the carbon credits
- The development of a green gas registry blueprint which can promote the development of a robust and reliable green gas market in Ireland

During the project, members strove for stakeholder engagement and the dissemination and communication of the project results to policy maker, industry and the wider community via workshops and face to face discussions.

To this end the project started with a workshop introducing the main ideas to a group of relevant stakeholders, amongst those energy academics, industry professionals and policy makers. Feedback from this workshop was used as a backdrop for the first draft of both sustainability certification scheme and registry blueprint. Towards the end of the project another workshop was held to present these drafts to a group of stakeholders. This time, stakeholder feedback was used to finalize the developed proposals.

1.2 Project team

The GreenGasCert project is collaboration between academia and industry, utilizing state of the art methodologies developed by European expertise and applied into the Irish context. Project partners are Deutsches Biomasseforschungszentrum (DBFZ), Deutsche Energie-Agentur GmbH (dena) - German Energy Agency and MaREI Centre.

dena is Germany’s centre of expertise for energy efficiency, renewable energy sources and intelligent energy systems. As the "Agency for the Applied Energy Transition" dena contributes to the attainment of energy and climate policy objectives.

DBFZ is looking for methods that facilitate an effective and sustained use of solid, liquid and gaseous bioenergy sources. To achieve this, DBFZ scientists are carrying out potential analyses, feasibility studies and practical tests in the laboratories of our research centre.

MaREI is the marine and renewable energy research and development Centre supported by Science Foundation Ireland. It combines the expertise of a wide range of research groups and industry partners, with the shared mission of solving the main scientific, technical and socio-economic challenges across the marine and renewable energy sectors.

1.3 Report outline

In the following chapters, the results of the one-year GreenGasCert project are presented, starting with an overview of the status quo in Ireland and a presentation of the certification scheme and registry structure. Chapter 2 summarises the main findings from a comprehensive assessment of the preconditions for the production of green gas in Ireland. Section 3 describes the main connections and interfaces between the certification scheme and registry. In chapter 4, important elements of the certification scheme are described in detail. Chapter 5 introduces the key elements and the mode of operation of the green gas registry blueprint. Here, aspects and advantages of a registry are described and examples from existing registries from other European member states are presented. Furthermore the requirements posed by European and Irish legislations are analysed and the theoretical setup of the Irish green gas registry is explained in detail. What characteristics of green gas are relevant? How is this relevant data transferred to the registry and verified? And how does the work flow look like? Furthermore, an example for a registry statement is given and suggestions for the role of auditors – important actors in the verification architecture are made. Wherever useful, examples from existing registries are given. Chapter 6 of this report summarises the main activities and results from the stakeholder engagement and dissemination activities as well as the recent policy developments regarding green gas in Ireland.

A case study based on the proposed scheme and blueprint is given in chapter 7. Finally, next steps and open issues – out of scope of this project – are touched on in chapter 8.

1.4 General structure of the green gas registry and certification scheme

The system developed in the GreenGasCert project represents a comprehensive approach to i) steer, measure and control the sustainable production of green gas in Ireland and ii) to develop and support a market framework for green gas in Ireland. General requirement

For the first point, the GreenGasCert project has developed a blueprint for a sustainability certification scheme. This work includes:

- A first set of sustainability criteria for the production and utilisation of green gas (D 1.3; Chapter 4.3)
- A comprehensive methodology for the calculation of life-cycle GHG emissions (D1.1; Chapter 4.2)
- A calculation tool for the operationalisation of the GHG emission calculation for green gases (Project Deliverable 1.4)
- A certificate blueprint as a direct product of the sustainability certification (Chapter 4.4)

The second, important element of GreenGasCert is the development of a framework for a blue print of a green gas registry. The registry will support the development of a market for green gas in Ireland, based on a concise framework to guarantee data security and to prevent fraud regarding the trade of sustainable green gases. The registry will support the development of markets for green gas in Ireland by ensuring transparency along the chain of custody from producer to end user and thus preventing double counting, by monitoring green gas end use and acting as a pillar for green gas support schemes.

Elements of this register, developed in the GreenGasCert project, include:

- The description of the requirements for a green gas register in Ireland (Section 5.3)
- The description of the relevant data and entities involved in the registry (Section 5.4)
- How data is transferred to and inside the registry (Section 5.5)
- The verification processes for the green gas register and work flow (Section 5.6 and 5.7)
- A draft registry statement (Section 5.8)
- A suggestion for the role of auditors (Section 5.9)

These elements have been primarily developed within the GreenGasCert Work Packages 1 (Certification, coordinated by DBFZ) and 2 (Registry, coordinated by dena). However, important information regarding preconditions in Ireland as well as links to expectations from stakeholders have been received from WP3 (coordinated by MaREI and IERC). Main conclusions from a comprehensive literature review regarding preconditions for the Irish context are included in Chapter 2. A comprehensive documentation or the stakeholder consultation, organised by IERC is included in D3.2 & D3.3.

An important step towards the practical implementation of both, registry and certification scheme is the development of a vision for the future market for green gas in Ireland, including interfaces and interactions between the sustainability certification scheme and the registry as well as between the various stakeholders involved.

2 Findings from the analysis of the preconditions for green gas production in Ireland (D3.1)

2.1 Introduction

2.1.1 Rationale for renewable energy

The EU Renewable Energy Directive (RED) aims to increase the share of renewable energy in the EU energy system. There are overall targets for the EU28 and individual targets for each member state, with further targets per energy type for each member state (EU RED). In 2015, the overall share of renewable energy in Europe was 16.4%, and is considered on track to meet the target of 20% of energy from renewable sources at Community level by 2020. The greatest share of renewable heat is solid biomass; for renewable electricity, the greatest increase in renewables is attributed to increased deployment of onshore wind energy; while biodiesel contributes most to meeting the transport target. Biogas does feature as contributing to all three energy vector targets, albeit in a smaller share (EC 2017).

Green gas or renewable gas is gas that is produced mainly from biological material and is often termed biomethane. It is also possible to produce gas from non-biological origins such as from electricity. In Ireland, the initial sources will be wastes and residues such as animal slurry and food waste. Over time, energy crops such as grass, willow and seaweed can be introduced. Biogas can be upgraded to natural gas standard and injected into the existing gas network; it is a form of renewable energy that can be used for electricity, heat and transport.

A green gas certification scheme is proposed for Ireland, an island economy in Northern Europe. The principal aim of the scheme is to enable a green gas market, and the facilitation of the production of biomethane, injection to the national gas grid and trading of the gas. The certification scheme will track and verify the MWh of green gas traded and certify the greenhouse gas (GHG) emissions saved. Six EU gas grids (Belgium, Denmark, France, Germany, the Netherlands, Sweden and Switzerland) have signed up to have 100% renewable gas by 2050 under the Green Gas Initiative (Green Gas Initiative). In Europe, 6 countries now have a green gas certification scheme. These are Germany, Austria, UK, France, Italy and Hungary. Not all of these are official government approved schemes, however the administration is sufficient to provide recognition and they have been accepted by the industry. A secondary aim is that the certification scheme will be compatible with other schemes in the region and as such, would allow for international trading. Certification schemes are normally developed in response to an incentive to produce renewable energy. In Germany, there are three separate certification schemes to reflect the different end uses of the gas, either electricity, heat or transport. In the UK, green gas certification is related to the Renewable Heat Incentive (RHI). The UK scheme is not however formally recognised by the government and there are therefore two separate schemes run by interested parties. Ireland is a small island economy, with a population of approximately 4.5 million people. A single certification scheme is therefore desirable for simplicity.

All EU countries are required to report their share of Renewable Energy Supply (RES) for each energy vector under the (RED). Certifying the amount and use of renewable energy produced and used will assist Ireland in this reporting requirement. In some cases, a multiplier is applied to the energy use.

For transport using advanced feedstock listed in Annex IX, the RES resource accounted for is doubled (RED 2015).

Ireland will likely meet its national target for renewable electricity. Meeting heat and transport targets will be more difficult. Solid biomass is proposed to meet renewable heat targets and an increased share of biofuels is proposed for transport (SAI 2017a). Both of these solutions would rely heavily on imports. While green gas can be deployed as any of the three energy vectors, in Ireland it would be more usefully deployed as renewable heat or transport, given the requirement to meet EU RED targets and avoid potential fines. A certification scheme for green gas would enable a market for selling to industry as renewable heat, or haulage and public transport companies for renewable transport. At the time of writing, summary details of a Renewable Heat Incentive (RHI) has been announced for the country considered. It is yet to be implemented. Feedstock for biomass and anaerobic digestion must meet sustainability criteria (Dep. of Comm. 2017) The Emissions Trading Scheme (ETS) is already in operation in Ireland.

2.1.2 State of the art in renewable gas

A large body of research has been carried out to assess the theoretical resource of various feedstocks for Anaerobic Digestion (AD) in Ireland. Browne et al have identified the potential resource for food waste as 2.8% of energy in transport (Browne et al. 2013); (Smyth et al. 2011); (Smyth et al. 2009) and (Wall et al. 2014) have examined grass biomethane. Taking into account biofuels produced from electricity, anaerobic digestion of wastes/residues and grass, and gasification of woody crops these resources were assessed at 19% of energy in transport in Ireland. Applying factors in the current RED the resources would meet 40% RES-T (Renewable Energy Supply – Transport) (Murphy et al. 2013). This has demonstrated that the resource is sufficient to introduce a green gas industry to this economy. The potential resource could be used for renewable transport (Murphy et al. 2013) or heat (Gallagher et al. 2013). More recently O'Shea et al have assessed the practical resource and potential build order of biomethane plants in proximity to the national gas grid (O`Shea et al. 2016a); (O`Shea et al. 2016b). The profitable resource was estimated as 12 PJ of biomethane (equivalent to 5.6% of transport fuel).

The primary commercially available resource of green gas is from wastes, residues and grass silage. These feedstocks were highlighted in an "Increased biomethane scenario" in a report produced by the Sustainable Energy Authority of Ireland (SEAI). This scenario assumes that food waste and slurry waste streams, and grass silage will the main feedstocks for Ireland, and that they will be injected into the grid at 42 above ground installations (SAI 2017b). The "Increased biomethane scenario" would supply approximately 8.5 PJ of energy by 2030 and 13.3 PJ by 2050. This is approximately 4% and 6.2% respectively of projected 2020 energy demand in Transport (SAI 2017c). An 'All AD feedstocks' scenario assumes maximum use of grass silage and other resources with additional injection points, and an 'Exploratory' scenario included gasification technology. The 'Increased Biomethane' scenario is considered the most likely biomethane scenario for Ireland by the authors.

Seaweed has been proposed as a feedstock for AD in Ireland (Browne et al. 2013), (Tabassum et al. 2017), however this is unlikely to be developed to an industrial level in the short term and as such need not be part of a certification scheme prior to 2020. Gasification of woody biomass has also been proposed (Gallagher et al. 2013) but there are very few plants producing biomethane from gasification globally, due to the high cost and low technology readiness level [TRL] of the technology (IEA). Again, this would not be considered for a certification scheme prior to 2020.

Gas generation through Power to Gas technologies, has been found to be potentially an extremely important means of storing renewable electricity in the form of green gas (Devlin et al. 2017). Combining Power to Gas technology with anaerobic digestion has the potential to increase the methane output by a factor of close to two and to have circular economy benefits (Wall et al. 2017). This technology is not deemed to be at a sufficiently high technology readiness level (TRL) though one facility is in place in Wertle Germany operated by Audi. Including sustainability criteria in the certification scheme is relevant to ensure the long-term viability of the industry. The proposed or recast Renewable Energy Directive proposes sustainability criteria of up to 70% greenhouse gas emissions savings by 2030 for transport and 85% for heat (EC 2016). Thus, it is plausible that a particular green gas system may provide a sustainable renewable fuel for use as a propellant but not as a source of renewable heat. For example, (Korres et al. 2010) have demonstrated that a grass biomethane system for transport can have a range of potential emissions savings. If carbon sequestration is not included the GHG savings are 54.2%; allowing for carbon sequestration of 0.6 t Soil C ha^{-1} $annum^{-1}$ the GHG savings are 75%; sequestration of 2.8 t Soil C ha^{-1} $annum^{-1}$ leads to GHG savings of 150%, (Korres et al. 2010). An assessment of a pre-commercial seaweed biomethane system associated with fish-farming demonstrated up to 61% GHG savings when compared with compressed natural gas as a transport fuel and 70% when compared with gasoline (Czyrnek-Delêtre et al. 2017).

2.2 Establishing the main AD pathways for Ireland

2.2.1 Food waste

Food waste has a potential to provide 2.65 PJ/a in Ireland, approximately 1.4% of expected energy in transport in 2020 Browne et al. 2012). As the Landfill Directive (EC 1999) has been implemented in Ireland more biodegradable waste has been diverted to energy recovery. However, in 2016, approximately 64% of biodegradable waste disposed to landfill was from household and commercial brown bin systems. Adequate treatment infrastructure is required in the state in order to manage the increasing diversion from landfill of this waste (EPA 2017).

There are two waste-to-energy facilities in Ireland based on incineration. This is not considered the best way of processing organic waste as the high water content reduces the Lower Heating Value [LHV] of the biomass and can negatively affect the incineration process whilst minimising the energy return. Based on life cycle assessment methodology, the waste treatment technologies are recommended in proper sequence from anaerobic digestion, heat-moisture reaction technology, composting, incineration and finally landfill (Gao et al. 2017).

Household organic waste is an important resource for Ireland as it is one of the resources that due to the associated gate fee can be profitably digested by 2020 and does not need a large RHI (O`Shea et al. 2016a). Some biogas plants using a similar resource are already in operation using waste from industrial food processing. It can therefore be an important feedstock to encourage and stimulate the green gas industry in Ireland.

Food waste digesters will most likely be based in urban areas, where the resource availability will be higher than rural areas. Even with this, the distance travelled by the waste is likely to be higher compared to on-farm digestion of agricultural products. The maximum theoretical distance for organic waste was assessed as 502 km (O`Shea et al. 2013a). This gives a lot of scope for use as a feedstock, and with minimal change to existing transport systems as waste is already transported for landfill or other processing.

2.2.1.1 Collection and processing

Realising the potential for food waste depends on the effective source segregation of waste. Contamination of waste with other household waste materials is a commonly cited as a challenge in the waste management industry (Browne et al. 2013a). These contaminants can have a negative impact on the digestion process.

Irish legislation requires that food waste producers segregate food waste for collection or treatment to ensure the waste does not contain potentially polluting wastes, products, materials or packaging (S.I. No. 508). At domestic level, local authorities must provide a brown bin collection service for food waste, and domestic food producers must ensure source segregate of waste unless it is composted or brought to an authorised facility. Segregated collection services were required to be available in all population agglomerations greater than 500 people by July 1st 2016. These have been established in most, but not all counties in Ireland (brownbin.ie).

Catering waste is considered Category 3 material under the Irish conditions for Approval and operation of Biogas plants transforming animal by-products and derived products in Ireland, which states the rules as regards animal by-products. Category 3 catering waste must be transformed by heating to 60°C for 48 hours twice, with a particle size less than or equal to 400mm. The substance must be mixed between each treatment and the digestate can only be supplied for use in the Republic of Ireland (DAFM 2014). There are no transformation requirements for domestic food waste.

2.2.1.2 Sustainability

From a greenhouse gas perspective, digesting the organic faction of municipal solid waste (OFMSW) has a net benefit related to the circular economy nature of the treatment of OFMSW and the mitigation of fugitive methane emissions from landfill. The typical and default GHG savings for biogas from municipal organic waste as compressed natural gas in the current EU Renewable Energy Directive are 80% and 73% respectively (RED). The typical value is an estimate of the greenhouse gas emissions for a particular pathway; default values are where factors are applied to parts of the pathway with relatively low emissions. Where the pathway is available in the RED, the default values can be used in lieu of a detailed assessment. Otherwise, the actual emissions value based on the formula provided in Annex C Part V are used. The default value would meet the emissions saving requirement of 70% for Transport in the proposed RED, but not the heat requirement of 80% by 2021 and 85% by 2026.

2.2.1.3 Potential yield

The composition of the OFMSW will have an impact on the biomethane yield. Samples of OFMSW without garden waste gave higher methane yields than samples which included garden waste. Catering waste samples were also found to have a higher methane yield compared to household waste streams (Browne et al. 2014). The biomethane yield of food waste from a university canteen tested in Cork, Ireland was assessed using small Biomethane Potential (BMP) tests and larger scale continuously stirred tank reactors (CSTRs). The small scale test used the automatic methane potential test system

(AMPTS^{TM}), which consisted of 15 number 500mL glass bottles. The larger scale tests were carried out in two CSTRs with a working volume of 5L. The BMP assays for a range of samples yielded results in the range 314-529 $m_n^3CH_4$/tVS food waste (Browne et al. 2012). The stoichiometric equation of a sample used was $C_{16.4}H_{29}O_{9.8}N$, which had a theoretical yield of 549 m^3 CH_4/tVS. This compares well with a larger scale commercial digester in Shropshire, U.K. processing mainly domestic food waste generated 642 m^3 biogas t^{-1} VS and a specific methane yield of 402 m^3 CH_4/tVS at a methane content of the biogas of approximately 62% (Banks et al. 2011). Both countries have a similar diet so a similar methane yield can be expected in Ireland. Table 1 below summarises the potential food waste yield for Ireland (Browne et al. 2012). The biomethane production of 70 million m^3_n yr^{-1} is equivalent to 2.65 PJ yr^{-1}, or 1.06% of energy in Transport in 2015 (SAI 2017a).

Table 1 Bioresource of OFMSW beyond 2016

Quantity of VS (29.4% DS of which 95.3% VS)	148,500 t VS yr^{-1}
BMP range 467–520m^3_n CH4/tVS	470 m^3_n CH_4 tVS^{-1}
Biomethane production	70 million m^3_n yr^{-1}
Energy yield at 37 MJ/mn3	2.6PJ/a

2.2.1.4 Energy balance and processing

The digester in Shropshire included for a 900m^3 tank mixed by continuous gas recirculation and maintained at 42 °C by external heat exchangers. During the study period of 426 days, 3,372 t/a of waste were processed, 95% of which was source-segregated domestic food waste. The average organic loading rate was 2.7 kg VS m^{-3} day^{-1}, based on the average volume of the digester contents. The biogas output was 156 m^3 $tonne^{-1}$ wet weight. The waste was first shredded and then macerated to mix the waste and reduce the particle size to less than 12mm, which is in line with the EU pasteurisation standard. The associated Combined Heat and Power (CHP) Unit was a 195 kW MAN unit with assumed electrical conversion efficiency of 32% at full load and a potential of 53% recovery of heat. The overall energy balance has been adapted to allow for comparison with other systems (Banks et al. 33).

2.2.1.5 Food waste digestate

Digestate from source segregated food waste can be used on tillage land as a soil improver (after pasteurisation) or made into garden compost (Browne et al. 2014). The digestate from the Shropshire plant had an average nutrient content of 5.6, 0.4 and 2.3 kg/tonne wet weight for Total Kjeldhal Nitrogen (TKN), Phosphorous (P) and Potassium (K) respectively. A nutrient mass balance taking into account water additions showed outputs equal to 86.1%, 32.8% and 96.4% of the input values of TKN, P and K (Banks et al. 2011). Data from Table 2 suggests a net yield of 1.25 GJ of energy from 1 tonne of food waste. In an Irish context with 530,000 t yr^{-1}; this can supply a net energy yield of 662,500 GJ yr^{-1} in the form of electricity and heat. The differentiation between gross energy yield from wastes (2.6 PJ/a from table 1) and net energy yield post treatment of waste (0.663PJ/a based on table 2) is explained by the need to treat waste. Without biogas production in a “do-nothing” scenario energy is spent in treating waste. Biogas production satisfies this energy demand in treating waste and leaves surplus energy for other uses which displace fossil fuel use.

Table 2 Overall Energy Balance for one year of operation - adapted from Banks et al. 2011

Parameter	Value (GJ yr^{-1})
CHP net electrical output	2,629
Parasitic electrical requirement of process plant	718
Net energy output as electricity	1,911
Recoverable heat output from CHP	4,547
Parasitic heat requirement of plant	1,377
Net energy output as heat	3,170
CHP natural gas used	57
Energy required for digestate transport and application to land	106
Total potentially recoverable energy (heat and electricity)[1]	4,919
Total potentially recoverable energy per wet tonne of food waste	1.25

2.2.2 Slurry

Slurry has a lower biomethane yield compared to other feedstocks. It is advantageous for anaerobic digestion for a number of reasons. It is abundant: Ireland, a state with a population of 4.5 million people, has a significant dairy industry with a national dairy herd of approximately 1.4 million cows (IFA 2017). Co-digestion of manure and organic feedstocks increases the biological stability of the AD process, when compared with mono-digestion due to the microbial fauna in the slurry (Rutz et al. 2013). Slurry is normally stored in open tanks releasing methane to the atmosphere. An advantage of using slurry for biogas production is that these fugitive emissions do not occur and as such biogas from slurry can be assessed as carbon negative. The Joint Research Centre (JRC), the European Commission's science and knowledge service has estimated that according to Intergovernmental Panel on Climate Change (IPCC) guidelines, an emissions credit of 17.5% of the methane produced, can be accounted for in greenhouse gas calculations (Giuntoli et al. 2015). Thus co-digestion of a substrate with slurry can be used to increase the GHG savings of the biomethane to be certified.

[1] Includes heat energy generated but not used at the time of the study.

Manure and digestive tract content are considered category 2 waste and can be transformed according to EU standards by heating to 70°C for 60 minutes, with a particle size less than or equal to 12mm prior to conversion to biogas. If biogas is produced from slurry, with imported amounts of slurry of less than 5,000 tonnes per annum, then there is no need for pasteurisation (DAFM 2014). External or imported manure must come from one herd only.

2.2.2.1 Potential energy yield

The slurry yield can vary throughout the year depending on the diet and lactation stage of the animals (Rutz et al. 2013). This variation should be considered when designing a biogas facility to ensure a reliable economic return (Allen et al. 2016). For slurry collected from an Irish farm the Dry Solids (DS) content varied from 57 to 96 g/kg depending on the time of year; with a Volatile Solids (VS) content on average of 75 g/kg DS (Wall et al. 2013). Dairy slurry tested in Ireland has been assessed as having a biomethane potential (BMP) in the range of 175 to 239 L CH_4 kg^{-1} VS (Allen et al. 2016); (Wall et al 2013). The higher value is equivalent to 16 m^3 CH_4 t^{-1} fresh weight (FW).

2.2.2.2 Slurry Digestate

Current practice is to spread slurry on land as fertiliser. If it were to be used for anaerobic digestion it is recommended to return the same amount of digestate by mass back to the farm. This ensures that farmers are not deprived of the fertiliser value from the cattle slurry they supplied to the anaerobic digestion facility (O`Shea et al. 2016b). If slurry (prior to AD) is compared with digestate (post AD) the availability of nutrients is significantly increased due to mineralisation of the nutrients in the digestate [34]. A comparison of digestate with pig slurry and dairy slurry has shown that digestates have a different chemical composition to the slurries, but without posing a higher risk with respect to their impact on soil microbial activity (Risberg et al. 2016). Additionally, the results suggested that digestate may be a more suitable fertiliser for soils with high clay and carbon content, and that slurries may be more suitable for sandier soils containing less organic carbon.

2.2.3 Grass silage

Grass has long been mooted as a potential feedstock for biomethane in Ireland. Farmers in Ireland are already familiar with managing grass; there is no need for land use change due to the high availability. The parasitic energy demand of mesophilic anaerobic digestion of grass silage is low when compared to first generation biofuels such as ethanol, in which alcohols must be evaporated off stillage (Murphy et al. 2008). Grass is considered an advanced biofuel and the feedstock is classed as ‘non-food cellulosic material’ under the proposed recast RED (EC 2016). It had been identified as the most significant resource for Ireland for Anaerobic Digestion and could produce up to 35PJ energy supply by 2035. This is 22% of the 2015 natural gas supply (SAI 2015).

2.2.3.1 Grass cultivation and yield

Grass is theoretically cultivated on an 8-year cycle with two cuts per year following the first year of cultivation. An Irish resource assessment by Smyth assessed a theoretical 137.5 ha farm with a grass yield of 12 t DS ha^{-1} yr^{-1} at 90% volatile solids. The fertilisers applied (Smyth et al. 2009) are annualised and summarised in the table below:

Table 3 Annual fertilisers applied for grass cultivation

Substance	Nitrogen	Phosphorous	Potassium	Lime
Quantity (kg ha^{-1} yr^{-1})	250	38.75	308.75	1,500

Teagasc is promoting a grass cultivation strategy known as Grass10. This focuses mainly on livestock and drystock and aims to increase the number of grazings per paddock to 10 and the amount of grass utilised to 10 tonnes grass dry matter per hectare (Teagasc 2017). Typically the available grass for cattle in a pasture situation (allowing for trampling by cattle) is 6 tonnes grass dry matter per hectare; thus Teagasc suggest that the yields can be increased by 67% to 10 tonnes without land use change. This strategy can also benefit farmers growing grass as a feedstock for anaerobic digestion. Farmers participating in a grassland measuring system run by Teagasc have increased average grass yields from 12.2 t DM ha^{-1} yr^{-1} in 2013 when the database started to 14.1 t DM ha^{-1} yr^{-1} in 2015 O'Leary et al. 2016. Thus with no additional land take farmers can increase yields by between 16 and 67% allowing for both food and fuel production.

2.2.3.2 Potential energy yield

The composition of biogas from grass is typically 55% methane (Murphy et al. 2008). This is reinforced by the stoichiometry of grass silage when assessed by Buswell Equation. Theoretical assessments of an Irish grass-based biofuel scenario assessed the gas production conservatively as 300 m^3 CH_4 tVS^{-1}[8]. This was based on based on a theoretical 137.5 ha farm with a grass yield of 12 t DS ha^{-1} yr^{-1} at 90% volatile solids. The gross energy per hectare was 122.41 GJ ha^{-1} yr^{-1} (Smyth et al. 2009). Subsequent testing in the lab demonstrated higher yields for grass mono-digestion of up to 400 m^3 CH_4 tVS^{-1} [40]. Further testing at a larger scale obtained a specific methane yield of 405l CH_4/kgVS (Wall et al. 2013). This value was used by (O'Shea et al 2016b) to assess the total theoretical grass biomethane resource for Ireland as 128.4 PJ.

It is unlikely that grass will be digested on its own. At high loading rates, the biomethane yield from mono-digestion of grass reduces over time. This can be mitigated by co-digestion with slurry, or by adding trace elements to the mix, giving a specific methane yield of up to 404 l CH_4 kg^{-1} VS at an organic loading rate of 4.0 kg VS m^3 day^{-1} (Wall et al. 2014). The BMP is considered by some as a reliable estimate of the methane yield of a substrate (Li et al. 2017). Others suggest that is unlikely that the result of a BMP assay can be achieved at full-scale production O'Leary et al. 2016. Hollinger et al recommended an extrapolation coefficient of 0.8 should be applied to avoid overestimating the methane production from a BMP (Holliger 2017). In Table 4 a conservative factor of 0.9 is applied as the lab testing by Wall et al (2014, 2013, 2013b) was undertaken in a continuous digester over long periods of time as opposed to a BMP over a 30 day period of time.

2.2.4 Energy balance

The gross energy per hectare and energy balance of a grass to biomethane system, based on a theoretical 137.5 ha farm adapted from (Smyth et al 2009) is presented below, and updated to reflect the higher methane yield as assessed in the lab (Wall et al. 2013).

Table 4 Energy balance of a grass to biomethane system (Smyth et al) with data from Wall et al

Energy	(Smyth et al) GJ ha^{-1} yr^{-1}	(Wall et al) GJ ha^{-1} yr^{-1}	(Wall et al) * 90% GJ ha^{-1} yr^{-1}
		SMY 404 L CH_4 kg^{-1} VS	SMY 404 L CH_4 kg^{-1} VS *0.9
Gross energy production	122.4	163.21	146.9
Parasitic demand and heat loss	17.1	17.12	17.1
Biogas for upgrading	105.3	146.09	129.8
Upgrading losses	1.58	2.19	1.95
Gross Biomethane Production	103.7	143.9	127.8

The emissions savings from using grass biomethane for transport were assessed as 75% (Korres et al. 2010), including for soil carbon sequestration. It should be borne in mind that the reactor type can result in a variation of energy production and emissions savings; variations of 15% in the emissions savings have been suggested (Singh et al. 2011).

2.3 Future energy systems

This section outlines the future resource of green gas in Ireland. This is unlikely to be realised in the short term, given the requirement for novel cultivation methods or technology. They are however, very relevant for Ireland's future energy mix.

2.3.1 Algae biomethane

Both micro and macro-algae (also known as seaweed) can be converted to biomethane. Micro-algae have been assessed as an unlikely source of biomethane in Ireland, given the extensive requirement for land for cultivation and unfavourable climatic conditions (O'Shea 2017, in press). It is suggested by the authors that extensive micro-algae cultivation could be more suited to tropical climates rather than temperate oceanic climates such as Ireland.

The opposite is true for macro-algae such as kelps whose growth is optimised in temperate climates such as in waters off Ireland. Ireland has extensive sea-based kelp forests. It would not be sustainable to harvest these, as it would damage existing ecosystems. Instead, it is proposed to cultivate seaweed for anaerobic digestion along with a fish farming industry; together these systems are known as integrated multi-trophic aquaculture (IMTA). The seaweed would mitigate the eutrophication caused by fish farming, which would in turn-improve the yields of the seaweed; this is an example of a circular economy.

In a European context Jacob et al., (2016) suggested that 1.25% of the current energy in transport demand of the EU, or 206 PJ/a, would require annual production of 168 Mt of seaweed integrated with 13Mt of farmed salmon. This was deemed to require 2603 seaweed digesters each digesting 64,500 tonnes of wet weight of *S. latissma*. Cultivating macro-algae alongside fish farming, prevents the associated pollution (Jacob et al. 2016). A sample Life Cycle Analysis of such a system, using renewable wind energy, has demonstrated GHG savings of 70% when compared with gasoline fossil fuel (Czyrnek-Delêtre et al. 2017). This reduces to 60% when displacing compressed natural gas as a propellant.

2.3.2 Willow biomethane

Short-rotation coppice willow (SRCW) has been proposed as an alternative to importing woody biomass. It is estimated that eleven 50MW_{th} gasifiers could supply a total of 10.4 PJ p/a with an area of land required of 6,800 ha per 50MW_{th} gasifier (Gallagher et al. 2013). Willow has the advantage that it can be grown on marginal land and cultivated in the vicinity of the bioenergy facility. SRCW would be converted to biomethane using gasification followed by methanation.

It is assumed that plant cost and required scale of cultivation of willow will be a limiting factor on realising the gasification resource in 2030. The gasification resource is constrained by technology. While biomass gasification is established technology for combined heat and power, the commercial application of syngas methanation is as yet limited (Hrbek 2016). The 20MW GoBiGas gasification plant in Sweden was an example of such a process. This is seen as small-scale demonstration technology and has recently closed operations.

2.3.3 Gaseous fuel from non-biological origin

Power to Gas (P2G) technology uses electricity to perform hydrolysis to split water into Oxygen and Hydrogen. The Hydrogen in turn can be combined with CO_2 to produce biomethane ($4H_2 + CO_2 = CH_4 + 2H_2O$). To be economically viable these systems require cheap electricity and a cheap concentrated source of CO_2 (Vo et al. 2016). Curtailed and constrained electricity would be essential elements in the production of cheap electricity. However, systems that operate for a few hours a day to avail of cheap electricity do not optimise the capital investment of the facility. Much work is required in optimising the whole Power to Gas system. Waste CO_2 from industrial processes, CO_2 from ethanol facilities and distilleries, and CO_2 from biogas upgrading are cheap concentrated sources of CO2. Both the hydrogen produced from electrolysis and methane produced from methanation are considered renewable gas. There is some confusion on the naming of these gases; often they are called e-gases as they are sourced from electricity. The EU RED uses the term gaseous fuel of non-biological origin (RED), (EC 2016).

Ireland due to its island status and its high portion of intermittent renewable electricity, mainly associated with wind, will have significant curtailment (Vo et al. 2016). An optimal biogas model has been proposed by (Ahern et al. 2015), where the facility would utilise a model whereby both CHP and gas grid injection systems co-exist. At times of peak demand for electricity the biogas system would incorporate demand driven biogas concepts to produce enhanced levels of electricity. Conversely at times of peak production of, and low demand for, electricity, excess electricity could be converted to hydrogen and this hydrogen could be used to upgrade biogas to biomethane ($4H_2 + CO_2 = CH_4 + 2\ H_2O$) and injected to the gas grid. This model is dependent on an established biomethane industry. Plant cost may be a limiting factor on realising this technology in the near future. There are commercial applications of this technology, notably in Wertle, Germany where a plant is run by Audi, generating e-gas for transport fuel (Goteborg Energi).

2.4 Environmental Sustainability

The main sources of food waste are domestic brown bin waste, canteen waste from restaurants, and waste from industrial food processing. Anaerobic digestion means that this waste resource can have a value. Biogas created from any wet organic waste product is highly sustainable; as the waste would otherwise go to landfill, and/or generate high levels of fugitive methane emissions. In the case of slurry, it is assumed that there is an emissions saving of 17.5% before any other processes are considered.

Considering grass which covers 91% of Irish agricultural land, Cross Compliance rules of the Common Agricultural Policy limit the amount of land that can be converted to other uses beyond grass. Ireland already has a significant amount of grassland, which could be used for anaerobic digestion. Teagasc, the Irish Agriculture and Food Development Authority, have a model in place (the Grass10 campaign) facilitating improved cultivation techniques increasing the yield of grass by 16 to 67% (Teagasc 2017). This would create a significant resource for AD that is both abundant and compliant with EU legislation and is in excess of present feed requirements.

Willow can be grown on marginal land, so that arable land is retained for food cultivation and other uses. Particularly for Willow, this marginal land includes peatland, so this crop could be grown on land that has been stripped for electricity generation from peat, thus retaining the land use of energy supply. Willow can remove heavy metals from soil. It is commonly planted next to domestic septic tanks to reduce contamination. An interesting use of this crop would be to clean toxic sites and then be used in turn to generate energy. The char and ash may be contaminated as a result. Harvesting willow on soft lands may be more expensive due to specialist machinery required.

The concept of using renewable electricity that would have otherwise been curtailed or constrained and combining with sequestered carbon leads to extremely sustainable Power to Gas systems. Power to Gas, has the potential to almost double the output of a biogas plant, as it converts CO_2 in biogas to CH_4. Indeed using the CO_2 from a bioenergy system such as upgraded biogas in a cascading bioenergy circular economy system especially when the digested substrate is a slurry or residue can put P2G into carbon negative category.

Micro-algae can also be used in a cascading system capturing CO_2 from bioenergy systems (Wall et al. 2017). Such algae biofuels can be very sustainable but are at a low technology readiness level (TRL) and are not expected to be commercialised for a number of years yet.

2.4.1 Evidence for emissions savings for the displacement of synthetic fertiliser by digestate

In a grass biomethane case study Smyth et al identified a mass of 15,695 t yr^{-1} of grass digestate (Smyth et al. 2009) for land application and displacement of synthetic fertiliser and the associated fossil fuel used in production of synthetic fertilisers. Emissions savings from displacement of synthetic fertiliser by digestate are not specifically included in the emissions calculations of the current or proposed RED (EC 2017). The RED does allow for allocation of emissions based on energy content as described above. However, there is limited data available on the energy content of digestate related to specific feedstocks so assumptions would be required.

It must be borne in mind that anaerobic digestion is more than a renewable energy system. It cannot be compared directly with a wind turbine for example. Anaerobic digestion is usually employed as a waste treatment system or a means to improve environmental sustainability. The digestate is a sustainable fertiliser. For example in Denmark a new organic biogas facility will be used to pipe 9 million m^3 biomethane to the gas grid but as it uses organic wastes the organic biofertiliser is a big element of the output (Messenger 2017). It is quite common also that the CO_2 separated from the CH_4 has an asset value such as use in carbon free carbonated water. Thus, biogas facilities treat waste, produce organic biofertiliser, produce decarbonised CO_2 for the beverage industry and also produce biomethane. Attributing all the emissions to the methane is not in keeping with the rationale for biogas facilities. Adams et al estimated 20% allocation to digestate based on the Higher Heating Value (HHV) of the feedstock. This method was not considered ideal, but that it has some sense in application for green gas (Adams et al. 2015).

2.4.2 Evidence for emissions savings from carbon sequestration from grassland

Sequestration of atmospheric carbon in Irish grasslands will only be acknowledged in IPCC greenhouse gas accounting methods when Ireland can produce evidence-based Measurement, Reporting and Verification (MRV) of carbon sequestration (Royal Irish Academy 2016). Byrne et al demonstrated that two farms based in Cork were net sinks of the order of 2 t C ha^{-1} y^{-1}. These included farm activity such as slurry spreading and animal respiration in the calculation and the authors concluded that the C sequestration would need to be verified with soil Carbon measurements. For the grassland only the soil carbon sequestration was estimated at about 1 t CO_{2eq} ha^{-1} y^{-1} (Byrne et al. 2007).

Including carbon sequestration of grass has a very significant impact on the LCA of grass-based dairy farming. However these effects are considered unreliable due to the uncertainty regarding the data available for Ireland (O`Brien et al. (2014, 2014b). The average of values used in these studies of 1.19 tCO_2 ha^{-1} is in line with values quoted above. For grass biomethane utilised as a transport fuel, a value of 0.6 t soil C ha^{-1} yr^{-1} yields a GHG saving of 75%; varying the sequestration rate chosen can substantially affect the result, giving GHG savings of up to 150% (Korres et al. 2010).

Given the limited soil sequestration data available for Ireland, and the extensive effort that would be required to measure sequestration for individual grassland sources, it may be more appropriate to use a conservative default value, such as the lower value of 0.6 t soil C ha^{-1} yr^{-1}, for sequestration in any GHG calculation for a green gas certification system. This would ensure that the system is credible.

2.5 Social and economic impact

2.5.1 Energy Supply and Security

2.5.1.1 Defining energy security

Energy security broadly refers to the ability to ensure an uninterrupted supply of energy at an economically viable price. Energy security has been traditionally thought of in terms of the geopolitics of fossil fuels. This is now changing as a result of climate action and meetings such as COP 21 in Paris and COP 23 in Bonn. There is little consensus on a final definition of energy security in literature given the vast amount of parameters and risks (García-gusano et al. 2017). Risks to security are either major external events such as disaster, conflict, political tensions and instability or major accidents. Internal risks refer to infrastructure capacity, investment uncertainty, resource variability and civil and labour disputes (Sustainable Energy Authority of Ireland 2016). Various indicators of energy security therefore have their limitations due to the inherent nature of indicators and also the various interpretations of energy security that indicators can be applied to. Green gas has potential to contribute to energy security in terms of the fuel supply, source diversity and as an indigenous source of fuel.

2.5.1.2 EU Energy security and renewables

In the EU, a long term relationship between energy security and renewables deployment has been identified based on data from 21 EU countries, including Ireland, from 1990 to 2013. This found that the main driver behind renewables deployment was energy security rather than environmental concerns and sustainability policies (Noel et al. 2016). Analysis by Chalvatzis et al (2017) focusing on countries most affected by the financial crisis found that renewable energy sources played a significant role in reducing import dependence. Ireland had the least diverse fuel mix of the countries considered followed by Portugal, Spain, Italy and Greece (Chalvatzis 2017).

2.5.1.3 Energy Security in Ireland

Ireland had an import dependency of 85% in 2014 and 95% of natural gas supply was sourced from Britain (Sustainable Energy Authority of Ireland 2016). In 2016 this changed significantly to 57.8% as a new gas field (the Corrib Gas field) came on stream (SAI 2017c). Natural Gas accounts for 53% of electricity generation in Ireland and 38% of heat demand. There is interdependence between heat and electricity when gas is the source, so having a more secure gas supply will have benefits for both energy sectors. Drivers for diversity in energy supply in the countries examined by Chalvatzis, including Ireland, were reduced transport use and an increase in renewables from 2008 to 2014 (Chalvatzis 2017). The reduced transport demand is a result of reduced economic activity so if the economy improves, as one would hope, this diversity gain may well be lost. In the Electricity sector, warnings of an over-reliance on limited sources of supply and the 1970s oil crises have led to greater diversification and reduced exposure to risk. (Gaffney et al. 2017)

According to SEAI, a fully developed biogas industry could supply up to 30% of Ireland's gas demand by 2030 (SAI 2015) Renewable gas has the advantage of being a more regular supply instead of the peak and decline over decades that has characterised Irish supply as Irish gas fields start, peak and then run out. There may be slight variation in the supply related to harvest but this will be much less significant compared with the variation associated with a gas field over time.

2.5.1.4 The role of renewable gas

The main modern renewable energies are wind and solar which are considered inexhaustible resources. While these have the advantage of *free* fuel until the point of processing, the downside is that they are not completely dispatchable (Noel et al. 2016). Biogas/biomethane is different from wind and solar in that the feedstock has either a cost, or in the case of food waste it may generate revenue in the form of gate fee. The biogas/biomethane system is reliant on a successful or reliable substrate. A significant benefit of biogas is that the technology is dispatchable and is capable of meeting a variable demand. Indeed the biogas output can be ramped up or down through feeding regimes and biogas storage. O'Shea et al have demonstrated that the timing of reactor feeding and upgrading can be optimised to meet electrical demand while minimising the storage requirement (Shea et al. 2016). Diversification of transport fuel is a particular concern for Ireland due to the near total dependence on oil, which is unique out of all sectors of the economy (Sustainable Energy Authority of Ireland 2016). Biomethane can address this and add to the diversity of supply sources for transport fuel.

2.5.1.5 Brexit

Brexit is considered a potential risk to the Irish energy market, as Ireland will no longer have interconnection with another EU country. A policy evaluation has noted that there are bilateral agreements between Ireland and the UK that are outside of the EU (Lynch 2017). In addition to this, it is impossible to cut supply to the Republic of Ireland without simultaneously cutting supply to Northern Ireland. The implications of trading with a non-EU partner can be considered relevant for the gas market but should not have a big impact on the certification scheme.

2.5.2 Jobs and economic growth

SEAI have estimated that over 4,000 jobs could be created in Ireland by 2050 in the biogas industry; this includes direct and indirect jobs. This is in a conservative scenario which includes for the digestion of the available wastes and grass silage resource in Ireland. According to the SEAI report these were not considered new jobs, as they are more likely to be related to upskilling from other industries ((SAI 2015). However, in times of recession employment is extremely important. This report considered employment at a national level.

A sample biogas plant producing 10,200,600 Nm^3 biomethane per year can be assumed to employ seven people (Karellas et al. 2010). This includes three skilled and four semi-skilled workers. As digesters can be expected to be located outside of Ireland's main urban centres (O`Shea et al. 2016b) the technology would be of benefit to the rural economy, where these would be considered 'new' jobs. Further jobs would be created transporting locally sourced feedstock to the digester as well as the digestate by-product.

2.5.3 Rural development

The countries with the most developed biogas or biomethane markets in terms of the number of plants are Germany, Italy and the UK (EBA 2015). In Germany biogas production was associated with job creation in the biomass sector and the strengthening of rural areas (Torrijos 2016). There were also adverse side-effects such as: competition for biomass use, a change in maize cultivation and use, and problems of acceptance. In Ireland, the dominant feedstock for biogas is grass, which is already in place. Grass can be used without competing with traditional agricultural systems, and could provide an alternative enterprise and income to farmers (McEniry et al. 2012).

There is considerably more research on the negative effects of renewable energy compared with possible positive effects. Analysis by Guenther-Lůbbers et al found that the benefits of biogas production can vary depending on the type of farming existing in the region. CHP facilities were seen as benefiting social and public relations due to the level of cooperation required to develop a district heating system (Guenther-Lůbbers et al. 2015).

2.6 Competitiveness and sustainability of agriculture, manufacturing and processing sector

Agriculture is the single largest contributor to Ireland's greenhouse gas emissions (EPA 2016). The Food Harvest 2020 strategy (DAFM 2010) aims to increase Irish beef and dairy output by 20% and 50% respectively between 2010 and 2020 while also reducing GHG emissions. Diverting the slurry associated with this farming to energy generation can help reduce the GHG emissions by realising the 17.5% emissions saving due to capture of fugitive CH_4 emissions from open storage tanks.

There is also the potential to reduce fossil mineral fertiliser application as nutrients in the slurry will be better mineralised reducing the requirement for fossil fertiliser. Improving grass yields for energy use will improve the efficiency of agriculture, and improve competitiveness as a result of diversifying grass use.

2.6.1 Safety

One of the challenges to the public perception of biofuels has been negativity, alleging that fuels produced through anaerobic digestion are not as beneficial or safe as they purport to be. The UK Environment Agency reported 12 serious pollution incidents in 2015, the latest year for which information is available in a report by the Environmental Agency (EA 2015). An analysis of accidents in biogas production and upgrading by (Moreno et al. 2016) found that the number of accidents is growing faster than production and that the main lessons learnt were to improve safety culture and risk awareness in the sector.

These were not considered 'new' accidents as the risks are well known in other industrial fields with similar operations. The Irish Chemical and Pharmaceutical Industry, from which such lessons can be learned, accounts for a substantial part of Irish Industrial production, approximately 45% of total Net Selling Value in 2015 (CSO 2016). Opportunities for collaboration and synergies with these sectors should be identified in order to ensure the safety of the product and a positive relationship with neighbours.

2.7 Implementing a certification scheme in Ireland

2.7.1 Establish a range of biomethane pathways that would be suitable for certification in the short term

Anaerobic digestion of wastes, residues and grass have been identified as the most suitable pathways for green gas certification in Ireland. This is due to their economic viability, technology readiness level and resource availability.

2.7.2 Evaluate the ability of the biomethane systems to achieve the EU emissions savings targets for heat and transport in the recast RED.

A simple greenhouse gas calculation based on BioGRACE has demonstrated that these pathways can meet the current proposed sustainability criteria for transport in the new RED but not heat. This is a concern for Ireland as renewable heat may the easiest route to market in the short-term as there is no need to change industrial process to accommodate green gas. Although there is currently limited infrastructure in place for renewable gas in transport, Gas Networks Ireland (GNI), the network operator, aim to have 70 CNG injection points by 2027, ten years from now.

2.7.3 Consider alternative pathways that would allow satisfaction of the sustainability criteria for renewable heat

In order to meet the proposed renewable heat sustainability requirements by 2026 advanced technologies such as power to gas and cascading bioenergy systems that maximise the use of resources and minimise GHG emissions may become a lot more relevant for Irish green gas systems. International Energy Agency Energy Technology Perspectives (IEA ETP) 2017 [79] see BioEnergy and Carbon Capture (Use) and Storage (BECC(U)S) as essential to maintain temperature rise below 2^{o}C rise. The use of Power to Gas systems which use curtailed electricity and capture and reuse the carbon dioxide from the biogas stream will greatly improve the sustainability and the GHG savings of the system (Tabassum et al. 2017). The same is possible using microalgae to upgrade biogas to biomethane. Thus the green gas technologies, which are seen as being at low TRL, may be required by 2026 to allow 85% GHG savings as opposed to fossil fuel displaced in the renewable heat sector.

2.7.4 Highlighting the challenges relating to the interaction between policy, reporting and national infrastructure

Considering the nature of the scheme, in other countries, certification has been in response to an incentive for a particular use. If transport were the dominant use chosen for Ireland, certification would be of the pathway with transport as the final end use. Certifying the transaction, with an optional end use, would be an opportunity to direct the biomethane towards a preferred use for Ireland.

Of concern, however is renewable energy auditing. For example if green gas is injected to the gas grid at a rural slurry digester with the desire is to sell the green gas via certificates to a captive fleet such as a city bus service, renewable energy auditing may not support the green gas model.

Through renewable energy auditing injection of green gas to the natural gas grid is deemed to follow the use of natural gas in the grid. Thus if 50% of natural gas is used in electricity production at 60% efficiency and 50% is used for thermal energy at 85% efficiency then the overall efficiency of the green gas utilisation will be 72.5%. In essence 1 unit of renewable energy supply (RES) in biomethane will produce 0.725 units of RES.

If the bus service were connected directly to the biogas facility it would be deemed to support 2 RES as the biomethane is an advanced transport biofuel (produced from wastes and grass silage) and as such the resource of transport biofuel is doubled as per the RED. As an example, Sweden, which does not have a gas grid, can claim full RES credits in this way.

If on the other hand the bus service takes natural gas from the gas grid though it has purchased green gas certificates; it is deemed to take the gas at the exact mix of the national gas grid. If for example 1% of the natural gas market is green then 99% is brown and the bus is operating on 0.02 RES as the RED allows a weighting of 2 to advanced biofuels.

This is an anomaly, which from an engineering scientific process does not make sense. The gas grid, which is an existing expensive distribution system with great potential for distribution of renewable green gas is penalised for distribution in an emerging industry. The benefit of the gas grid will only be accounted for when the gas grid is significantly decarbonised.

As the proposed RED is in draft format and highly likely to change, advocacy may be required to introduce more favourable criteria for heat in order to enable the green gas for renewable heat market in Ireland. This will be important to ensure that heat is a viable use for Irish green gas in the future.

3 Interface between certification scheme and registry

The following figures 1 and 2 shows the general framework with the two main elements of GreenGasCert on a macro level. The general set-up for the development of both, certification scheme and registry has been based on a set of general assumption, with implications for the development of the main structure of the overall system. These assumptions include first ideas regarding the nature of market actors and operators of the certification scheme and the registry.

In general, sustainability criteria defined by the GreenGasCert system (and reflecting criteria from the EU RED framework, etc.) will be assessed along the value chain for green gas production. This process will involve on-site audits and will, whenever suitable, be based on already existing certification and auditing practices in the Irish agricultural sector or for anaerobic digestion practices in Ireland.

Throughout this process, information regarding the sustainability and the mass flow of the feedstock, biogas or biomethane will be collected or generated and will be passed throughout the whole process chain. The final product of this process is a sustainability certificate which shows that the sustainability criteria of the system have been met by all operators throughout the value chain. Furthermore, the sustainability certificate will include information about the GHG mitigation potential as well as additional information regarding the total amount of green gas produced, etc. This sustainability certificate will be issued to the operator responsible for the last process step before grid injection. Once a green gas amount is injected into the grid, the corresponding sustainability information will be transferred to the green gas registry.

The registry will serve as a platform to link the sustainable production of green gases to the market(s) for green gas. With help of the registry, market actors can trade different quantities of green gases with different characteristics (e.g. feedstock, GHG performance, etc.).

Inside the registry, market actors will be able to trade green gas amounts (registry certificates) and cancel them for different target markets (voluntary markets, support schemes, obligations, etc.). The information from the sustainability certificate can thus be passed up to the final user of the green gas while the registry setup assures the data quality inside the registry.

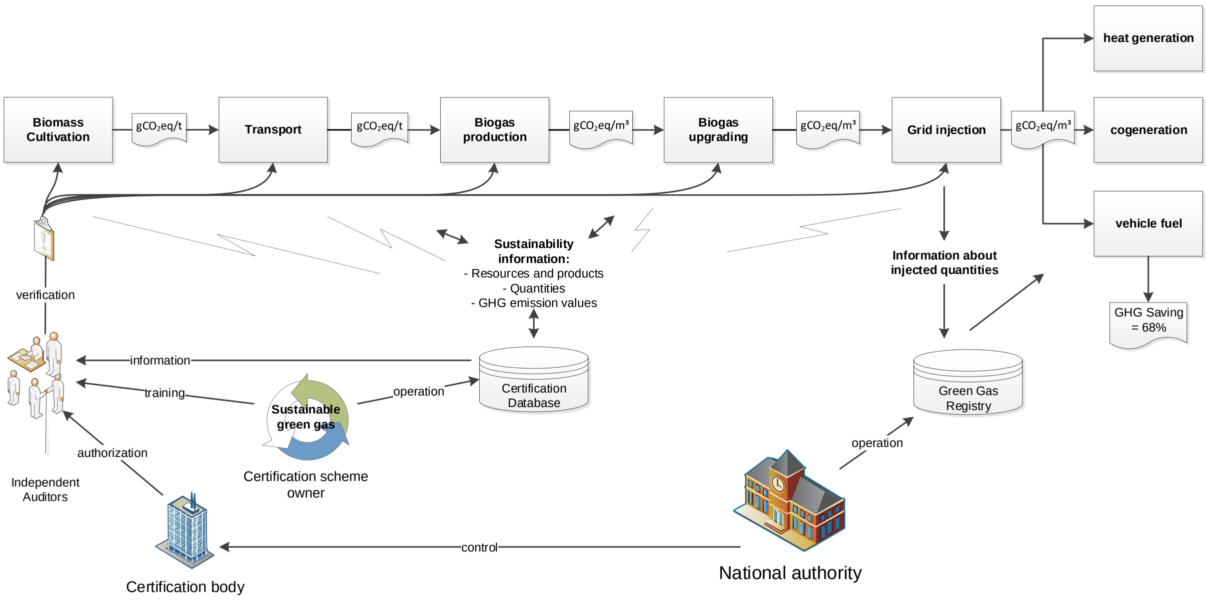


Figure 1 A sustainability certification scheme and registry for Ireland – the system overview

It is important to mention, that various participants will be involved in this system. Furthermore, the specific role and nature of the various operators will influence the exact formulation of the different elements of the system. The subsequent chapters of this report, describing the certification scheme and registry, are based on the following scenario for the role of the various market actors:

- The green gas registry and certification scheme are operated by private companies
- The certification scheme defines clear rules and criteria for the certification process, these criteria will be checked by independent auditing/certification companies (e.g. TÜV, DEKRA, etc.). Auditors will be trained and recognised by the certification scheme.
- A national authority (possibly the National Standards Authority of Ireland, NSAI) will supervise and control the rules for the certification processes. This authority will also oversee the independence of the business relationship between certification scheme and auditing company.
- The green gas registry will serve as a platform for the trade of sustainable green gases. The interface to the certification scheme will guarantee the amounts and sustainability characteristics (e.g. GHG performances) of the registered green gases.
- Both systems, certification scheme and register can be linked to existing national databases or reporting procedures (e.g. national biofuels obligation scheme).

Chapter 7 of this report illustrates the process of sustainability certification as well as the registry elements and links to the biomethane market by means of a case study example.

An overview, how the interface between the information coming from the sustainability evaluation (sustainability certificate) could be implemented, is shown in Figure 2. The information about the GHG emissions is included into the registry certificate and when the final use of the green gas is decided, the total GHG emission can be calculated by using standard values.

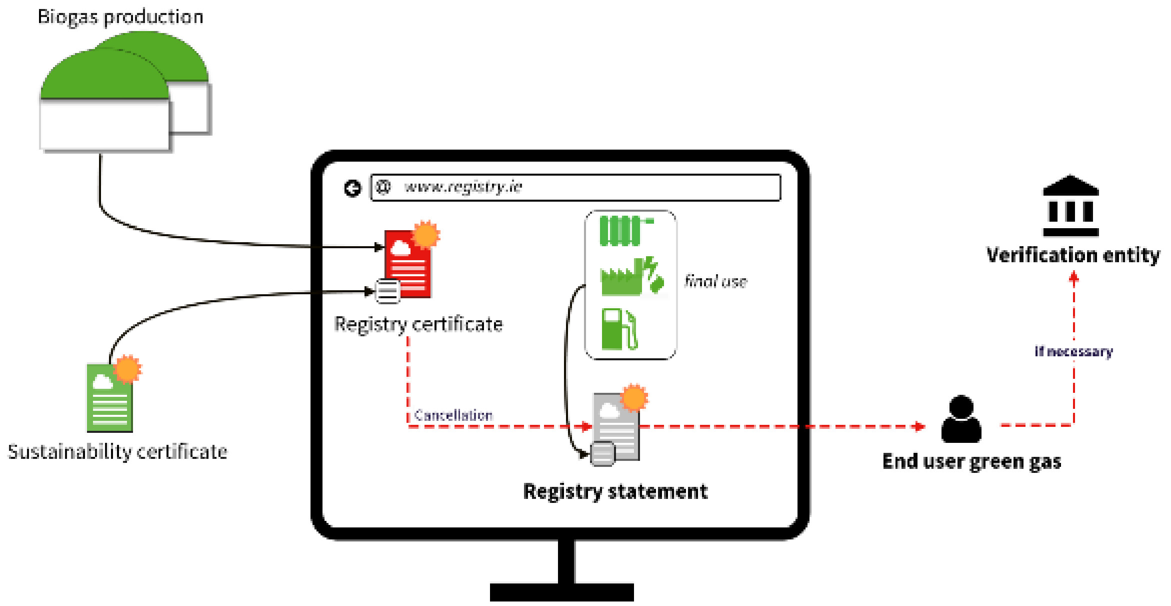


Figure 2 Interface between certification scheme and registry

4 Certification system

This chapter summarises the main elements of the sustainability certification blueprint developed in the GreenGasCert project. The chapter includes findings from the deliverables produced under work package

The Green Gas Cert project has developed a blueprint for an Irish certification system for green gas and the associated greenhouse gas emissions savings. It considers the gas sources, production systems and potential end uses that will be unique to Ireland. The blueprint developed includes the following main elements:

- A GHG calculation methodology, suitable for green gases and in compliance with the requirements of the EU RED directive
- A tool for GHG calculation based on the defined methodology and suitable for relevant stakeholders
- A first set of sustainability criteria, in addition to the criterion of the GHG mitigation performance
- A template for a sustainability certificate

These Elements will be described in more detail in the following subchapters.

4.1 Certification of Renewable Gas in Ireland – GHG calculation methodology (D1.1)

This section describes the GHG calculation methodology defined in the GreenGasCert project. The following short subsection summarises the main elements and features of the methodology and the tool to be developed.

4.1.1 The GGCS GHG calculation approach in a nutshell

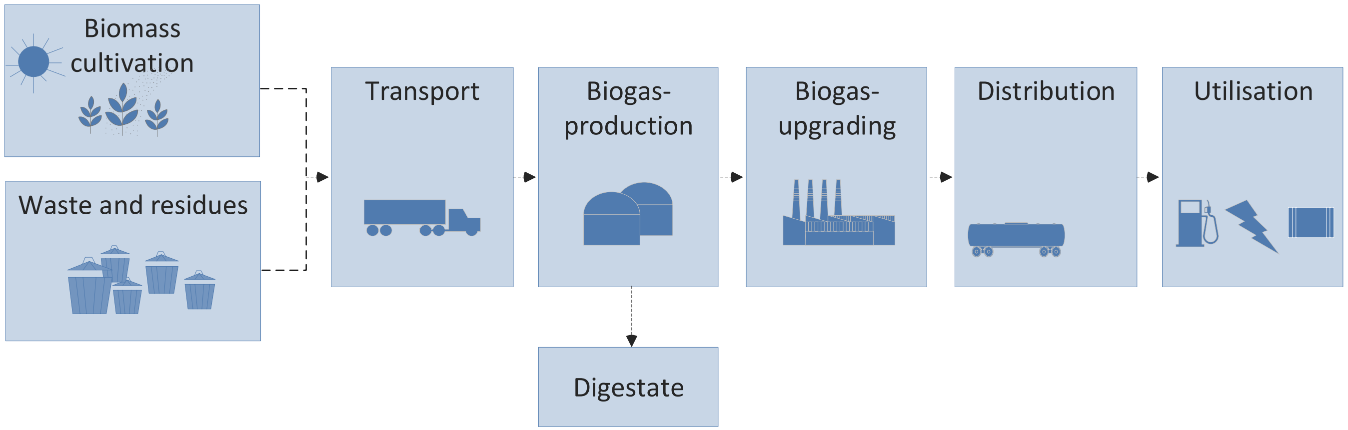


Figure 3 Examplary generic biomethane value chain

- Covers the complete life cycle of green gases
- The GGCS carbon footprinting approach allows differentiating between different methodological set-ups such as the EU RED methodology, LCA, etc.
- Results will be presented for intermediate products (Feedstocks, Biogas, Biomethane) as well as for the application of green gas in different applications (transport, electricity, heat)
- Can be used by Farmers and producers of Biogas, Biomethane and Green Gases
- Will be implemented and supported by a calculation tool

4.1.2 Introduction

Assessing greenhouse gas (GHG) emissions of products and processes has become increasingly significant over the past years. Especially in the field of renewable energy, many studies have been conducted to analyse the potential benefit of novel, alternative energy sources in comparison to the use of traditional fossil energy carriers.

Different methods and technical standards do exist for the calculation of GHG emissions. Amongst others, the GHG protocol standard as well as the ISO 14067 are available. Most of the currently available standards and methods are based on the concept of life cycle assessment (LCA), which has been described in the ISO 14040. An important reason for standardization is that this process increases comparability and transparency of study results. The LCA approach described by ISO 14040 standards allows for an assessment of potential impacts associated with the production and utilisation of a product or a process. Depending on the impact category, potential impacts on soil, water, air, human health and more, can be described and quantified. Most of the described methods for GHG calculation or carbon footprinting are based on the LCA approach, but focus solely on the impact category of Global Warming Potential.

With the market entry of biofuels for transportation purposes and the introduction of mandatory sustainability criteria on EU level (as part of the EU Directive 2009/28/EC, EU RED), GHG emission calculations have become an important topic in the context of sustainability certification. The proof of specific GHG mitigation thresholds, as for example defined in the EU RED has to be based on a robust, transparent and reproducible methodology. Furthermore, the methodology has to be applicable in a certification process which defines specific requirements in terms of simplicity, robustness, data availability, etc. Consequently, the methodology for GHG calculations included in Annex V of the EU RED is less complex compared to other scientific standards for carbon footprinting.

4.1.3 Requirements for GHG calculations in the context of this project

The objective of the first task in the GreenGasCert Project is to define a robust methodology for the calculation of GHG emissions for green gas supply chains (with a clear focus on biogas and biomethane) in Ireland. The method shall be in compliance with the EU legislation and shall include Irish specifications. Thus, the current methodology defined in the EU RED will be the basis for the work in this project. However, while the sustainability certification as well as the individual calculation of GHG emissions is by now a common practice for liquid biofuels such as biodiesel and bioethanol, calculations for biomethane are often associated with methodological and data-related uncertainties and fuzzinesses. Furthermore, a number of specialties in regard to biogas supply chains as well as regional, Irish specific parameters have to be integrated into the methodology throughout the project. In the context of this deliverable, we will describe a methodology to calculate:

1. Emissions from the production of green gases (or respective intermediates and feedstocks) and
2. The GHG mitigation potential of the green gas used in various applications compared to reference values.

4.1.4 Principles for the calculation of GHG emissions

The methodology described in Annex V of the EU RED was designed mainly to assess GHG emissions for liquid biofuels and bioliquids and to calculate the GHG emission savings compared to the use of fossil fuel references. It has been widely used for biofuels since the introduction of the EU RED in 2009. Since the current draft of the RED recast for the 2021 – 2030 timeframe aims at an extension of the sustainability criteria to other sectors of bioenergy (electricity and heat) and a common GHG calculation approach, this methodology seems to be the most appropriate solution for the topic of GHG emission calculations in the Green Gas Certification Project for Ireland. There is however little experience with the application of this methodology for biogas and biomethane in practice.

Annex V of the EU RED includes the description of a simplified approach (compared to the above mentioned, more complex and comprehensive ISO or DIN standards for LCA and carbon footprinting) for the calculation of a biofuel producers individual GHG- mitigation potential. The EU RED methodology defines the basic framework for the calculations by a clear definition of:

- the system boundaries (well- to-wheel),
- the allocation of by-products (based on the lower heating value of products and by-products),
- the functional unit for the expression of the result calculated (per MJ of energy carrier produced),
- the life cycle impact assessment approach (limited to category of global warming GHG-emissions),
- the characterization factors for the conversion of greenhouse gases into CO_2- Equivalents,
- the reference value for the comparison and interpretation of the result (at least for the transportation sector).

The clear definition of this methodological framework allows for a consistent comparison of different value chains from individual operators on a common basis as well as a constant benchmark and monitoring of the development of the biofuels GHG-mitigation potential over time.

4.1.4.1 Calculating GHG emissions

Following this approach, the GHG emissions from production and use of green gases shall be calculated as:

$$E = \underbrace{e_{ec} + e_{l} + e_{p} + e_{td} + e_{u}} \qquad \underbrace{- e_{sca} - e_{ccs} - e_{ccr} - e_{ee}}$$

E = Total emissions from using the green gas

GHG emissions from:

e_{ec} = Feedstock production

e_{l} = Land-use change

e_{p} = Processing

e_{td} = Transport & Distribution

e_{u} = Use

GHG emissions savings through:

e_{sca} = Improved agricultural management

e_{ccs} = Carbon capture and geological storage of CO_2

e_{ccr} = Carbon capture and replacement of CO_2

e_{ee} = Excess electricity from CHP

According to this equation, the total GHG-emissions of the green gas will be calculated considering both, the emissions from the various process steps (left side of the equation) involved in its production and utilisation and the potential GHG-emission savings from different processes (right side of the equation).

According to this equation, the total GHG-emissions of the green gas will be calculated considering both, the emissions from the various process steps (left side of the equation) involved in its production and utilisation and the potential GHG-emission savings from different processes (right side of the equation).

The essential idea of this approach is that emissions within one supply chain are calculated by every supply chain element individually. Beginning with the biomass cultivation, covering processing elements for the production of green gases and ending with the utilisation (for this phase of the project we focus energy production only). Throughout this process, every interface passes information regarding the GHG emissions associated with the production step to the next interface downstream. This enables the last interface to sum and report the total emissions for the green gas produced. Finally, depending on the application for the produced energy carrier, a reference value can be used to calculate the GHG mitigation potential of the green gas value chain.

4.1.4.2 Calculating GHG emissions for each term of the equation

GHG emissions are calculated for each interface and, based on the amount of processed intermediate product and are passed along to the downstream interface. The same calculation principle applies to the terms e'_{ec}, e'_{p}, e'_{td}. In order to determine the GHG emissions of these interfaces, the auxiliaries and energy carriers used in the process chain are multiplied by their emission factors[2] and divided by the amount of intermediate or main product. The European Commission published a list with standard

[2] Emission factors are "emission backpacks" of materials, energies or products. They reveal the environmental impacts (e.g. GHG emissions) connected to the production and use of a material / energy / product. Scientific papers and approved databases serve as sources for emission factors.

values for emission factors. The list can be downloaded from European Commission´s website. It is not exhaustive. If an individual calculation is prepared, emission factors should be taken from this list. According to the note of the European Commission on this topic, it is allowed to use values from different sources, if it is highlighted in the documentation and reasons for not using the standard value are to be documented (EC 2017).

In case, the carbon content of the green gas investigated is derived from biomass, the CO_2-GHG-emissions from the process of utilisation (e'_u) shall be rated as zero.

$$e'_{ec,p,td,u} = \frac{\sum(Amount\ of\ material\ input * Emission\ factor\ of\ the\ material\ )}{Yield\ or\ quantity\ of\ the\ (intermediate)\ product}$$

The term e‘ represents the GHG emissions based on the (intermediate) product of the respective process step (e.g. g CO_2-eq./Nm^3 of biogas). The term e stands for the GHG emissions based on the product’s energy content (e.g. g CO_2-eq./MJ of biomethane).

Special rules apply to calculating the terms e'_l, e'_{sca}, e'_{ccs}, e'_{ccr}, e'_{ee}, which are explained in the following sub-sections.

4.1.4.3 Allocating GHG emissions between main and by-products

If by-products are produced as part of the green gas production process, the GHG emissions resulting from the production process (until the co-product is produced) are allocated between the main product (green gas) and the by-product (e.g. digestate). A number of possible approaches exist for such an allocation procedure. However, since the GHG calculation approach in this project is aiming for compliance with the RED framework, the allocation shall be based on the lower heating value (based on the fresh matter) of the main product and the by-products.

The allocated value is passed on to the downstream interface and is calculated as follows:

$$e_{allocated} = GHG\ emissions\ up\ until\ the\ production\ of\ the\ by-product * Allocation\ factor(AF)$$

$$AF = \frac{m_{main\ product} * H_{lower,\ main\ product}}{m_{main\ product} * H_{lower\ main\ product} + m_{by-product} * H_{lower\ by-product}}$$

$$where\ m = mass, H = heating\ value$$

4.1.4.4 Calculating the GHG mitigation potential

As described above, the last interface will calculate the overall emissions and the emission saving. In advance, the base of the emission figure must be converted. Since the interfaces producing feedstock or intermediates do not necessarily know which the end use will be and how efficiently final biofuels will be produced, emissions are calculated in g CO2-eq/t. The last interface will therefore have to convert the base into MJ, to enable referencing to a fossil fuel comparator. It is important to mention in this context, that the emissions need to be reported as emissions per t dry substance. If necessary the following formula may be used for conversions (EC 2015):

$$e_{ec}feedstock_a\left[\frac{gCO_2eq}{kg_{dry}}\right] = \frac{e_{ec}feedstock_a\left[\frac{gCO_2eq}{kg_{moist}}\right]}{(1 - moisture\ content)}$$

Once the total emissions have been calculated, the GHG emission saving potential is calculated by the final interface in the value chain using the formula below:

$$GHG\text{-}reduction = \left[\frac{E_{Fossilfuel} - E_{Green\ gas}}{E_{Fossilfuel}}\right] * 100$$

$E_{Fossil\ fuel} = total\ emissions\ of\ fossil\ reference\ fuel\ (depending\ on\ the\ type\ of\ application)$

$E_{Green\ gas} = total\ emissions\ from\ the\ production\ and\ utilisation\ of\ the\ green\ gas$

4.1.4.5 Standard values and individual calculations

In order to decrease unnecessary administrative burdens for market actors, the process of GHG emission calculation of a green gas in the context of sustainability certification can be supported by using default values. These default values can cover typical green gas production value chains including typical feedstocks and technology set-ups. In the context of this project, three possibilities will exist for green gas producers to proof that the GHG-mitigation potential of their product meets the defined requirements and thresholds:

1. The use of the default values provided by the certification scheme
2. An individual calculation based on actual values
3. A combination of actual values and disaggregated default values.

Throughout this project, a number of default values for green gas value chains in Ireland will be developed. These default values will supplement the existing default values included in the EU RED as well as future EU RED 2 default values. If there is no default value for a certain supply chain available, an individual calculation is inevitable. If default values are available, the overall emissions are ether determined by the total default value or a combination of disaggregated default values and actual (individually calculated) values. In the current version of the RED default values for biogas pathways only exist for dry manure, wet manure and municipal organic waste. Individual emission calculations are necessary for all other feedstock types.

There is one exception for the emissions associated with the cultivation of biomass (eec). Apart from individual calculation and the use of disaggregated default values, a user may also apply values from “NUTS 2 reports [3]” (EC 2010). The so called “NUTS 2 values” take region specific data into account, e.g.

[3] The NUTS 2 reports contain emission values from cultivation of feedstock typical for certain regions („NUTS 2 regions“). These can be considered to be more accurate, since the default values in the RED have a global scope

on soil and climate. The European Commission published a table containing NUTS 2 values reported by the member States. This table contains values for ethanol from winter wheat, spring wheat, corn, rye, winter barley, summer barley, and triticale as well as for biodiesel from rape seed, sunflower and soybean. Furthermore there are values for pure vegetable oil from rape seed and sunflower. Data availability for the different countries and fuels differs (European Commission 2017). Since there are no values for biogas or biogas substrates available (for Ireland only values for wheat ethanol, rapeseed oil and rapeseed biodiesel were reported), there is no relevance of NUTS 2 values for this project. However, Ireland specific NUTS2 values for green gas substrates might be available in the future.

If there is a combination of disaggregated default values (which are expressed in the unit g CO_2eg/MJ) and actual values (expressed in unit g CO_2eq/kg) it is important to have information on assumptions made for the calculation of disaggregated default values. To convert the MJ base into kg, information on the LHV is necessary. A table on the assumptions applied for the calculation of default values can be found in (EC 2015, S. 8.)

4.1.4.6 Calculation procedure

The calculation steps for each value chain process are explained in the following sub-chapters.

Various types of data from different data sources are required as part of the GHG balance. These are summarised in Table 5.

Table 5 Types and sources of data

Types of data	Sources of data
Operating consumption data (raw material production, processing, transport)	Actual measurement required
Emission factors	Taken from literature, databases
Heating values	Taken from literature, databases, actual measurement
Nitrous oxide emissions	Model approaches as per IPCC or GNOC

4.1.4.7 Emissions from extraction or cultivation of raw materials (e_{ec})

The first calculation step requires a clear characterisation of the type of feedstock used for the green gas production process. The differentiation between cultivated biomass and waste and residue materials as feedstock has a significant influence on the result for this process step. In case wastes or residues are used as feedstock, emissions from the "production" of these materials shall be rated as zero. The emission calculations for value chain elements based on these materials shall be started with their collection.

It is not always clear whether a material can be considered a waste or a residue. For calculations in the EU RED context, there is a report dedicated to this topic. This report includes definitions and additional information (European Commission 2012). For the purpose of this project, a decision tree for the differentiation of different material categories has been developed. It is included in A1 of the project Deliverable D1.1.

Furthermore, it should be kept in mind that national regulations differ among the European countries and member states. As a result, materials declared as wastes or residues in one country can be characterised differently in others. There is no register or similar to merge and manage this information. In case of doubt, the respective national authority need be asked for guidance.

In case the feedstock for green gas production is cultivated, this process of biomass production needs to be reflected in the calculations. As generally described above, all input materials need to be considered. The respective emissions of the process of biomass cultivation are calculated by multiplying the amount of the relevant input materials with the respective emission factors. The sum of total emissions is divided by the yield of the product or intermediate. For the calculation of e_{ec}, the following inputs and outputs have a major influence shall be considered in particular:

Table 6 Types and sources of data for biomass cultivation

Inputs	Outputs
Seeds	Crop Yield
Fertilizer (synthetic, organic) CaO, N, P_2O_5, K_2O	Residues or by-products[4]
Pesticides	N_2O emissions
Diesel (field preparation, harvesting, etc.)	
Heat, Electricity (e.g. for post-harvest processing)	
Plant protective agents	

The consideration of emissions originating from the production of inputs for cultivation or extraction is highly relevant for the production of chemicals, fertilizers or diesel fuel. Beyond the system boundaries however are manufacturing of machineries used, such as trucks, tractors and field equipment. Besides, the CO_2 uptake by biomass during growth is not considered here. This is accommodated by the assumption of zero emissions during the use phase of the fuel. An important part of the GHG emissions from biomass production is usually associated with direct and indirect N_2O emissions which occur as a consequence of N-fertiliser application. These field emissions are dependent on the type of crop cultivated, the specific crop management and the kind and quantity of

[4] Residues or by-products can also be inputs, e.g. in case of biogas digestate

fertilizer used. For the calculation of N_2O emissions in the context of this project, two approaches are applicable. Following, the European Commission's recommendation for calculations in the EU RED context, the IPCC calculation methodology is applicable. (EC 2010). Furthermore, the GHG calculation tool for green gas value chains to be developed in this project will include a N_2O calculator based on the GNOC calculation methodology.

4.1.4.8 Emission savings from improved agricultural management (e_{sca})

An improved agricultural management can lead to soil carbon accumulation over time. In the process of GHG emission calculations, this accumulation is translated into a GHG-credit that can be attributed to the final product of the value chain. The following agricultural management practices can be result in an accumulation of additional soil organic carbon:

- Shifting to reduced or zero-tillage,
- Improved crop rotations and/or cover crops, including crop residue management,
- Improver fertilizer or manure management,
- Use of soil improver (such as compost) (EC 2010).

A user is allowed to take the savings into the calculation if he is able to prove that soil carbon content was increased by the cultivation of the relevant raw material. Prove should be supported by results of soil analysis. For the purpose of this project we recommend that specific definitions of qualified agricultural management practices and appropriate analytical methods shall be developed in close cooperation with national Irish authorities.

If such evidence is given, the GHG savings can be calculated with the following formula:

$$e_l \left[\frac{kg\ CO2eq}{kg\ harvest\ yield}\right] = \frac{CS_R \left[\frac{kg\ C}{ha}\right] - CS_A \left[\frac{kg\ C}{ha}\right]}{harvest\ yield_{main\ product} \left[\frac{kg}{ha * a}\right] * a_c[a]} * 3.664 - \frac{1}{AF * CF}$$

e_l‘	Annualised greenhouse gas emissions from changes in carbon stocks as a result of land-use changes
CS_R	Carbon stocks associated with the reference land use per unit of area at the time of reference or 20 years before production of the raw material, depending on which point in time is later.
CS_A	Carbon stocks associated with the actual land use per unit of area. When the carbon stocks accumulate over more than one year, the CSA value is considered to be the estimated carbon stocks after 20 years or at the time when the plants are mature, depending on which point in time is earlier.
a_c	No of years in which the relevant crop has been grown
AF	Allocation factor
CF	Conversion factor

4.1.4.9 Emissions from Land-use change (e_l)

As part of the general sustainability criteria defined for the sustainability certification scheme to be developed in this project, we do exclude the use of biomass produced on land with high carbon stocks or high biodiversity for the production of green gases. Besides the definition of no-go areas which shall not be used for biomass production, other land use change scenarios could be relevant in the context of this project. For the calculation of GHG emissions from feedstock production, emissions from land use change shall be included. A land-use change is defined as a change in land cover between the following seven categories:

- Forest land
- Grassland
- Cropland (includes fallow land)
- Wetlands
- Settlements
- Other land
- Perennial crops (e.g. SRC, oil palm)

If a land-use change occurs, the carbon stock of the soil will change and as a result emissions may occur. The RED has determined a specific due date for the consideration of emissions from land use change (01.01.2008). If a regarded area has had the same assignment to one of the above listed land categories on 01.01.2008 and afterwards, there is no need to consider emissions from land-use change. If there has been a change in land-use since then, emissions from carbon stock change have to be calculated with the following:

$$e_l{}^{‘}\left[\frac{kg\ CO2eq}{kg\ harvest\ yield}\right] = \frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{harvest\ yield_{main\ product}\left[\frac{kg}{ha * a}\right] * 20[a]} * 3.664 - \frac{1}{AF * CF}$$

$e_l{}^{‘}$	Annualised greenhouse gas emissions from changes in carbon stocks as a result of land-use changes
CS_R	Carbon stocks associated with the reference land use per unit of area at the time of reference or 20 years before production of the raw material, depending on which point in time is later.
CS_A	Carbon stocks associated with the actual land use per unit of area. When the carbon stocks accumulate over more than one year, the CSA value is considered to be the estimated carbon stocks after 20 years or at the time when the plants are mature, depending on which point in time is earlier.
AF	Allocation factor
CF	Conversion factor

4.1.4.10 Emissions from processing (e_p)

For the production of green gas products a number of different processing steps can be necessary. The calculation of emissions from these processing steps shall include emissions from the process itself as well as emissions from the production of inputs (chemicals, materials), wastes and leakages (e. g. wastewater, product losses).

For typical biomethane value chains, it might be appropriate to discuss at least two main processing steps. The first processing step includes the production of biogas from a feedstock or a combination of feedstocks. The main product of this processing step, the biogas, may be upgraded in subsequent process steps. The inputs and outputs are quantified for a defined mass balancing period (e. g. one year). The total direct and upstream emissions are divided by the amount of biogas produced.

Table 7 Types and sources of data for processing I

Inputs	Outputs
Electricity, kWh/a	Methane yield, Nm^3/a
Process heat, MJ/a	Digestate, m^3/a
Process additives, kg/a	Methane loss, Nm^3/a

Data for the consumption of electricity and process heat should be available as measured and verifiable figures. Quantities of materials fed (e.g. additives) into the process should be proven by delivery notes, invoices, etc.

An important factor for the GHG-emission calculation of the biogas production process can be methane emissions from leakage and losses. Since these emissions are usually not specified for each biogas facility, we will follow the general assumption from the JRC staff working publication (source). Thus, a leakage of 1% (raw biogas) is assumed as default value. Biogas producers shall be allowed to use lower values for methane leakage in case they can provide actual measurements.

In case the energy supply of the biogas production process is supplied internally and biogas is used to produce heat and power, additional methane emissions from slippage can occur.

Subsequently to the production of raw biogas, the emissions from the upgrading of biogas to biomethane will be considered. Upgrading of biogas means the enhancement to a quality equivalent to the quality of natural gas. The main steps thereby are the removal of CO_2 and eventually H_2S, in case no desulphurization took place in the fermentation reactor. The main inputs are electricity, process heat and depending on the upgrading technology, activated carbon for desulphurization.

Table 8 Types and sources of data for processing II

Inputs	Outputs
Electricity, kWh/a	Waste water, m^3/a
Process heat, MJ/a	Biomethane yield, Nm^3/a
Activated carbon, kg/a	

After the upgrading to biomethane, the heating value of the biomethane produced needs to be defined, either by direct measurement by calculation. This is necessary because the heating value of the gas to be fed in needs to be adjusted by adding liquefied gas in order to meet the necessary requirements.

$$Q = V_{Biomethane} * c_{methane} * H_{s,Methane}$$

where

Q	is the amount of energy of the biomethane in [MJ/a]
$V_{Biomethane}$	Volume flow of the treated biomethane within the period of observation in m^3/a (as measured by the discharge of biomethane from the biomethane treatment process)
$c_{methane}$	Methane concentration of the treated biomethane within the period of observation in % (as measured by the discharge of biomethane from the biomethane treatment process)
$H_{s,methane}$	Calorific value of methane at 39.9 MJ/m^3

Conditioning of the upgraded biomethane can differ from site to site. It includes adjustment of the pressure and heating value. The main input in this process step is electrical energy for pumps and compressors. The pressure adjustment depends on the working pressure of the upgrading unit and the pressure of the gas grid to be fed in. The amount of liquefied gas to be added, depends on the methane concentration of the upgraded biomethane and the characteristics of the gas in grid.

4.1.4.11 Transport and distribution (e_{td})

All emissions resulting from transport and storage of raw materials, intermediates and final products shall be considered in the calculation. In biogas supply chains the main transport process is the transportation of the raw materials to the biogas plant. Since the emissions from this process are usually significantly lower than those of the other processes in the value chain, typically default values are used for this process step. If an actual value shall be calculated for transportation, the following data needs to be considered:

Table 9 Types and sources of data for transportation

Mass of the transported biomass (m), kg
Means of transport, t, fuel (capacity and fuel type)
Transport distance, loaded (d_{loaded}), km
Transport distance, empty (d_{empty}), km
Fuel consumption loaded (f_{loaded}), l/km
Fuel consumption empty (f_{empty}), l/km

With this information being provided and the necessary emission factor of the transportation fuel used, the emissions from transport can be calculated as follows:

$$e_{td} = \frac{(d_{load.} * f_{load..} + d_{empty} * f_{empty}) * EF}{mass\ of\ biomass}$$

4.1.4.12 Emission savings from carbon capture and geological storage (e_{ccs}) and carbon capture and replacement (e_{ccr})

Innovative technologies for the capture and utilisation or storage of CO_2 from bioenergy processes are considered an important technology to achieve global targets for climate protection. GHG emission savings from these technologies and can be estimated using the following formula for e_{ccs}:

$$e_{ccs}\left[\frac{g\ CO_2eq}{MJ}\right] =$$

$$\frac{produced\ CO_2[kg] - energy\ consumed\ [MWh] \times EF\left[\frac{kgCO_2eq}{MWh}\right] - input\ materials\ [kg] \times EF\left[\frac{kgCO_2eq}{MWh}\right] \times 1000}{biofuel\ produced\ [t]\ \times 1000 \times LHV_{biofuel}\left[\frac{MJ}{kg}\right]}$$

Savings from carbon capture and replacement can included in the calculation if the captured CO_2 is originating from biomass and is used to replace fossil-derived CO_2 in commercial services and products. Furthermore the emission saving shall be limited to emissions avoided through the capture.

The following formula shall be used to calculate e_{ccr}:

$$e_{ccr}\left[\frac{g\ CO_2eq}{MJ}\right] = \frac{produced\ CO_2[kg] - energy\ consumed\ [MWh] \times EF\left[\frac{kgCO_2eq}{MWh}\right] - input\ materials\ [kg] \times EF\left[\frac{kgCO_2eq}{MWh}\right] \times 1000}{biofuel\ produced\ [t]\ \times 1000 \times LHV_{biofuel}\left[\frac{MJ}{kg}\right]}$$

4.1.5 Distinctive features for the GHG calculation of biogas processes

4.1.5.1 Calculation of GHG emissions of biogas from multiple substrates/substrate mixes

Biomethane facitilies are typically supplied by a number of different feedstock producers. In order to exploit the resource potential in the catchment area and to ensure security of feedstock supply and flexibility, biogas plants typically run on more than one substrate in a so called co-digestion process. In addition, the goal of operators usually is to always operate the plant at full capacity to ensure an optimal economic performance. Both circumstances have an influence on the GHG calculation procedure. To appropriately address the co-digestion of different feedstocks at the same time, GHG emissions are calculated for each substrate stream individually. For this purpose, default values for typical biogas/biomethane yields of the feedstocks involved can be used. A first selection of biogas and methane yields for typical feedstocks is included in Annex A2. The GHG emission value for the total production shall be calculated based on the sum of the GHG emission figures for the individual substrate batches in the relevant period (e.g. one year) (weighted average). The value shall be calculated using the following equation:

$$E = \sum_{1}^{n} S_n \cdot \left(e_{ec,n} + e_{td,feedstock\ ,n} + e_{l,n} - e_{sca,n}\right) + e_p + e_{td,product}\ + e_u - e_{ccs} - e_{ccr}$$

Where S_n is the share of feedstock n, in fraction as input in the digester

$$S_n = \frac{P_n \times W_n}{\sum_1^n P_n \times W_n}$$

Where P_n = energy yield [MJ] per kilogram of wet input of feedstock n and W_n = weighting factor of substrate n defined as:

$$W_n = \frac{I_n}{\sum_1^n I_n} \times \frac{(1 - AM_n)}{(1 - SM_n)}$$

Where I_n = annual Input to digester of substrate n [t FS]; AM_n=Average moisture of substrate n [kg H_2O/kg FS]; SM_n= Standard moisture for substrate n

A special element of the GHG emission calculation for biomethane are potential emission savings from the use of manure as a biomethane substrate. According to the JRC staff working document (ref.) and the current RED 2 proposal (EC 2016) potential GHG emission savings from biomethane production based on manure might be included under the term esca. Section 6.3 discusses this topic in more detail.

If compliance with the sustainability criteria shall not be shown for the total gas volume-e.g. due to diversification or to take own usage into account, the overall figure is multiplied with the percentage corresponding to the quantity actually relevant for the calculation of the GHG savings.

4.1.5.2 Allocation of the digestate as a by-product of the fermentation process

Industrial processes do often produce more than just one product. In that case, the emissions produced up to this process are typically split or allocated between the process outputs (if they are products). The allocation/consideration of by-products is therefore a central aspect of carbon accounting and LCA. In general, several methodological approaches do exist to allocate emissions between products or main and by-products. Depending on the specific goal and scope, LCA studies typically include allocation approaches based on mass, energy content or economic characteristics. Furthermore, substitution or credit approaches have been used in a number of existing studies to include potential GHG mitigation effects from the use of by-products.

In order to allow for compliance with the EU RED framework, allocation procedures in this context of this project shall be based on the lower heating value of the products to be allocated. If co-products have negative energy content, an energy content of zero shall be used for calculations (European Commission 2009).

For the production of biomethane, the digestate is typically the most important by-product. In practice the digestate is usually used as a fertilizer. The digestate usually contains most or almost all nutrients from the feedstock. Since digestate, depending on the specific set-up of the biogas/biomethane facility, can be usually characterised by high water content, the allocation principle of the lower heating value does obviously underrate the value of digestate. Consequently, the allocation of emissions between biomethane and digestate will in practise often result in a zero emission allocation to the digestate.

In some cases, digestate is mechanically or thermally treated in order to separate liquid and dry phase of the by-product. This process step can help to produce a by product with a higher economic value. In that case, the actual calculation rules for allocation included in annex V of the EU RED are not explicit. The important point in this discussion is to define the actual point in the process, where allocation will take place.

Additional insight to this discussion is provided by the „Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels" (European Commission). According to this communication, the "allocation should be applied directly after a co-product (a substance that would normally be storable or tradable) and biofuel/bioliquid/intermediate product are produced at a process step. This can be a process step within a plant after which further 'downstream' processing takes place for either product. However, if downstream processing of the (co-) products concerned is interlinked (by material or energy feedback loops) with any upstream part of the processing, the system is considered a 'refinery' and allocation is applied at the points where each product has no further downstream processing that is interlinked by material or energy feedback-loops with any upstream part of the processing." (COM 2010).

This basically means that for those cases where individual process steps are connected and where feedback loops do exist or in case mass and energy flows cannot be allocated explicitly to a single process step, the overall system can be considered a black box (or refinery). In this case, the overall emissions resulting from sub-processes within the black box unit are allocated between the different (by-)products from the process.

Emissions to be divided shall be eec + el + those fractions of ep, etd and eee that take place up to and including the process step at which a co-product is produced (European Commission 2009).

As shown in Figure 4, it might be difficult do decide, at which point allocation occurs, when the liquid-solid separation takes place at the very end of the process and biogas production, upgrading and digestate treatment are interconnected to each other. In case of such close connected process steps and due to the corresponding feedback loops (e.g. recirculation of the liquid phase from the treatment of the fermentation residue to the fermenter), the refinery approach described in EU COM 2010/C 160/02 is transferable to the biomethane system (EC 2010). The recommendation also states: "if the system is considered as a 'refinery'…the allocation occurs at the point in time when the individual products no longer undergo any further downstream processing connected through a material or energy feedback loop to an upstream part of the process." This would be after the treatment of the digestate as illustrated in Figure 4 (since the treatment of the digestate also represents a feedback loop through the recirculation of the liquid phase).

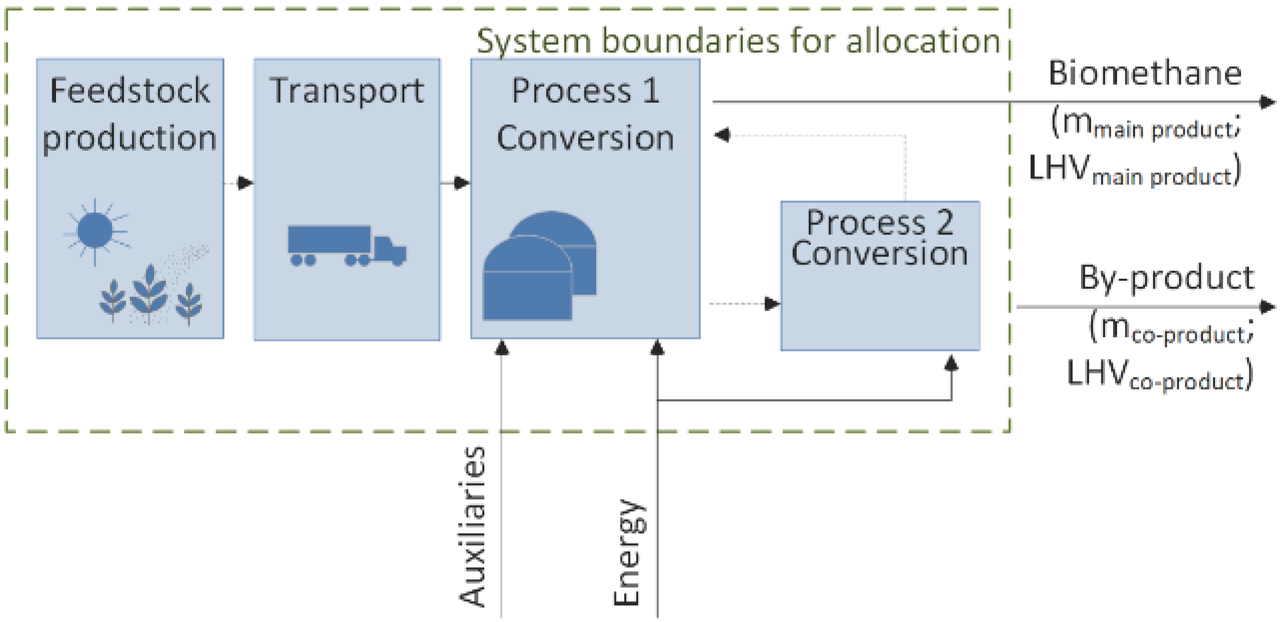


Figure 4 Allocation between main- and by-products, (DBFZ, own illustration)

4.1.5.3 *Inclusion of GHG emission savings due to the fermentation of wastes and residues from agriculture*

Storing manure or landfilling waste leads to considerable GHG emissions. Biogas and biomethane production can help to avoid methane emissions which would arise from the conventional treatment and storage of these materials. It is important to notice, that this discussion has two aspects. The first point is the discussion of potential options to include these emission savings under the equation discussed in 4.1.4. This will be done, using the example of manure fermentation in one of the case studies for the exemplary calculations. The second aspect is the use of scientifically sound credits for the emission savings attained, based on the best available scientific literature. A number of publications summarising the magnitude of the potential are available (e.g. Kirchmeyr et al.). Since the avoidance of emissions takes place at the stage of feedstock supply, the emission credit should be considered as negative emissions in the term e_{ec}.

For the purpose of this project, a bonus of 45 gCO_2eq / MJ manure shall be attributed and included under the term esca for improved agricultural and manure management in case animal manure is used as a substrate for the production of biogas and biomethane. The value of 45 gCO_2eq. / MJ follows the recommendation of the EU Commission publication „Commission Staff Working Document – State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU" (SWD(2014) 259), published in August 2014. Furthermore, this value is in line with the current discussion regarding emission savings from manure fermentation in the RED 2 context.

4.1.6 Specific characteristics of biogas and biomethane production in Ireland

The main objective of WP 1 in the Green Gas Certification project for Ireland is the development of a GHG calculation methodology which is both, in compliance with the European legislation and tailor made for the Irish frame conditions. For this purpose, important inputs from WP3 as well as information from a recent publication of the Irish sustainable energy authority, describing the potential for a future Irish biogas industry (SEAI 2017) will be considered. Based on this information, a number of case studies will be developed which serve to illustrate the theoretic approach of the GHG calculation described in the previous chapters. Table 10 shows the results of a scenario for feedstock potentials, costs and biogas production potentials in 2035 from the SEAI 2017 study. The most promising resources are manure and grass silage, which could contribute to 2% and 22% of the natural gas supply, respectively (this figure prerequisites improved management and release of land). Since grass silage is the only non-waste feedstock, the cost for this feedstock is estimated many times higher than for the other feedstock (some having even negative costs).

Table 10 Feedstock potentials and cost indications for a 2035 Biogas scenario in Ireland (SEAI 2017)

Feedstock	Quantity in 2035	Cost	Potential biogas production in 2035
kt	€/t	ktoe	PJ
Food waste	511	-60 to 0	28
Agri food waste	305	Assumed zero	28
Sewage sludge	174	Not estimated	11
Manure (pig and cattle)	5,679	0 to 1.85	59
Food waste	511	-60 to 0	28

4.1.7 Exemplary calculations

This chapter will illustrate the calculation methodology determined in the previous chapters using examples of conversion pathways reflecting typical Irish feedstock and feedstock combinations. These examples shall represent realistic chain of custodies within the biogas industry in Ireland and cover different feedstock and energy products as well as plant capacities. Therefore inputs and results from other WPs, especially WP3, on Irish research data, stakeholder information, etc. has been considered.

Case studies to be considered:

- Manure,
- Grass silage,
- Food waste
- Combinations of the above

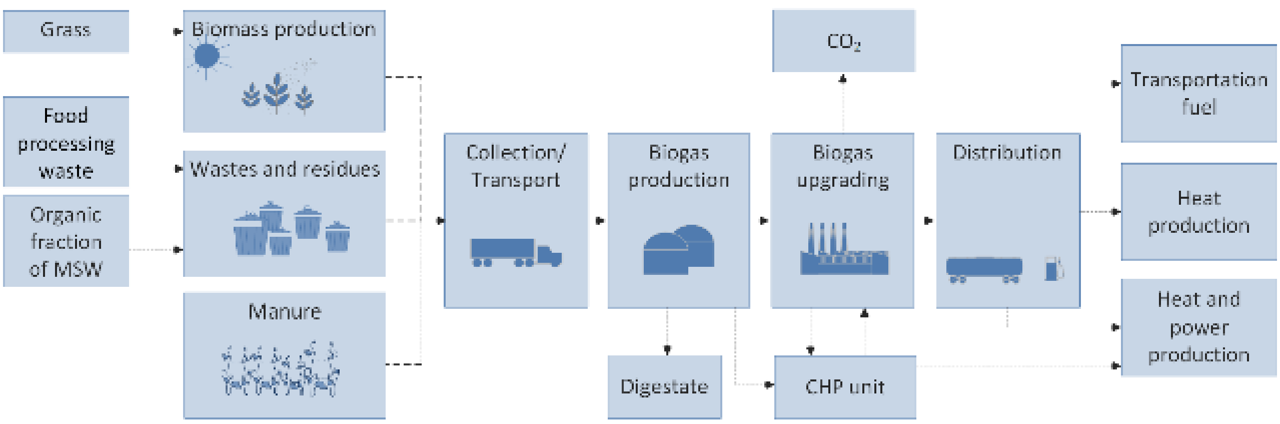


Figure 5 simplified illustration of exemplary pathways for calculations in chapter 4.2.7

Below the GHG emission calculations will be described for each of the process steps involved different exemplary calculations are presented following the order of the production steps. This shall increase the understanding of the influence of different biomass types/transport options/conversions/end uses on the potential impact in terms of GHG emissions.

4.1.7.1 Emissions from extraction or cultivation of raw materials (e_{ec})

As described, it will be necessary to conduct several calculations (one for each substrate flow), in case a biomethane plant uses different substrates from several producers. This subsection will demonstrate the calculation approach for the process of biomass production.

Grass silage production

Grass has long been mooted as a potential feedstock for biomethane in Ireland and has been identified as the most significant resource for Ireland for anaerobic digestion and could produce up to 35PJ energy supply by 2035. This is 22% of the 2015 natural gas supply (SEAI 2017).

For this exemplary calculation we assume a grass production on an 8-year cycle with two cuts per year. In order to seek compliance with the RED methodology on the one hand and to reduce the effort for the calculations on the other, we will calculate the GHG emissions from grass production on a per year basis. This means that inputs and production yields will be averaged for each production year. Following the approach described in (Smyth et al. 2009), we will use the following assumptions for the GHG emission calculation of grass production.

Table 11 Material and energy inputs and outputs of the biomass cultivation

Material/Energy	Input/Output	Unit	Value	Source
N Fertilizer	I	$kg*ha^{-1}\ a^{-1}$	275	(Smyth et al. 2009)
K_2O Fertilizer	I	$kg*ha^{-1}\ a^{-1}$	295	(Smyth et al. 2009)
P_2O_5 Fertilizer	I	$kg*ha^{-1}\ a^{-1}$	30	(Smyth et al. 2009)
Diesel (field preparation, harvesting, etc.)	I	$l*ha^{-1}\ a^{-1}$	39,46[5]	(KTBL 2017a)
N_2O field emission	O	$Kg\ N_2Oeq*ha^{-1}\ a^{-1}$	4,49	(Institute for Energy and Environmental Research 2015)
Biomass yield	O	$t\ DS*ha^{-1}\ yr^{-1}$	12	(Smyth et al. 2009)

[5] Includes field work for harvest and transport of biomass, N, P, K-fertilization, taking data of supplier 1 into account

In order to calculate the emissions resulting from the production process characterised above, the input data from Table 11 and the emission factors listed in A2.1 will be combined in the following equation:

$$e_{ec,Supplier1} = \frac{\left(\frac{N\ input}{ha*a}*EF\right)+\left(\frac{P\ input}{ha*a}*EF\right)+\left(\frac{K\ input}{ha*a}*EF\right)+\left(\frac{Diesel\ input}{ha*a}*EF\right)+\left(\frac{N2O\ emissions}{ha*a}*CF\right)}{X\ \frac{kg\ grass}{ha*a}}$$

$$= X\ \frac{kg\ CO2eq}{kg\ grass} = \boldsymbol{X}\ \frac{kg\ CO2eq}{t\ grass}$$

Based on the assumptions for this exemplary pathway, the calculation results in emission of 272.4 kg CO_2eq/t DS grass silage at the farm gate. The sum of the different inputs, each of them multiplied with the relevant emission factor is related to the substrate yield per hectare and year. The yield of silage has been taken from (Smyth et al. 2009).

$$e_{ec,Supplier1} = \frac{\left(\frac{275\ kg}{ha*a}*5.88\right)+\left(\frac{295\ kg}{ha*a}*0.66\right)+\left(\frac{30\ kg}{ha*a}*1.18\right)+\left(\frac{39.5\ l}{ha*a}*2.1\right)+\left(\frac{4.49\ kgN2O}{ha*a}*298\right)}{12000\ \frac{kg\ DS\ grass\ silage}{ha*a}}$$

$$= 0.278\ \frac{kg\ CO2eq}{kg\ grass\ silage} = \mathbf{272.4}\ \frac{kg\ CO2eq}{t\ DS\ grass\ silage}$$

As briefly described in 4.1.4.7, there are direct and indirect emissions from nitrogen fertilisation. The significance of these emissions for the total emission of the biomass cultivation becomes clear, when considering the emission factors in the above shown equation. In general, the nitrogen fertilization can be considered the main source of GHG emission during the cultivation of biomass.

Direct emissions arise from fertilizer production, which is a very energy intensive process. The field emissions are again subdivided into direct and indirect emissions, whereas direct N_2O emissions are caused by microbial activity in the soil and indirect emission are composed of the atmospheric deposition and the nitrate leaching. Therefore main influencing factors on the field emissions are soil type, type of crop, yield, quantity and kind of applied fertiliser.

For GHG emission calculations, there are two common and accepted methods available – the IPCC Tier 1 methodology and the GNOC method, developed by the Joint Research Center. For this example calculation the biograce tool I was applied, which makes use of the IPCC methodology. The tool is recognized by the European Commission to provide GHG calculation data. For the calculation of N_2O emission it is possible to refine the result by inserting specific data on the above mentioned influencing factors. The calculation resulted for this example in 4.49 kg N_2O per hectare and year.

Assuming a dry substance content of 22% (Smyth et al. 2009), the result of 272.4 kg CO_2eq/t DS grass silage-1 at the farm gate equals 59.94 kg CO_2eq/t FM grass silage-1.

Sensitivity analysis – Variation of N-Fertiliser upstream emissions

An important factor for the total amount of GHG emissions associated with the agricultural process for the production of biogas feedstock is the choice of the synthetic nitrogen fertiliser (in case no organic N-fertiliser is used). Upstream emissions can differ significantly between the various N-fertiliser products on the market. Emission factors for different N-Fertiliser can be taken from (Institute for Energy and Environmental Research 2015) and are included in A 2.1. To illustrate the potential impact from the choice of fertiliser on the total emissions from the process of biomass cultivation, we varied the emission factor for the nitrogen fertiliser, assuming a) the use of the average emission factor used under 4.1.71, b) the use of urea as N-fertiliser, c) the use of ammonium nitrate (AN) as N-fertiliser and d) the use of calcium ammonium nitrate (CAN) as N-fertiliser. For this calculation, all input parameter as well as the biomass yield as shown in Table 12 remain unchanged.

The results of this small sensitivity analysis show a significant influence of the upstream emissions from the production and supply of the N-fertiliser on the total result for the GHG emissions from biomass production. Compared to the base case (emission factor of 5.9 kg CO_2eq.*kg N-1; taken from BioGrace) for an average N-fertiliser mix, the use of Urea (emission factor of 1.9 kg CO_2eq.*kg N-1) results in significantly lower overall GHG emissions per t DS of grass silage produced. Figure 6 Impact of the variation of the type of N-fertiliser used on the overall emissions from biomass cultivation.

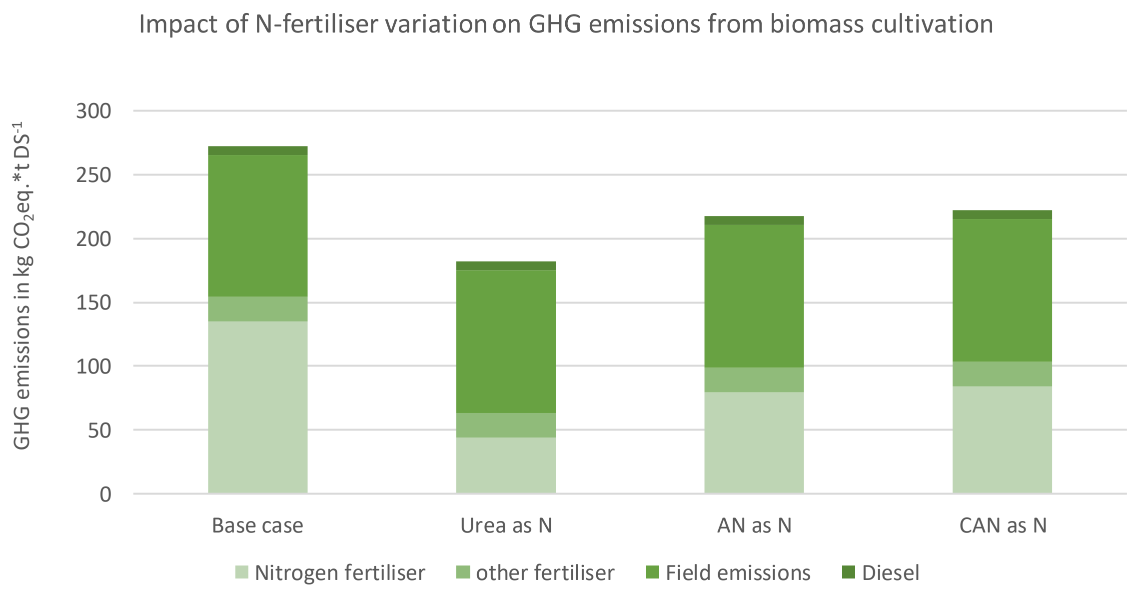


Figure 6 Impact of the variation of the type of N-fertiliser used on the overall emissions from biomass cultivation.

Manure

Manure is considered to be a waste from livestock production. It is therefore associated with zero emissions up to the point of collection and first transport. Since wastes are not cultivated, also the emissions from land use change are not applicable, as well as emission savings from improved agricultural management.

There is one specialty associated with the use of manure as biogas feedstock, which shall be discussed in this section. By utilizing manure for anaerobic fermentation, instead of storage and application on the field, emissions arising from microbial activity during storage and application will be avoided. If manure is stored, methane and further emissions (e.g. N_2O, NH_3) are released to the atmosphere, while when utilized in the biogas process, are captured and energetically used.

The estimation of the avoided emissions is rather complex. For the development of an emission factor, the kind of animal, the diet of the animal, the climate conditions, the husbandry and manure management system, have to be taken into account (Kirchmeyr et al. 2015). This is usually done on the basis of national inventory reports according to the Tier 1 method and Tier 2 method, respectively. Within the biosurf project, emission factors were calculated. The results are shown in Figure 7. It can be seen that there is a variation of the factors originating from the influencing factors mentioned above. Also the missing bars in chart indicate lacking national data, which make calculations even more difficult. More calculations were prepared by using emission factors of 79 gCO_2eq/MJ biomethane for cattle manure and 115 gCO_2eq for pig manure based on (Friehe et al. 2013).

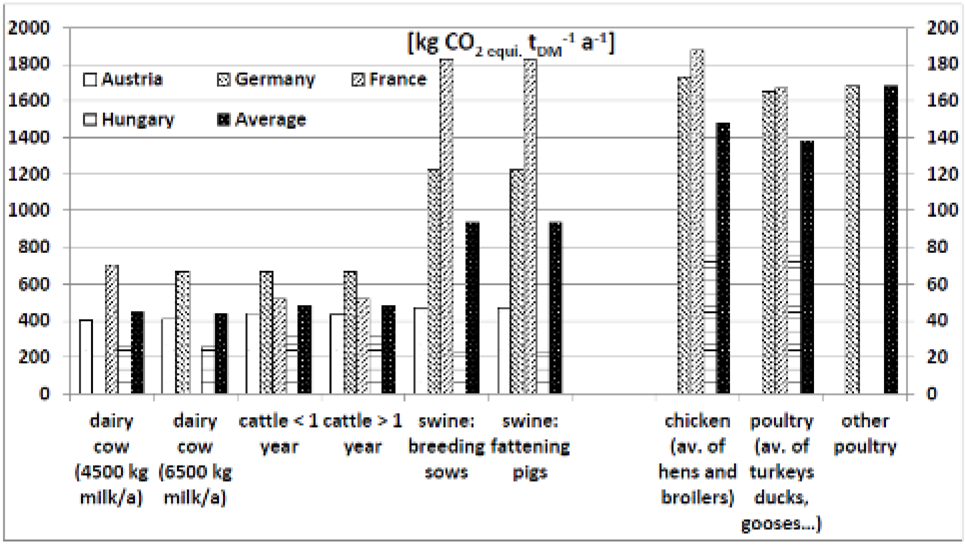


Figure 7 GHG emissions per tonnes of dry matter per year, country and animal category (Kirchmeyr et al. 2015)

In the version of the renewable energy directive currently valid, the methodology to be applied in order to be in line with the directive does not offer this potential saving to be realized so far, as there are no default values defined. As can be seen from the equation in 4.1.4, the RED methodology allows in general to consider emission credits. Since the RED was designed to ensure the sustainability of (conventional) liquid biofuels, the credits in the equation target these pathways and enable to account for emission savings from improved agricultural management (e_{sca}), carbon capture and geological storage of CO_2 (e_{ccs}), carbon capture and replacement of CO_2 (e_{ccr}) and excess electricity from CHP (e_{ee}). Options for more specific pathways, such as the manure to biomethane pathway are therefore not explicitly mentioned, also maybe due to the very low market relevance of biomethane based transportation fuels. However, it is assumable that this will change in the future, since proposal for the revised version of the RED, which will be in force in the next period (starting in 2020), contains a more comprehensive approach to address this topic. In the relevant section it expands the term “improved agricultural management” to “improved agricultureal and manure management” and furthermore determines a bonus of 45 g CO_2eq/MJ manure, in case animal manure is used as substrate for biogas and biomethane production (European Commission 2016). This value is based on the work of the Joint Research Center, which published a report in which the value is deduced, differentiated in CH_4 and N_2O emissions from manure (Giuntoli et al. 2017). This practically implies, that the avoided emissions due to anaerobic fermentation of manure will be addressed for in the term e_{sca} of the equation presented in 4.1.4. The value can be converted into 112 g CO_2/MJ biomethane, assuming a biomethane yield of 0.4027 MJ per MJ of manure.

The calculation of emissions starts with the feedstock production and when dealing with waste and residues with the collection. As in case of manure, climate relevant effects occur when manure is stored or are avoided if manure is fermented, another logical perception is to consider the emission credit in the term e_{ec} of the calculation formula as negative emissions. Both approaches will lead to same result of the total emissions. It should be mentioned that the above stated valuation represents the actual situation. Once the recast of the RED is valid more details on how to include the credit can be expected.

For the application of the GHG credit within the individual calculation of GHG emissions of biomethane production, we recommend using a credit of 112 gCO_2eq/MJ biomethane due to its reference in the RED2 proposal and as it fits into the range of scientifically sound results mentioned above.

Food waste

Food waste is considered a waste and residue material. There are no emissions included in the calculation up to the first transport of the material.

4.1.7.2 Emission savings from improved agricultural management (e_{sca})

Grass silage

For the purpose of the exemplary calculation we have assumed no emission savings from improved agricultural management for the grass silage production system. However, in case there is evidence for emission savings from an improved agricultural management (compare final project report, chapter 2.4.2) this factor can be included in the emission calculations.

4.1.7.3 Transport and distribution 1 (e_{td1})

Transport of substrate

The calculation of the emissions associated with the transport of the feedstock grass silage shall be illustrated vicariously for all of the exemplary value chains. The first transportation step includes the transport of grass silage from the field to the biogas plant. We assume a transport distance of 10 km. For the calculation of GHG emissions, data regarding the transport distance (loaded & unloaded) as well as the energy demand for the transport are relevant. The data in the table below includes energy demand for transport using a 24 t truck.

Table 12 Energy demand from transportation

Parameter	Value	Unit	Source
Transport distance, loaded (d_{loaded})	10	km	example
Transport distance, empty (d_{empty})	10	km	example
Fuel consumption, loaded (f_{loaded})	0.49	l/km	(BLE 2010)
Fuel consumption, empty (f_{empty})	0.25	l/km	(BLE 2010)

For the calculation of the transport emissions, we have used the emission factor for diesel included in A2.1 of D1.1. By using the following equation, the transport of 24 t of biomass over 10 km results to 0.65 kg CO_2eq per tonne:

$$e_{td1,Supplier1} = \frac{\left(\left(0.49\,\frac{l}{km} * 10\,km\right) + \left(0.25\,\frac{l}{km} * 10\,km\right)\right) * 2.1\,\frac{kg\,CO_2eq}{l}}{24\,000\,kg} = \mathbf{0.65}\,\frac{kgCO_2eq}{t}$$

Sensitivity analysis – Impact of transport distance for manure transport

Manure is characterised by a relatively low energy content when comparing with other biogas feedstock. Depending on the location and size of a biogas plant, this can be disadvantageous. It seems therefore relevant to examine the influence of the transport distance on the GHG emissions.

The transport emission per mass of biomass (tonne manure) is obviously not different from the one for grass silage, which we calculated in the previous section using the formula below.

$$e_{td} = \frac{(d_{load.} * f_{load..} + d_{empty} * f_{empty}) * EF}{mass\ of\ biomass}$$

To relate the result to the functional unit MJ biomethane the result of 0.65 kg CO_2 eq./t was converted. The transport distance was varied between 5 and 40 km. Figure 8 shows results of the emissions for the production of biomethane from manure. The bars represent the total emissions, differentiated in the share of the different stages according to the calculation formula against the transport distance of the substrate. The significance of the substrate transport is comparably low in general. Nevertheless, it can be seen, that increasing transport distance has a negative effect: The total emissions increase from 20.6 (5 km distance) to 22.7 g CO_2eq*MJ biomethane $^{-1}$ (40 km distance) while the percentage of the transport emissions on the total emissions increase from 1.4 % (5 km distance) to 10.4 % (40 km distance).

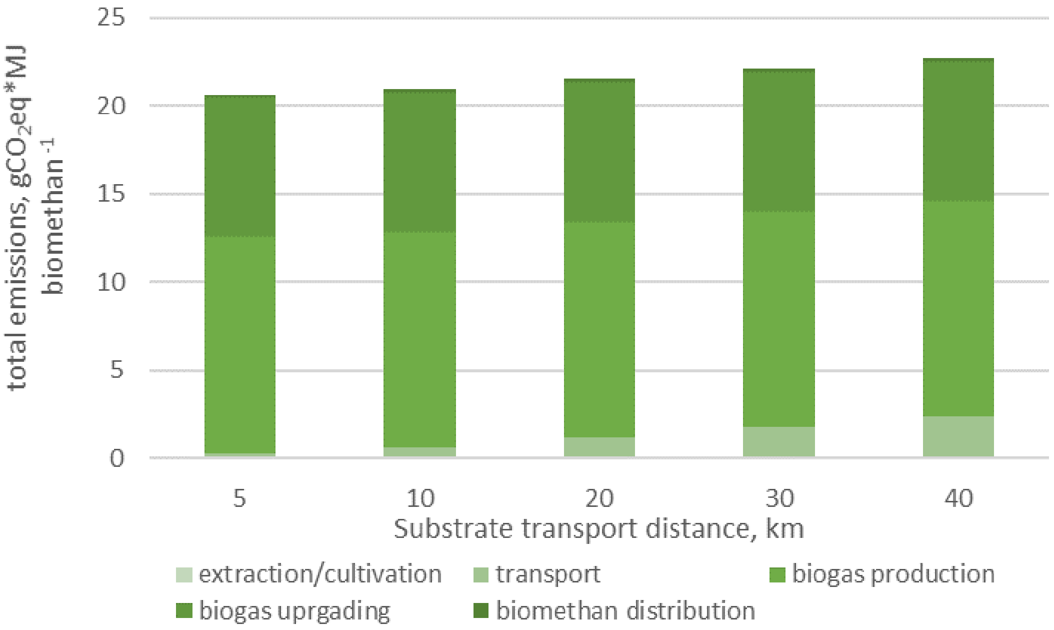


Figure 8: Impact on substrate transport distance on total emissions and percentage of transport emissions on total emissions for biomethane from manure (results without allocation of emissions to the by-product and without consideration of credits)

4.1.7.4 Emissions from processing (e_p)

Production of biogas from grass silage

After the transport of grass silage to the biogas plant, we assume a biogas production based on an annual input of 15,242 tonnes FM. Assuming a specific biogas yield of 600 lN/kg oDS, a dry substance content of 22% and a organic dry matter content of 90%, leads to a biogas yield of 1810749.6 m^3N/a or 995912 m^3N/a, when expressed as methane yield (methane content of biogas: 55%).

For the production of biogas in a continuously stirred biogas reactor, electricity for the equipment and process heat for maintaining a mesophilic temperature level of the substrate is required. The amounts of electricity and heat assumed to be necessary for the purpose of the exemplary process are given in the table below.

The main outputs of the process are digestate and biogas. According to JRC (JRC 2017), methane emissions might occur at different stages in the biogas production process. Following the recommendations given in (Institute for Energy and Environmental Research 2015), we assume methane emissions of 1% related to the raw gas output.

Table 13 Material and energy inputs and outputs of the biogas process

Material/Energy	Input/Output	Value	Unit	Source
Gras silage	I	15,242	t FM	own calculation
Electricity	I	288074	kWh_{el}/a	own calculation
Process heat	I	1160960	kWh_{th}/a	(KTBL 2017b)
Digestate	O	t/a	11449	(KTBL 2017b)
Net biogas yield	O	m^3_N/a	1792642	own calculation
Net Methane yield	O	m^3_N/a	985953	own calculation
Methane loss	O	m^3_N/a	9959	own calculation

Following the principle described in the previous calculations, we combined the energy demand described in Table 13 and the emission factors in A2.1 of D1.1

$$e_{p1} = \frac{\left(288074\frac{kWhel}{a} * 0.47\frac{kg\ CO_2eq}{kWh}\right) + \left(1160960\frac{MJth}{a} * 0.07\frac{kgCO_2eq}{MJ}\right) + \left(7171\frac{kg\ CH_4}{a} * 23\frac{kgCO_2eq}{kg}\right)}{985953m^3CH_4}$$

$$= \mathbf{0.386}\ \frac{kg\ CO2eq}{m^3CH4}$$

For the calculations in this process step, two points need to be highlighted specifically.

Firstly the supply with process energy is usually the biggest driver for emissions for this process. The magnitude of total emissions depends on the total energy demand of the process and the upstream emissions associated with the supply of process energy. The magnitude of total emissions depends on the total energy demand of the process and the upstream emissions associated with the supply of process energy. As a consequence, the choice of the source of energy for the process is crucial for the total emissions from process energy consumption. For this exemplary calculation, we are assuming a process energy supply based on externally provided power. Heat is supplied by a boiler operated with natural gas. In practice, different scenarios for the supply of process energy might occur depending on the specific economic prerequisites of the biogas plant to be investigated.

Secondly, the methane emissions are calculated assuming a loss of 1% related to the output of the anaerobic fermentation process. Assuming the above described yield of biogas from the substrate used, a total loss of 15844 m^3 CH_4 * yr^{-1} has been calculated. The contribution of these methane emissions to the GHG emissions of the process, is calculated by a) a conversion of the unit from m^3 to kg (assuming a density of 0.72 kg/m^3) and b) the consideration of the specific global warming effect of methane (23times CO_2).

Consequently, the emissions calculated for the process of biogas production sum up to 0.386 kg CO_2eq/m^3 CH_4. For the purpose of this exemplary calculation we are assuming that the digestate is stored in a gastight storage unit and off gases are being burned[6].

Upgrading of biogas to biomethane

For an upgrading of the biogas produced from the previous production step, a number of upgrading technologies do exist. For this exemplary calculation we are assuming the use of a pressure-swing-adsorption process (PSA). This upgrading technology does not require a supply of process heat. The amount of electricity required for upgrading of the biogas is estimated to be 0.25 kWh per m^3 of raw gas. Furthermore, the upgrading technology can be associated with methane slippage. These emissions can differ significantly depending on the type of upgrading technology used. Following the general assumption for the calculation of default values included in Annex V of the EU RED, we are assuming methane slippage of 1% (related to the total output of the process).

Table 14: Material and energy inputs and outputs of the biogas upgrading process

Material/Energy	Input/Output	Value	Unit	Source
Methane content of raw biogas	I	985953	m^3_N/a	own calculation
Electricity	I	448461	kWh_{el}/a	(KTBL 2017b)
Methane loss	O	9860	m^3_N/a	(KTBL 2017b)
Methane	O	976094	m^3_N/a	own calculation

The sum of the electricity and the methane emission to the air, multiplied with the respective emission factors are divided by the quantity of biomethane output, applying the formular below:

$$e_{p2} = \frac{\left(448461\,\frac{kWh}{a} * 0.47\,\frac{kg\ CO_2eq}{kWh}\right) + \left(7099\,\frac{kg\ CH_4}{a} * 23\,\frac{kgCO_2eq}{kg}\right)}{976094\ m^3CH_4} = \mathbf{0.38}\ \frac{kgCO_2eq}{m^3}$$

[6]A storage of the digestate in an open, or partly-open system might lead to additional emissions which have to be considered

8.4.2.1 Biogas production from manure

In this example calculation a plant is using liquid and solid cattle manure as substrate to produce biogas. The data in the table below correspond to a yearly substrate input of 10,000 t of solid cattle manure and 15,000 t liquid cattle manure.

Table 15: Material and energy inputs and outputs of the biogas generation from manure

Material/Energy	Input/Output	Value	Unit	Source
Electricity	I	141,225	kWh_{el}/a	(KTBL 2017c)
Process heat	I	1,401,365	kWh_{th}/a	(KTBL 2017c)
Digestate	O	23,175	t/a	(KTBL 2017c)
Methane yield	O	776,738	$m^3{}_N/a$	(KTBL 2017c)
Methane loss	O	7,768	$m^3{}_N/a$	own calculation

Using the input and output data in the table above in the equation below, leads to a result of 0.465 kg CO_2eq per m³ biomethane:

$$e_{p1} = \frac{\left(141225\frac{kWhel}{a} * 0{,}47\frac{kg\ CO_2eq}{kWh}\right) + \left(5044914\frac{MJth}{a} * 0{,}07\frac{kgCO_2eq}{MJ}\right) + \left(7768\frac{kg\ CH_4}{a} * 23\frac{kgCO_2eq}{kg}\right)}{776738m^3CH_4}$$

$$= \mathbf{0.441}\frac{kg\ CO2eq}{m^3CH4}$$

Upgrading of biogas from manure to biomethane

Upgrading of biogas is done via a pressure swing adsorption process. The relevant inputs and outputs are given in Table 16.

Table 16: Material and energy inputs and outputs of the biogas upgrading process

Material/Energy	Input/Output	Value	Unit	Source
Methane	I	768,970	$m^3{}_N/a$	own calculation
Electricity	I	353,063	kWh_{el}/a	(KTBL 2017c)
Methane loss	O	7,690	$m^3{}_N/a$	(KTBL 2017c)
Methane	O	761,280	$m^3{}_N/a$	own calculation

According to (KTBL 2017c) a methane loss during the process of 1% of the raw gas is assumed. The sum of the electricity and the methane emission to the air, multiplied with the respective emission factors are divided by the quantity of biomethane output, appling the formular below:

$$e_{p2} = \frac{\left(353063\frac{kWh}{a} * 0{,}47\frac{kg\ CO_2eq}{kWh}\right) + \left(7767\frac{kg\ CH_4}{a} * 23\frac{kgCO_2eq}{kg}\right)}{761280m^3CH_4} = \mathbf{0.285}\ \frac{kgCO_2eq}{m^3}$$

Production of biogas from food waste

To exemplary calculate the GHG emissions from the production of biogas produced from food waste as a feedstock, a model biogas plant consumes 20,000 t FM of food waste per year. Assuming 16% dry matter content and 87% organic dry matter content in the dry mass as well as a biogas yield of 94.7 m³ /t FM, the plant will produce 1,893,120 m³ biogas per year, which is equivalent to 1,135,872 m³ CH_4 presuming a methane content of 60%. Complete data needed to calculate GHG emissions from biogas from food waste are given in Table 17.

Table 17: Relevant material and energy inputs and outputs for the calculation of emissions from biogas production from food waste

Material/Energy	Input/Output	Value	Unit	Source
Food waste	I	20,000	t FM/a	assumption
Electricity	I	189,312	kWh_{el}/a	own calculation
Process heat	I	1,138,815	kWh_{th}/a	(KTBL 2017a)
Biogas yield	O	1,893,120	m^3_N/a	(KTBL 2017a)
Digestate	O	17,671	t/a	(KTBL 2017a)
Methane yield	O	1,135,872	m^3_N/a	(KTBL 2017a)
Methane loss	O	11,359	m^3_N/a	own calculation
Net methane yield	O	1,124,513	m^3_N/a	own calculation

The calculation was done in line with the other example calculations. The sum of the inputs multiplied by their corresponding emission factor, divided by the net methane yield results in 0.381 kg CO_2eq/m³:

$$e_{p1} = \frac{\left(189{,}312\frac{kWhel}{a} * 0{,}47\frac{kg\ CO_2eq}{kWh}\right) + \left(1{,}138{,}815\frac{MJth}{a} * 0{,}07\frac{kgCO_2eq}{MJ}\right) + \left(7768\frac{kg\ CH_4}{a} * 23\frac{kgCO_2eq}{kg}\right)}{1{,}124{,}513\ m^3CH_4} = \mathbf{0.381}\frac{kg\ CO2eq}{m^3CH4}$$

Upgrading of biogas from food waste to biomethane

The produced biogas shall be upgraded to biomethane in a wet scrubbing process. Just as the pressure swing adsorption, the wet scrubbing process does not require any thermal process energy input. The relevant inputs and outputs of the upgrading process are given in the table below. Besides the input of electricity the methane loss is a further relevant factor. It is estimated to be 1% of the raw gas quantity (KTBL 2017a).

Table 18: Material and energy inputs and outputs of the wet scrubbing process

Material/Energy	Input/Output	Value	Unit	Source
Methane	I	1,124,513	m^3_N/a	own calculation
Electricity	I	281,128	kWh_{el}/a	(KTBL 2017a)
Methane loss	O	11,245	m^3_N/a	own calculation
Net methane yield	O	1,113,268	m^3_N/a	own calculation

Using the established equation with the data given in Table 18results in the following result for the emissions from biogas upgrading:

$$e_{p2} = \frac{\left(281{,}128 \frac{kWh}{a} * 0{,}47 \frac{kg\ CO_2eq}{kWh}\right) + \left(11{,}245 \frac{kg\ CH_4}{a} * 23 \frac{kgCO_2eq}{kg}\right)}{1{,}113{,}268\ m^3 CH_4} = \mathbf{0.284}\ \frac{kgCO_2eq}{m^3}$$

4.1.7.5 Allocation

The potential challenges and specialties associated with an allocation of emissions between main and by-products have been described above. For the specific case of biomethane production, the currently binding requirements from the EU RED regarding an allocation based on the lower heating value will usually lead to an underestimation of the by-product digestate. Since the digestate is often characterised by high water content, the lower heating value of this by product will consequently be very low or even negative. In some cases, the digestate is treated to separate its liquid and solid phase. In this case, the solid phase of the digestate could have a positive lower heating value. This chapter aims to illustrate the allocation calculation according to the EU RED methodology. Furthermore, the effect of liquid phase separation on the allocation shall be highlighted.

4.1.7.5.1 Allocation without liquid phase separation of digestate

The first step is to calculate the allocation factor based on the masses and lower heating values of biogas and digestate in the following equation. In this first reflection, we assume that the digestate has not been treated thermally or mechanically. Since the characteristics of the digestate are site specific, it will be necessary to analyse the digestate for the determination of its LHV. For this example, we assume the LHV to be negative (according to the EU RED, Annex V, a negative LHV is set to zero for the sake of simplification). The LHV of biogas (after the process of anaerobic fermentation and before upgrading) is assumed to be 27.5 MJ/kg. The figures for the mass of product and by product can be found in the subchapters above.

$$AFbiogas = \frac{mass\ biogas * LHVbiogas}{mass\ biogas * LHV\ biogas + mass\ digestate * LHV\ digestate}$$

$$AFbiomethane = \frac{1290702\ kg * 27.5\ MJ/kg}{1290702\ kg * 27.5\frac{MJ}{kg} + 11449000kg * 0} = \mathbf{1}$$

In this case, due to the non-positive LHV, the allocation factor for biogas will remain 1. This means, the total emissions occurring until the production of both main and by-product will be allocated to the main product biogas. In case, the digestate is treated to separate liquid and dry phase, the additional energy consumption of this process needs to be considered in the calculation of GHG emissions for the biogas production process.

4.1.7.5.2 Allocation with liquid phase separation of the digestate

To show the influence of the inclusion of digestate treatment in the calculation, it is assumed that a treatment as additional processing step is available in the considered system.

$$AFbiomethane = \frac{1290702\ kg * 27.5\frac{MJ}{kg}}{1290702\ kg * 27.5\frac{MJ}{kg} + 11449000kg * 2.8\ \frac{MJ}{kg}} = \mathbf{0.53}$$

According to this equation, an assumed LHV for digestate of 2.8 MJ/kg (based on own calculations) will result to an allocation factor of 0.53. To apply the factor, it is necessary to define the exact location of the allocation point. While the digestate is treated, water is returned into the digester, to reduce the fresh water demand. Since this is a considered a closed loop, the refinery approach described in 4.1.5.2 may be applied. As a result, the emissions summed up from biomass cultivation up to the biogas production may be allocated using the above calculated allocation factor:

$$e_{allocated} = GHG\ emissions\ up\ to\ the\ production\ of\ the\ by - product\ * 53\%$$

It has to be noted here that the treatment (separation of liquid and dry phase of the digestate) is associated with an input of additional energy. The emissions associated with the use of additional energy for the treatment of the digestate need to be considered in the calculations for this process step.

4.1.7.6 Transport and distribution 2 (e_{td2})

Distribution of biomethane - Biomethane from grass silage

When leaving the upgrading unit, the biomethane shall be fed into the gas grid. Energy input for transport through the gas grid and adjustment of the gas pressure at the feed in point are listed in table 19.

Table 19: Transport of biomethane through the gas grid

Material/Energy	Input/Output	Value	Unit	Source
Methane	I	983488	$m^3{}_N/a$	own calculation
Electricity	I	0.0025	kWh_{el}/m^3	(Oehmichen et al. 2016)
Process heat	I	0.0576	MJ/m^3	(Oehmichen et al. 2016)

$$e_{td2} = \frac{\left(2459\frac{kWh}{a} * 0.47\frac{kg\ CO_2eq}{kWh}\right) + \left(56649\frac{MJ}{a} * 0.07\frac{kgCO_2eq}{MJ}\right)}{983488\ m^3CH_4/a} = \mathbf{0.005}\frac{kgCO_2eq}{m^3CH4}$$

4.1.7.7 Emission savings from carbon capture and geological storage (e_{ccs}) and carbon capture and replacement (e_{ccr})

The term carbon capture and storage aims at a set of technologies to capture, transport, and store CO_2 emitted from power plants and industrial facilities. The goal of CCS is to prevent CO_2 from reaching the atmosphere by storing it in suitable underground geological formations. For green gas production facilities, this term could be relevant, in case for example CO_2 from biogas upgrading is captured and stored or replaces the use of fossil CO_2 in other industrial applications.

4.1.7.8 Total emissions

Grass silage

In this section we will calculate the total emissions resulting from the production of biomethane for the exemplary pathway.

Firstly, the total emissions per MJ of Biomethane will be calculated for the specific values calculated in the previous chapters. Secondly, we will discuss the procedure for the calculation of emissions for biomethane plants with multiple feedstock suppliers.

Total emissions per MJ Biomethane for the exemplary grass silage pathway

In this section, we will sum up the emissions from the previous process steps and convert the expression of the result to the chosen functional unit (1 MJ of biomethane). The following table summarises the results of the process steps investigated so far. Furthermore, the table includes the unit information for each of the results.

Table 20 Total emissions for the previous process steps (based on different functional units)

Process	Result of emission calculation	Unit
Biomass cultivation	272.4	kg CO_2eq. * t DS^{-1}
Transport of substrate	0.65	kg CO_2eq. * t FM^{-1}
Biogas production	0.386	kg CO_2eq. * m^3 CH_4^{-1}
Biogas upgrading	0.382	kg CO_2eq. * m^3 CH_4^{-1}
Distribution	0.005	kg CO_2eq. * m^3 CH_4^{-1}

In order to calculate total emissions for the biomethane produced, related to the functional unit of 1 MJ biomethane we are assuming a lower heating value of 36 MJ per m^3 of biomethane. Based on this lower heating value we can calculate the results in g CO_2eq. * MJ $biomethane^{-1}$ for the process steps of biogas production, biogas upgrading and distribution.

To calculate the emissions from biomass cultivation and transport, the specific feedstock factor (necessary amount of feedstock to produce 1 MJ of biomethane) is needed. Based on the information from chapter 8.4., 976094 m^3_N CH_4 (total output after upgrading) are produced from 15,242 tonnes FM grass silage. This relates to 64.04 m^3 CH_4 * tFM grass $silage^{-1}$ and 2305.4 MJ CH_4 * tFM grass $silage^{-1}$. So consequently, we can calculate the emissions per MJ of biomethane from transport by dividing 0.65 kg CO_2eq. * t FM^{-1} by 2305.4 MJ CH_4 * tFM^{-1}. This results in emissions of 0.282 g CO_2eq.*MJ $biomethane^{-1}$ for the process of substrate transportation. Finally, we calculate the specific emissions from biomass cultivation per MJ of biomethane produced. The Initial results for the biomass cultivation process show emissions of 272.4 kg CO_2eq. * t DS^{-1} and 59.9 kg CO_2eq/t FM grass $silage^{-1}$. Dividing these results by the specific biomethane yield per t substrate described above (2305.4 MJ CH_4 * tFM grass $silage^{-1}$). Will lead to a result of 26.0 g CO_2eq.*MJ $biomethane^{-1}$ for the process of biomass cultivation.

*Table 21 Total emissions for the exemplary pathway based on grass silage as per gCO_2eq*MJ biomethane*

Process	Emission results	Unit
Biomass cultivation	26.0	$gCO_2eq.$ * MJ biomethane^{-1}
Transport of substrate	0.282	
Biogas production	10.73	
Biogas upgrading	10.6	
Distribution	0.144	
Total emissions	47.75	$gCO_2eq.$ * MJ biomethane^{-1}

Exemplary application of the calculated allocation factor

In the previous section, we have calculated an allocation factor for biogas assuming an allocation between biogas and the separated solid phase of the digestate as main and by-products of the biogas production process.

This section will illustrate the effect of the application of this emission factor on the result of the overall emissions from biomethane production shown. To calculate the emissions after allocation of the by-product, we will multiply the unallocated emissions from the process steps of biomass cultivation, transport of substrate and biogas production with the allocation factor for biogas. Since, no by-products are produced during the process steps of upgrading and distribution, the emissions of these process steps are allocated entirely to the main product biomethane. The allocation process is illustrated in the following table.

Table 22 Allocation of emissions for the exemplary pathway based on grass silage

Process	Emission results (w/o allocation)		AF	Emission results (with allocation)	Unit
Biomass cultivation	26.0		0.53	= 26.0*0.53 = 13.78	$gCO_2eq.$ * MJ biomethane^{-1}
Transport of substrate	0.282		0.53	= 0.282*0.53 = 0.149	
Biogas production	10.73		0.53	= 10.73*0.53 = 5.69	
Biogas upgrading	10.6		1	= 10.6*1 = 10.6	
Distribution	0.144		1	= 0.144*1 = 0.144	
Total emissions	48.9			30.36	$gCO_2eq.$ * MJ biomethane^{-1}

Manure

In analogy to the procedure done in the example calculation for grass silage, we also converted the emissions of the different processes to a MJ biomethane basis. The results are listed in Table 23.

Table 23: Total emissions for the exemplary pathway based on manure as per gCO_2eq*MJ biomethane

Process	Emission results (w/o allocation)		Allocation factor	Emission results (with allocation)	Unit
Biomass cultivation	0 (-112[7])		0.26 (1)	0 (-112)	$gCO_2eq.$ * MJ biomethane^{-1}
Transport of substrate	0.59		0.26	0.15	
Biogas production	12.3		0.26	3.2	
Biogas upgrading	7.9		1	7.9	
Distribution	0.14		1	0.14	
Total emissions	**20.9 (-91,1)**			**11.4 (-100.6)**	**$gCO_2eq.$ * MJ biomethane^{-1}**

The total emissions to produce 1 MJ of biomethane from manure are 20.9 g CO_2eq without allocation of emissions to the by-product digestate. The method for calculating the allocation factor and multiplying with the results of the individual process steps was applied in accordance to the approach described in 4.1.7.5.2. The application of the allocation by the LHV of the solid fraction of the digestate leads to total emissions of 11.4 g CO_2eq/MJ biomethane, which is about one third of the emissions arising from the grass silage to biomethane pathway. It can be seen from the two tables above that zero cultivation emissions for the manure pathway drive the much lower overall emissions.

Moreover the emission credit for the avoided emissions from manure due to the use as biomethane feedstock was included in Table 23. The influence of the credit on the result is remarkable and even leads to negative emissions. The credit is not allocated between biomethane and the by-product digestate. The allocation factor put in parentheses was therefore set to 1.

Total emissions per MJ of biomethane based on multiple substrate flows

Biogas plants using only one kind of feedstock are very rare in practice. In the previous two exemplary calculations, we have shown how to calculate the GHG emissions of one substrate flow. In this example, we want to show how total emissions of biomethane produced from a substrate mix can be calculated. For this theoretical example we assume a process in which grass silage and manure are used as substrate, using the results from the previous example calculations to some extent. The crucial input and output parameters for the modelled process are given in Table 24.

[7] Application of the emission credit for avoided emissions due to the use of manure as feedstock for biomethane production

Table 24: Inputs and Outputs of material and energy of the exemplary biogas process fed with a substrate mix of manure and grass silage

Material/Energy	Input/Output	Value	Unit	Source
Grass silage	I	15,242	t FM/a	own calculation
Manure	I	25,000	t FM/a	own calculation
Electricity	I	464,391	kWh_{el}/a	own calculation
Process heat	I	2,084,356	kWh_{th}/a	(KTBL 2017a)
Digestate	O	34,624	t/a	(KTBL 2017a)
Net biogas yield	O	4,292,988	m^3_N/a	(KTBL 2017a)
Net Methane yield	O	2,303,528	m^3_N/a	(KTBL 2017a)
Methane loss	O	23,035	m^3_N/a	own calculation

With the figures in the table and equation below, the GHG emissions per MJ biomethane were calculated. As can be seen in the equation, the terms for emissions from feedstock production, transport, land use change as well as the credit for improved agricultural management, are incorporated as share of the respective feedstock on the total substrate input by multiplying with the term S_n, whereas the emissions for processing, transport and distribution of the product, utilisation, as well as credits for carbon capture and storage (C_{CS}) and carbon capture and replacement (C_{CR}) are calculated for the substrate mix, not the individual partial substrate flows.

$$E = \sum_{1}^{n} S_n \cdot \left(e_{ec,n} + e_{td,feedstock\ ,n} + e_{l,n} - e_{sca,n}\right) + e_p + e_{td,product} + e_u - e_{ccs} - e_{ccr}$$

First of all, the share of feedstock n, in fraction as input into the digester (S_n) was calculated for the two feedstock materials grass silage and manure, dividing the individual mass of feedstock quantity per year by the total mass of the substrate mix, resulting in a substrate mix composition of 38% grass silage and 62% manure. Since the emissions for e_{ec}, $e_{td,\ feedstock}$, e_l and e_{sca} were already calculated for the individual substrate flows in the previous two example calculations, we just extracted the figures and compiled Table 25 below.

Table 25: Composition of the substrate mix and emissions in gCO_2eq per one MJ biomethane differentiated in substrate mix and constituent parts of the substrate mix

Emission term	Gras silage	Manure	Substrate mix	Unit
Share of feedstock S_n	38	62	100	%
Extraction/cultivation of feedstock e_{ec}	26.0	0		g CO_2eq *MJ biomethan^{-1}
Transport and distribution of feedstock $e_{td\ feedstock}$	0.282	0.59		g CO_2eq *MJ biomethan^{-1}
Land use change e_l	0	0		g CO_2eq *MJ biomethan^{-1}
Improved agricultural (and manure) management e_{sca}	0	0 (112)[8]		g CO_2eq *MJ biomethan^{-1}
Processing e_{p1} (Biogas production)			9	g CO_2eq *MJ biomethan^{-1}
Processing e_{p2} (Biogas upgrading)			7.9	g CO_2eq *MJ biomethan^{-1}
Transport and distribution of the biomethane $e_{td\ product}$			0.14	g CO_2eq *MJ biomethan^{-1}
Use of biomethane e_u			0	g CO_2eq *MJ biomethan^{-1}

The calculation of the emissions from processing (e_p), transport and distribution of the biomethane ($e_{td\ product}$) and use of the biomethane (e_u) for the substrate mix was done on the basis of the data obtained from the KTBL tool (KTBL 2017a) used to create a process model. The terms were calculated according to the procedure applied for the calculation of emissions of individual substrate flows. The results are given in Table 25.

Applying the figures in Table 25 in the equation above, results in total emissions for biomethane produced from the given substrate mix of 27.4 g CO_2eq*MJ biomethane^{-1}:

$$E = 0.38 * (26 + 0.282 + 0 - 0) + 0.62 * (0 + 0.59 + 0 - 0) + 16.9 + 0.14 + 0 - 0 - 0 = \mathbf{27.4}\ gCO_2eq * MJ\ biomethane^{-1}$$

This result does neither consider the allocation of emissions to the by-product nor the credit for manure used as biogas feedstock. Including the emission credit for the use of manure as feedstock ($e_{sca,\ manure}$=112 g CO2eq/MJ biomethane) results in minus 42 g CO_2eq*MJ biomethane^{-1}:

[8] 112 g CO_2eq/MJ biomethane corresponds to 45 g CO_2eq/MJ manure, which is the credit for using manure as a biomethane feedstock. The credit was described in detail in 4.1.7.2

$$E = 0.38 * (26 + 0.282 + 0 - 0) + 0.62 * (0 + 0.59 + 0 - 112) + 16.9 + 0.14 + 0 - 0 - 0 = -\mathbf{42}\ gCO_2eq * MJ\ biomethane^{-1}$$

As a further step, allocation of emissions to the by-product was included. For this purpose, an allocation factor corresponding to the biogas production of the substrate mix was calculated first:

$$AFbiogas = \frac{mass\ biogas * LHV biogas}{mass\ biogas * LHV\ biogas + mass\ digestate * LHV\ digestate}$$

$$AFbiogas = \frac{4{,}722{,}287\ kg * 27.5\ MJ/kg}{4{,}722{,}287\ kg * 27.5 \frac{MJ}{kg} + 3{,}462{,}4000 kg * 2.8\ MJ/kg} = \mathbf{0, 6}$$

Biogas production was chosen as allocation point, meaning all arising emissions up to the process of biogas upgrading were multiplied with the allocation factor, resulting in minus 22 g CO_2eq*MJ biomethane^{-1}:

$$\begin{aligned} E &= 0.38 * (26 * 0.6 + 0.282 * 0.6 + 0 - 0) + 0.62 * (0 + 0.59 * 0.6 + 0 - 112 * 0.6) + 9 * 0.6 \\ &\quad + 7.9 + 0.14 + 0 - 0 - 0 \\ &= 0.38 * (15.6 + 0.1692 + 0 - 0) + 0.62 * (0 + 0.354 + 0 - 67{,}2) + 5.4 + 7.9 \\ &\quad + 0.14 + 0 - 0 - 0 \\ &= -\mathbf{22}\ gCO_2eq * MJ\ biomethane^{-1} \end{aligned}$$

Total emissions of biomethane produced from food waste

The results of the calculation of the individual terms are given in Table 26. There are no emissions arising for cultivation. It is assumed, that the point of origin of the food waste is located in 10 km distance from the biogas plant. The biogas upgrading unit is situated next to the biogas plant. The feeding of the biomethane into the gas grid takes place on site, too.

Table 26: Summarized results of emission calculation for the production of biomethane from food waste

Process	Result of emission calculation	Unit
Biomass cultivation	0	$kgCO_2eq. * t\ DS^{-1}$
Transport of substrate	0.65	$kgCO_2eq. * t\ FM^{-1}$
Biogas production	0.381	$kgCO_2eq. * m^3\ CH_4{}^{-1}$
Biogas upgrading	0.284	$kgCO_2eq. * m^3\ CH_4{}^{-1}$
Distribution	0.0052	$kgCO_2eq. * m^3\ CH_4{}^{-1}$

In order to calculate the overall result, the results for the different terms of the calculation were converted to the common unit g CO_2eq/MJ biomethane and listed in Table 27. For a detailed description on the conversion of the figures to a common unite, please see 0. The summed up emissions figures in Table 27 mount up to 19 gCO_2eq/MJ biomethane.

Table 27: Summarized results of emission calculation for the production of biomethane from food waste converted in g CO_2eq/MJ biomethane

Process	Emission results	Unit
Biomass cultivation	0	$gCO_2eq. * MJ\ biomethane^{-1}$
Transport of substrate	0.323	
Biogas production	10.592	
Biogas upgrading	7.901	
Distribution	0.144	
Total emissions	**18.96**	$gCO_2eq. * MJ\ biomethane^{-1}$

4.1.7.9 Utilisation of biomethane in different applications

One of the most attractive characteristics of the biomethane technology is that biomethane can be used in a number of applications and energy sectors. Throughout this chapter we will use exemplary calculations to illustrate the calculation of emissions from, as well as the emission savings associated with, the use of biomethane for transportation purposes, heat production as well as heat and power production in CHP units.

Transport

In case a GHG emission saving shall be calculated for the use of biomethane as a transportation fuel, a reference value needs to be defined. For the purpose of this project, we will apply the fossil comparator as defined in the EU RED. Thus, the GHG emission saving of our biomethane pathway will be calculated by a comparison of the specific GHG emissions from the biomethane production and supply (here 47.75 gCO_2eq. for 1 MJ of Biomethane without allocation and 30.36 gCO_2eq. for 1 MJ of Biomethane with allocation) with the fossil reference value as stated in the EU RED (83.8 gCO_2eq/MJ) using the equation below

$$GHG\text{-}saving = \left[\frac{E_{Fossilfuel} - E_{Biofuel}}{E_{Fossilfuel}}\right] * 100$$

For our example the total GHG emission add up to 47.75 g CO_2eq/MJ biomethane. With this figure, a saving of 43 %[9] can be achieved.

$$GHG\text{-}saving = \left[\frac{83.8 - 47.75}{83.8}\right] * 100 = 43\ \%$$

In the equation below, the calculation of the GHG emission saving is shown considering the allocated GHG emission value. This results in a much higher saving of 64 %

$$GHG\text{-}saving = \left[\frac{83.8 - 30.36}{83.8}\right] * 100 = 64\ \%$$

CHP

There are two major aspects to consider when biomethane shall be converted into heat and power in a combined heat and power plant (CHP) - the energy demand of the plant and the methane loss, which also occurs during the combustion of biomethane. In the present example it is assumed that the biomethane is used on site in a CHP. There is no further transport and distribution necessary. Furthermore there is a demand of electricity to run the cogeneration unit. It is estimated to be 1 % of the electrical efficiency (Giuntoli et al. 2017) and gives the possibility to subtract 1 % from the gross electrical efficiency or to calculate the amount and multiply with the emission factor for electricity. The first option was chosen in this example, as it seems more practical. The relevant parameters of the CHP unit are given in the table below:

Table 28: Parameters of the cogeneration process

Parameters of the cogeneration process	
Net thermal efficiency	46%
Net electrical efficiency	40%
Biomethane input	983488 m^3/a
Methane slip	0,2%
Electricity input	1% of gross el. efficiency

[9] It has to be pointed out, that this example is a theoretical reflection using grass silage in a mono-fermentation process. This leads to a relatively low saving of GHG emission. In practice, a co-digestion of grass silage with manure will be more commonly. This pathway will results in a higher total GHG saving.

$$e_{CHP} = \frac{\left(1406\frac{kg\,CH_4}{a} * 23\frac{kgCO_2eq}{kg}\right)}{974142\ m^3CH_4} = \mathbf{0.04}\ \frac{kgCO_2eq}{m^3} = \mathbf{1.1}\ \frac{gCO_2eq}{MJ}$$

The methane slip of the plant leads to a release of 1952 m³ of biomethane per year. This corresponds to an emission of 0.04 kg CO_2eq/m³ of biomathane as calculated with the formula above, which equals 1.1 gCO_2eq/MJ biomethane.

The emission from the biomethane loss is added to the total emission which results in 50 g CO_2 eq/MJ. This emission value represents all emissions up to the electricity or heat produced by biomethane.

In the final step, the total emissions need to be assigned to emissions associated with the production of heat and electricity, respectively. This is done by allocating the emission to the exergy content, as described in European Commission 2016. We follow this approach, using the equations below

$$EC_{el} = \frac{E}{\eta_{el}}\left(\frac{C_{el} * \eta_{el}}{C_{el} * \eta_{el} + C_h * \eta_h}\right)$$

$$EC_h = \frac{E}{\eta_h}\left(\frac{C_h * \eta_h}{C_{el} * \eta_{el} + C_h * \eta_h}\right)$$

$EC_{el,h}$‘	Total greenhouse gas emissions from the final energy commodity (heat or electricity)
E	Total GHG emissions of the fuel before conversion into final energy commodity
η_{el}	The electrical efficiency, defined as the annual electricity produced divided by the annual energy input, based on its energy content.
η_h	The heat efficiency, defined as the annual useful heat output divided by the annual energy input, based on its energy content
C_{el}	Fraction of exergy in the electricity, and/or mechanical energy, set to 100 % (C_{el} = 1).
C_h	Carnot efficiency (fraction of exergy in the useful heat).

The Carnot efficiency is calculated as follows:

$$C_h = \frac{T_h - T_o}{T_h}$$

C_h	Carnot efficiency (fraction of exergy in the useful heat).
T_h	Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery
T_0	Temperature of surroundings, set at 273.15 kelvin (equal to 0 °C)

Carnot efficiency was calculated using the equation above. A temperature of the useful heat at point of delivery of 120 degree Celsius (423.15 K) was assumed and the temperature of surroundings was set to 10.5 degree Celsius (283.55 K). This results in a Carnot efficiency of 0.33:

$$C_h = \frac{423.15 - 283.55}{423.15} = \mathbf{0.33}$$

The allocation of emission to electricity produced in the CHP was done using the equation introduced above:

$$EC_{el} = \frac{50\ gCO_2eq * MJ^{-1}}{0.4}\left(\frac{1 * 0.4}{1 * 0.4 + \ 0.33 * 0.46}\right) = \mathbf{90.62}\ gCO_2eq * MJ^{-1}electricity$$

The allocation of emissions to the heat produced in the CHP was done accordingly and resulted in 57.7 $gCO_2eq*MJ_{heat}^{-1}$.

$$EC_h = \frac{50\ gCO_2eq * MJ^{-1}}{0.46}\left(\frac{0.33 * 0.46}{1 * 0.4 + \ 0.33 * 0.46}\right) = \mathbf{57.7}\ gCO_2eq * MJ^{-1}\ heat$$

For cogeneration, there is a respective fossil fuel comparator listed in A 2.3 of D1.1. There are also values differentiated into heat and electricity production in the RED recast. Nevertheless, we want to use the one from the RED (85 gCO_2eq/MJ), to be in line with current legislation:

$$GHG\text{-}savings\ excess\ electricity = \left[\frac{85 - 90.6}{85}\right] * 100 = \mathbf{-6.6}\ \%$$

$$GHG\text{-}savings\ of\ excess\ heat = \left[\frac{85 - 57.7}{85}\right] * 100 = \mathbf{47.2}\ \%$$

However, as can be seen from the above, GHG savings turned out very different for electricity and heat, respectively. For electricity, the calculation resulted even in a negative GHG saving, which means, that the biomethane based electricity production in a CHP causes slightly more GHG emissions, compared to the fossil reference. In contrast, with the production of heat, a GHG saving of 47.2% could be achieved.

Heat

The production of heat by the conversion of biomethane in a condensing boiler can be an interesting option for the production of sustainable heat. In our exemplary calculation, we are assuming the use of a condensing boiler resulting in specific process characteristics shown in Table 29. It is assumed that the total amount of heat produced in this process will be used.

Table 29: Specifications of a calorific value boiler

Parameters of the calorific value boiler	
Net thermal efficiency	95%
Biomethane input	983488 m^3/a
Useful heat output	33382415 MJ/a

Up the point of the combustion, the biomethane emissions have been calculated with 48.9g CO_2eq/MJ. Following the equation below, the production of 1 MJ thermal energy from our exemplary biomethane pathway will result in 51.5g CO_2eq/MJ_{th}.

$$EC_h = \frac{E}{\eta_h}$$

As fossil fuel comparator, we use the value 80g CO_2eq/MJ (European Commission 2016). Consequently, a GHG emission saving of 33.1 % is calculated.

$$GHG\text{-}saving = \left[\frac{77 - 51.5}{77}\right] * 100 = \mathbf{33.1}\ \%$$

Changing the value for the upstream emissions of the biomethane to the allocated emission value will obviously lead to higher GHG emission savings:

$$GHG\text{-}saving = \left[\frac{77 - 33.3}{77}\right] * 100 = \mathbf{56.8}\ \%$$

4.2 Sustainability Criteria (D1.3)

A fully operational and acceptable sustainability certification scheme for green gases, which is in compliance with EU RED requirements should include the requirements defined by the EU RED and, if appropriate, additional sustainability criteria. As a starting point for the GreenGasCert certification scheme blueprint, the following general criteria, included in figure 7 are being proposed. These criteria include the EU RED minimum sustainability criteria as well as a couple of additional criteria, covering major aspects of the public debate about a sustainable production of biofuels and green gases.

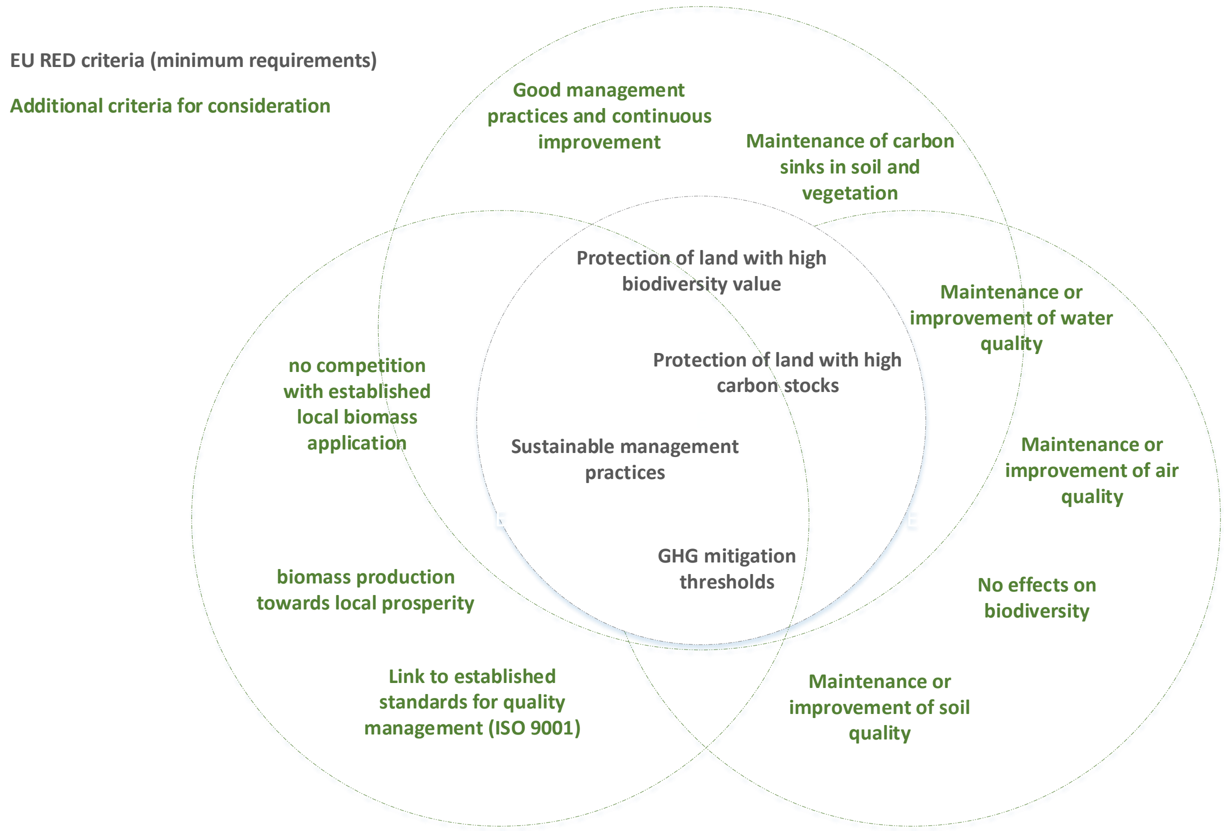


Figure 9 GreenGascert criteria set

The proposal for the GreenGasCert criteria does include:

4.2.1 Protection of land with high biodiversity value

The criteria ‘protection of land with high biodiversity value’ ranks among the principle of sustainability requirements for cultivation of biomass. It is one of the mandatory criteria in the RED. Examples for a practical implementation of this indicator can be found in almost all recognised EU certification schemes. For example, one indicator used by the ISCC system explores whether the cultivation of biomass feedstock is affecting or will affect species that are critically endangered or mentioned in the IUCN Red List. This indicator is examined by a determination of protected areas, the conservation and population status of the area.

4.2.2 Protection of land with high carbon stocks

The protection of land with high carbon stocks also pertains to sustainability requirements for cultivation of biomass. It is the second mandatory EU RED requirement. The criteria includes the protection of wetlands including swamps, marshes or bogs, as well as other bodies of water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water (the depth of which at low tide does not exceed six metres). Appropriate indicator can be checked based on the status of the respective land/area status (i.e. retained and not actively changed or adversely affected. This can be supported by remote sensing methods.

4.2.3 Sustainable management practices

The cultivation of the feedstock used for the production of green gases should follow the guidelines for good agricultural management practices established on a national level in Ireland and in the EU. The fulfilment of these requirements is often a mandatory precondition for farmers to receive payments or subsidies from the EU or from national institutions. The requirements regarding good agricultural management practices define a general principle. In practice, to avoid unnecessary additional effort for market actors, a check of compliance with this principle can be linked to existing reporting procedures for agricultural producers. One example could be a self-declaration for domestic biomass producers in Ireland referring to the documentation procedures for the EU subsidy payments.

4.2.4 GHG mitigation thresholds

The GHG mitigation potential of the green gas produced is another major sustainability criterion of the GreenGasCert system. The GHG mitigation potential will be calculated in a stepwise approach. Firstly, actual emissions of the specific biomethane value chain to be certified will be calculated. Secondly, the GHG mitigation potential will be calculated by a direct comparison of the actual emissions of the biomethane produced and the respective comparator value as defined by the EU RED. Chapter 4 of this report describes the calculation of GHG emissions and the GHG mitigation potential of green gases.

4.2.5 Maintenance of carbon sinks in soil and vegetation

Maintenance of carbon sinks in soil and vegetation in relation to biomass cultivation for green gases is an important precondition for ensure GHG mitigation effects from the green gas utilisation. Indicators for the maintenance of carbon sinks in soil and vegetation might be the observation of potential land use change (direct and indirect), tree counting or remote sensing and compensation measures if vegetation is removed and replaced by plants with lower ability of carbon sequestration. The amount of carbon captured in vegetation and soils should not decrease due to biomass production for biogas or –methane in the long term.

4.2.6 Maintenance or improvement of water quality

Maintenance or improvement of water quality is an important criterion to ensure a long-term sustainable production of biomass and avoid negative impacts to human health and other impact categories. In general, this criterion affects processes of biomass cultivation as well as biomass processing. To ensure the maintenance or improvement of water quality, water leaving the manufacturing facility should meet drinking water quality standards. REDcert applies sample collection and on-site data measuring for water quality assessment to bring evidence of fulfilment of the indicator.

4.2.7 Maintenance or improvement of air quality

This criterion is relevant mostly for downstream processes including biomass conversion and processing to biomethane. Various examples for the operationalisation of this indicator do exist. For instance, the *Better Biomass* certification system and the ISCC system include indicators related to this criterion.

4.2.8 Maintenance or improvement of soil quality

This criterion includes recommendations and requirements regarding the use of agricultural fertilisers. In general, fertilisers should be of trustworthy origin and selected according to nutritional requirements of the soil. Furthermore, an evenly distribution of organic matter should be guaranteed. Several existing certification schemes do include information about kinds of mineral fertiliser and limes that are permitted in order to maintain or improve soil quality.

4.2.9 Good management practices and continuous improvement (Link to established standards for quality management (ISO 9001))

To establish a basis for the establishment of well-organised management processes at all stages of biomethane production, the existence or the implementation of quality management processes could be a meaningful criteria. This includes management processes assuring for example open communication processes or a good relationship between customers and the farm, the availability of a business plan or a commitment of continuous improvement for each production unit. The operationalisation of these criteria can be linked to the existence of established standards for quality management (e.g. ISO 9001). The ISO 9001 standard is based on a number of quality management principles such as a strong consumer focus, the motivation and implication of top management, the process approach and continuous improvement. Indicators for the revision of this standard and their audit guidelines still need to be investigated by further research.

4.2.10 Biomass production towards local prosperity

Production and processing of biomass can enable job creation in rural areas and chances for their development leading to local prosperity due to strengthening the economic infrastructure. A measurable indicator is the quantity of jobs created. The relevant data could be retrieved from databases or checked by documents. Conclusions might be drawn back to local development and prosperity.

4.2.11 No competition with established local biomass application

Biogas or biomethane production should not be in competition with well-established sustainable utilisation pathways. This can help to avoid negative leakage effects such as indirect land use change, etc.

4.2.12 Operationalisation of the final GreenGasCert criteria set

All of the proposed criteria need to be operationalised by defining clear, transparent and measurable indicators. Examples for the practical operationalisation of all proposed indicators do exist in literature as well as in other, recognised certification schemes. Thus, follow up activities to the GreenGasCert project should focus on the finalisation of the criteria set based on a stakeholder engagement process. Secondly, it is of high importance to check connections and potential overlaps to existing national requirements and legislations in Ireland. In case existing regulations already ensure the fulfilment of GreenGasCert criteria, no additional checks should be necessary.

4.3 Pilot certificate (D1.6)

An important outcome of the certification process is the final sustainability certificate for the biomethane produced. The certificate proofs compliance with the GreenGasCert and EU RED requirements. It will be fed into the green gas registry. During the GreenGasCert project, together with the partners, a template for the sustainability certificate has been developed. This template is included in the following two pages.

Logo certification body

Certificate of conformity

Logo certification scheme

„Name of certification body“ certifies compliance of

“Name of Operator”

“Street of operator”

“Zipcode and City of operator”

according to

“Name of Standard or certification scheme”(Version) as well as 2009/28/EC RED

Certificate Number:	GGCS-XX-001-001
Validity of Certificate:	yyyy-mm-dd – yyyy-mm-dd

Date of issue

Signature, Stamp

Logo certification body

Logo certification scheme

Annex to certificate

Certification scope:

The certified company is a

Wählen Sie ein Element aus.
Wählen Sie ein Element aus.
Wählen Sie ein Element aus.

Year of initial operation of the interface: Klicken oder tippen Sie, um ein Datum einzugeben.

Product(s) and origin

Product	Biomass	Biomass origin	Quantity		Mass balance period	Lower heating value	
Wählen Sie ein Element aus.	Wählen Sie ein Element aus.	Wählen Sie ein Element aus.	Klicken oder tippen Sie hier, um Text einzugeben.	Wählen Sie ein Element aus.	Klicken oder tippen Sie, um ein Datum einzugeben. toKlicken oder tippen Sie, um ein Datum einzugeben.	Klicken oder tippen Sie hier, um Text einzugeben.	Wählen Sie ein Element aus.
Wählen Sie ein Element aus.	Wählen Sie ein Element aus.	Wählen Sie ein Element aus.	Klicken oder tippen Sie hier, um Text einzugeben.	Wählen Sie ein Element aus.		Klicken oder tippen Sie hier, um Text einzugeben.	Wählen Sie ein Element aus.

GHG emission	
Klicken oder tippen Sie hier, um Text einzugeben.	Wählen Sie ein Element aus.

The final use of the biomass/biofuel is/will be

- ☐ Heat and Electricity from CHP
- ☐ Heat
- ☐ Vehicle fuel
- ☐ unknown

The biomass within the scope of this certificate complies with 2009/28/EC Article 17, 2-6

5 Green Gas Registry

This chapter introduces the key elements and the mode of operation of a green gas registry. It is based on the deliverables of work package two of the GreenGasCert project. The link between sections and deliverables as mentioned in the proposal is made by indicating the deliverable number in the title of the corresponding section – with one exception: The deliverable called questions and answers (D2.1 Q&A) is a working document developed at the start of the project. The Q&A was used to first summarize questions arising during the work on the different aspects of the registry blueprint. Throughout the project more and more questions could be answered by Irish experts inside and out of the project team and during stakeholder workshops. Some questions turned out to be irrelevant to the project or not possible to be answered during the duration of the project, for example because certain support schemes had not been finalized yet. The results of the Q&A influenced the work on the other deliverables and shaped the content of chapter 7. As the Q&A is of no further use after the end of the project it is the only deliverable from work package 2 not included in this document.

Before taking the plunge into registry details, this chapter starts by providing motivation for the establishment of a green gas registry, the main advantages and possible uses (section 5.1). Then, some examples from other member states are presented in order to get a first insight into the work flow and functions of a green gas registry. The following section takes a look at the most important boundary conditions and requirements stemming, for example, from the Renewable Energies Directive of the European Union.

Section 5.4 continues with providing a data framework for the registry by defining relevant data for it. How this relevant information comes to the registry is the content of section 5.5. An important step is then the verification of the data, which will be explained in section 5.6. Data quality and reliability is one of the main tasks for the registry.

The following sections will then illustrate how the workflow inside and outside the registry is set up (section 5.7), how a registry statement from the registry could look like (section 5.8) and which role auditors could have in the context of the registry (section 5.9).

5.1 Why a green gas registry?

The future green gas registry for Ireland will allow verifying and trading of green gases by offering a platform which is robust, reliable and open to all involved stakeholders.

Key issues for a green gas registry system are

- To comply with legal requirements, e.g. RED II (the Renewable Energy Directive recast)
- to register only existing green gas amounts
- to enable back tracing of green gas amounts for government authorities or court decision
- to prevent fraud, i.e.
    - to reduce opportunities for double registration: e.g. in other registries
    - to prevent double marketing by its users
    - to prevent double counting
    - to help prevent double compensation by government authorities for the same green gas amount

For Ireland, the purpose of the green gas registry will be the support of a sustainable green gas market by establishing a certification scheme based on standards defined by the above mentioned regulations. Furthermore, the establishment of a green gas market on the basis of a registry may be useful also to those planning to address a voluntary market. For green gas producers, such as farmers, the registry could provide a feasible solution to obtain an (additional) income by selling their produced green gas. If the registry verification scheme relies on auditors, these would need reliable framework conditions and clearly defined measurement and verification rules to achieve an adequate income by auditing. Traders in green gas could sell new products, relying on a sufficiently large and diverse market with a standardized verification procedure.

End users of green gas need to be able to verify that the gas is in fact of renewable origin. It is further necessary for end users that properties such as emission reduction or used feedstock and the origin of the green gas can be verified. The registrar itself needs a robust and secure verification procedure to be recognized by the authorities and trusted by all involved stakeholders.

5.1.1 Transparency, mitigation of fraud, promotion of green gas market

If the registry provides data security and is set up to prevent fraud, trade of green gas is facilitated. All procedures concerning the green gas certification and trade need to be transparent. The registry will be able to provide this in a robust and reliable manner.

The registry can also be used to fulfil mass balancing requirements. Depending on the interpretation of mass balancing (see info box below), the registry can completely fulfil the requirements of mass balancing or will be a key element for fulfilling it (e.g. together with data from gas balancing groups).

What is mass balancing inside the gas grid?

The use of mass balancing systems is required in the RED in article 18 (or article 27 in the RED revision) for biofuels, and therefore also for green gases. The implementation of mass balancing for transport of green gas consignments through the gas grid, however, is a point of discussion. In the member states, this is defined in different ways.

One crucial point is the definition of the mass balancing system's boundaries. Often they are set for the national gas grid's dimensions. Recent initiatives like ERGaR (http://www.ergar.org/) define the whole European Gas Grid as a mass balancing system. Thus, cross border trade would be simplified.

When mass balancing is closed inside the mass balancing system, comprehensive information about **injection** and **withdrawal** of a specific gas consignment from the gas grid is available (amount, period, grid access point, meter number,...).

Monitoring of green gas use

The registry can also be a powerful instrument to monitor green gas production and consumption. It can easily be tracked, which markets are delivered with green gas. Furthermore, and also locations of production and consumption can be analysed.

An example for possible results of data analysis results supported from the registry is given in Figure 8, where the different target markets of biomethane in Germany are shown.

Recent developments in the Eurostat regulations regarding green gases also make it necessary or at least useful for member states to monitor end consumption. The current state of the SHARES[10] tool does not allow to allocate green gas to different markets but allocates the consumption of green gas it in a simplified manner (biomethane is allocated equally to the three possible target markets heat, transport, energy). If in the future the SHARES tool will in the future allow the allocation of green gas to different markets according to the actual end use, the green gas registry will provide reliable information for the SHAREs tool.

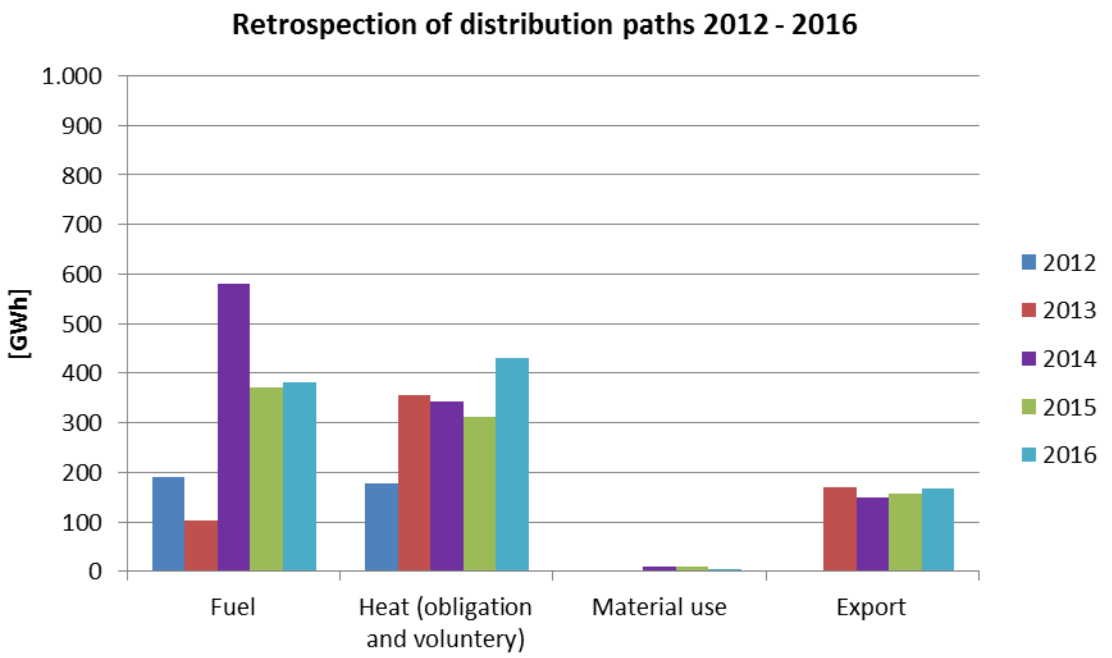


Figure 10: Distribution of biomethane use in Germany from 2012-2016 (Source: dena Biogasregister, EEG support scheme is exluded)

Pillar for support schemes and prevention of fraud

Several European countries registries are already possess established registries (see section 5.2).

These registry systems have been designed for very specific tasks and questions (e.g. the German Renewable Energy Sources Act). The requirements define the basis for the specifications for each of the existing systems, but are almost always used as an instrument to execute a support scheme of the member state. Thus a registry can be a helpful instrument for support schemes. Registries also help to avoid fraud with their security measures, when at the same time offering easy and secure trading.

[10] http://ec.europa.eu/eurostat/web/energy/data/shares

International cooperations

Registries can also be used to set up international trade activities for green gas certificates. They provide the necessary tools and data in order to connect to an international green gas trade hub like ERGaR (http://www.ergar.org/).

International cooperations can help to complete or at a certain point even replace support schemes as more target markets are available to green gas producers and traders can be reached and supplied.

5.2 Examples for Sustainability Certification and Registration of Renewable Gases.

This section describes some existing renewable gas registries and sustainability schemes, which help Irish stakeholders to get an overview and a general understanding of different approaches, scopes and framework conditions for the establishment of a renewable gas verification and documentation system.

All registry systems have been designed for very specific tasks and questions (e.g. the dena biogasregister for the German Renewable Energy Sources Act). The requirements set in the regulatory frameworks define the basis for the specifications for each of the existing systems. Thus, an exact definition of the goal and scope is an important step in the beginning of a certification scheme.

In the following, three existing biogas registers are introduced, each of them having a different background and a different scope regarding legal requirements. It is the Biogasregister Deutschland, the Danish biogas registry operated by Energinet and the German sustainable biomass registry (nabisy).

When it comes to sustainability verification, the three examples have very different scopes and approaches. In order to point out the key differences of the three examples, the following questions are addressed in relation to the creation of a renewable gas certification scheme:

- What is the purpose of the register?
  Here, the main focus of the register and the motivation for the development of the register is pointed out.
- What is registered?
  The considered registries are restricted to a certain type of renewable energy they are handling.
- Who is the registrar?
  Here, it is pointed out which institution or company manages the register and if the registrar has a mandate.
- Who are the main stakeholders?
  The main stakeholders are listed, their role and responsibilities are explained in the following question.
- How does the register work?
  With this question, the general setup and functioning of the register shall be pointed out and the general work flow of the register is explained.
- Does the register include links to sustainability certification schemes?

Which information from the certification process is collected and processed by the register?

5.2.1 Biogasregister Deutschland

Link: http://www.biogasregister.de/en/

What is the purpose of the register?

The two main functions of the Biogasregister Deutschland are to complete mass balancing requirements arising from national laws, namely the Renewable Energy Sources Act (EEG) and the Renewable Energy Heat Act (EEWärmeG), and to standardize the proof of green gas properties – the so called criteria catalogue - according to regulatory requirements. Nevertheless, there is no obligatory use of the register for the remuneration of feed-in premium or the fulfilment of any renewable quotas.

At the same time, the Biogasregister Deutschland is also used for disclosure purposes for voluntary markets. Furthermore, there is an increasing activity to use the guarantees of origin from the Biogasregister Deutschland to transfer green gas to other European countries and vice versa.

What is registered?

In the Biogasregister Deutschland only gases within the gas grid can be registered. The major part of renewable gases in the Biogasregister Deutschland is green gas derived from anaerobic digestion. Some Power-to-Gas (PtG) plants are also registered, if they produce H2 and inject it into the gas grid. As part of the registration process, the gases are documented with regard to amount, origin and properties.

Who is the registrar?

The Deutsche Energie-Agentur GmbH (dena) – the German Energy Agency is managing the Biogasregister Deutschland. Dena is a state-owned limited company with expertise in the green gas market. When setting up the Biogasregister Deutschland, dena did so in collaboration with 14 stakeholders from the green gas and gas industry. These stakeholders also helped with the initial financing of the register. There is no government mandate to provide the registry services, but a strong commitment from industry stakeholders and a comprehensive acceptance from public authorities.

Who are the main stakeholders?

The main stakeholders in the Biogasregister Deutschland are the producers, the auditors, the traders and the end consumers of green gas. The number of end consumers, as a lot of private end consumers are also addressed, is relatively high.

For the remuneration of the feed-in tariffs according to the EEG, the power grid operators use the guarantees of origin from the Biogasregister Deutschland in order to verify the feed-in claim of combined heat and power (CHP) plants running on green gas.

The Guarantee of Origin (GoOs) can also be used to prove the use of green gas according to the Renewable Heat Act (EWärmeG) where the GoO has to be transferred to the local building authorities.

Other green gas registries are connected to the Biogasregister Deutschland by cooperation and GoOs can be exchanged. Voluntary labels like Naturemade rely partly on the information and proofs provided by the Biogasregister Deutschland.

How does the register work?

A producer registers a green gas plant and the quantity of green gas produced in a certain period of time. Additionally, the properties of the green gas can be defined by the use of the criteria catalogue. The registered green gas quantity and qualities have to be confirmed by an auditor. Once the auditor has confirmed the quantity and quality (attributes) of the green gas, there is a final check by the registrar (dena) after which the amount of green gas can be used to issue GoO for end consumers.

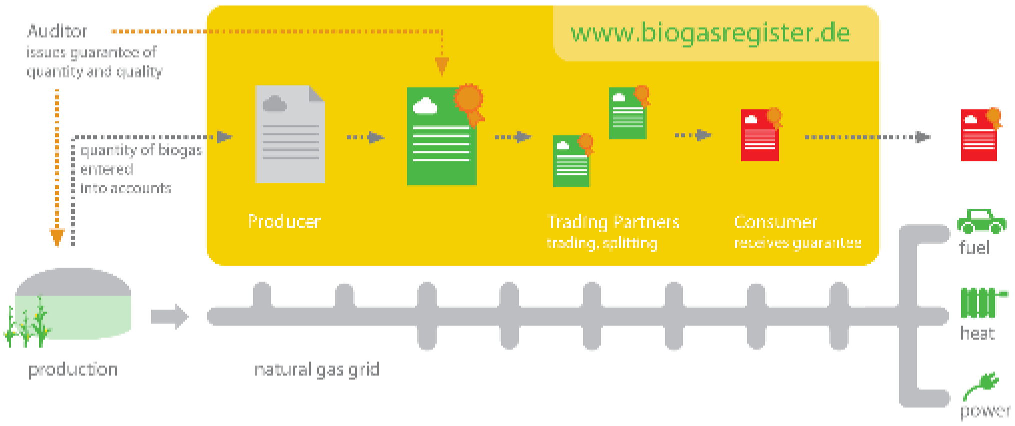


Figure 11: Workflow of the Biogasregister Deutschland

Does the register include links to sustainability certification schemes?

This registry was designed to comply with the requirements of the RED. However, approval is still missing.

Which information from the certification process is collected and processed by the register?

The following information is collected and processed in the registry

- Proof of Origin
- Proof of Quantity
- Proof of Quality

5.2.2 Nabisy - Sustainable Biomass System

Link: https://nabisy.ble.de/

What is the purpose of the register?

The scope of the register is to fulfil the requirements of the Directive 2009/28/EC, which was translated to national law in Germany by the BiokraftNachV and the BioStNachV. In these documents, the requirements for the sustainability of biofuels for transport and bioliquids for electricity are defined.

What is registered?

The focus of the Nabisy system is sustainable biofuels that are produced and traded to fulfil the biofuel quota obligations in Germany in the transport sector. Nabisy includes green gas with sustainability certification, in case of an end use in the transport sector. Besides the chain of custody, the origin and the greenhouse gas emission of each consignment is registered.

Who is the registrar?

In Germany, the federal office for agriculture and food (BLE) is the competent authority for the implementation of the sustainability criteria laid down in Directive 2009/28/EC on the promotion of the use of energy from renewable sources (Renewable Energy Directive). It is a federal office of the federal ministry of food and agriculture (Bundesministerium für Ernährung und Landwirtschaft, BMEL). The BLE has a governmental mandate to operate the sustainable biomass system.

Who are the main stakeholders?

The German government is the constituent of the register, which is managed by the BLE. The verification standards are maintained by voluntary schemes (e.g. RedCert, ISCC, NTA 8080) recognized by the European Commission or the BLE. The BLE is moreover the authority, approving and monitoring certification bodies. The certification bodies verify the implementation of the sustainability criteria in on-site audits and certifying according to one of the voluntary schemes (see Figure 2). Market actors along the whole supply chain of biofuels are involved in and are subject to the certification process. Only the final producer[11], besides storage and transport of a biofuel (e.g. a biodiesel plant or a green gas plant) is in touch with Nabisy. The use of Nabisy as well as the certification is mandatory for biofuel market participants within the EU.

Nabisy was initially developed to ensure the sustainability of biofuels only. Further functions have accrued over time, e.g. in the context of the use of liquid waste biomass in processes and power plants obligated to participate in emission trading (ETS) or the electricity generation with bioliquids. According to the different functions of the database, there are several institutions with access to Nabisy: The German main customs offices, the biofuel quota body, the German Emissions Trading Authority, network operators as well as the competent authorities of other member states of the European Union. The German customs authorities for instance, check upon the provision of the "proofs of sustainability" (PoS) whether the petroleum companies have fulfilled the biofuel quota obligations in the past year.

How does the register work?

[11] Final producer in this context means the element in the supply chain which is not followed by any further processing step downstream

As briefly described above, the entire supply chain of a biofuel is subject to certification. Hence, Information on quantities and GHG emissions is passed from one supply chain element to the next. At the final processing stage (final biofuel producer), this information is included in a proof of sustainability (PoS). The PoS will be registered by the final producer in Nabisy. The registration of the biofuel volume within the PoS is required within three months after production. The respective certification body is responsible for the correctness of the PoS.

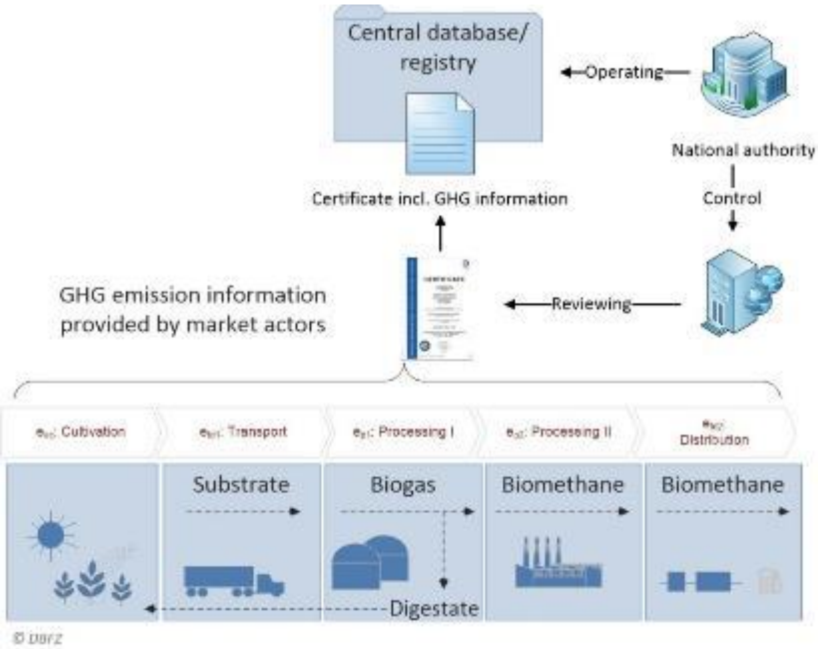


Figure 12: Flow of sustainability information and involved parties (DBFZ)

Each PoS is represented by a database entry. Figure 10 shows that Nabisy unifies sustainability information of all chain of custodies in the biofuel business. Information is fed in by participants of the market, whereas mostly public institutions extract information from the database. Nabisy works independently from the mode of transport (e.g. inside /outside of the gas grid)

Table 30: Opportunities and functions of the Nabisy database

Competent agency	Legal basis	Function	Details
Bundeanstalt für Landwirtschaft und Ernährung (BLE)	BiokraftNachV	Securing RED-requirements	Review Basis for yearly experience and evaluation report for the German government and the EU Commission
Customs authorities (Biofuel quota body)	BiokraftNachV	Securing RED-requirements	Counting towards quota obligation for transport fuels
German Emissions Trading Authority	BioStNachV	Verification of GHG calculations	Consideration of biofuels in emission trading reporting (GHG calculation)
Grid operators	EEG, BioStNachV	Eligibility to receive power grid feed in tariff	For electricity from bioliquids feed in tariffs are granted
Competent authorities of other EU member states	BiokraftNachV, RED	Securing RED - requirements	If biofuels are traded between EU member states

Does the register include links to sustainability certification schemes?

The register is strongly linked to the sustainability certification schemes demonstrating compliance with the sustainability criteria for biofuels and recognized by the European Commission ("voluntary schemes") and national schemes, respectively. The content of the database is generated during the certification process of a respective supply chain.

Which information from the certification process is collected and processed by the register?

Each PoS contains information gathered along the entire supply chain of a biofuel during the certification process. With full details, the following data is given by the PoS:

- No. of the PoS
- Issuing organisation
- Information on traceability (Name, address and certificate no. of supply chain element, receptor of biofuel, name and registration no. of certification scheme
- General data on the biomass/biofuel (type, country of cultivation, quantity, energy content)
- Statement whether §§4-7 BioStNachV/BiokraftNachV are fulfilled (sustainable cultivation of biomass and sustainable production of the biofuel)
- GHG mitigation potential (GHG emissions, fossil fuel comparator, country/region of application, used default values, if applicable)
- Details of the mass balance system in place

5.2.3 Danish Biomethane Register

Link: https://en.energinet.dk/Gas/Biomethane#Info

What is the purpose of the register?

In Denmark, the support scheme for green gas is limited to biomethane and based on a feed-in tariff for injected green gas. On top of receiving the feed-in subsidy, the green gas plant operators also have the possibility to trade certificates which are created in the Danish Biomethane register from the injected biomethane. Therefore, the Danish register gives an additional stimulus to the green gas market in Denmark.

What is registered?

Only biomethane injected into the public Danish gas grid is registered in the Danish register.

Who is the registrar?

The Danish biomethane register is managed by Energinet, the Danish national transmission system operator for electricity and natural gas. Energinet received a mandate from the Danish Ministry of Energy, Utilities and Climate. However, using the register is not mandatory for green gas plant operators (the feed-in tariff support is granted nonetheless).

Who are the main stakeholders?

In the Danish Green gas registry, the main stakeholders are the producers, the traders and the end consumers. The ministry of Energy, Utilities and Climate provided the mandate to Energinet to manage the register.

How does the register work?

The producers have to ask for registration in the register and, after a successful registration, receive monthly certificates on their account, depending on the amount of green gas measured by remote gas meters. Every MWh creates one Guarantee of Origin (GoO) in the Danish register. These GoOs can be traded within the system. A trader can then decide to cancel a certificate by pointing out a final consumer of the green gas.

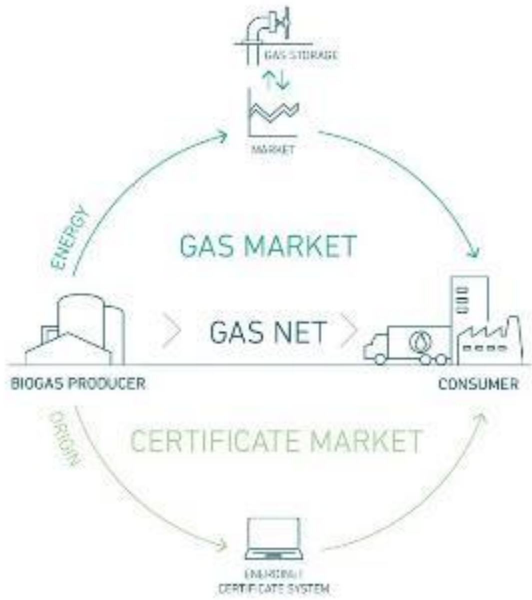


Figure 13: Work flow of Danish Green gas Register (Energinet) [12]

Does the register include links to sustainability certification schemes?

No.

Which information from the certification process is collected and processed by the register?

The following information is collected and processed in the registry

- Proof of Origin
- Proof of Quantity

5.2.4 Summary

In order to sum up the differences between the registers, the different stakeholders are listed in the following overview table.

[12] https://en.energinet.dk/Gas/Biomethane/Biomethane-Certificates (last checked 28.03.2018)

Table 31: Overview of the different registers

	Biogasregister Deutschland (dena)	nabisy (German Biofuel register) (BLE)	Danish Green gas Register (Energinet)
Active users of register	Plants / Producers Traders Auditors	Plants / Producers Traders petroleum companies Customs authorities	Plants / Producers Traders
Receiver of final registry statement	End Consumers – Use for heating – Use in CHP – ETS –	petroleum companies (companies obliged to fulfill biofuel quota) other countries' registries for sustainability claims	End consumers
Authorized bodies which examine support claims and fulfillment of obligations	Power grid operator (EEG) Government authorities (customs authorities) Local authorities (EWärmeG, EEWärmeG)	customs authority (biofuel quota)	None
How is renewable gas registered / /verified?	Manual input by producers Auditors	Manual input by producers Auditors	Remote meter readings
Sustainability verification / Links to sustainability schemes	None	sustainability criteria for biomass (RED)	None
Which information is collected and processed	Proof of Origin Proof of Quantity Proof of Quality	Proof of Origin Proof of Quantity Proof of Quality	Proof of Origin Proof of Quantity Proof of Quality

5.3 Requirements for a green gas registry (D2.2)

This section describes the requirements for an Irish green gas registry arising from regulations on the European and Irish level. The section does not deal with requirements regarding the operation of the registry, auditing requirements, or requirements of the different users of the registry. Non-functional requirements, e.g. software platform, system security, resilience, maintenance, etc. are outside the scope of this project and thus not addressed here. The information presented here is based on literature review.

On the European level requirements arise from the Renewable Energy Directive (2009/28/EC, RED) and the recast thereof.

5.3.1 Renewable Energy Directive (RED)

The Renewable Energy Directive (RED) of 23 April 2009 establishes a common framework for the promotion of energy from renewable sources (European Commission 2009). It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy (16 % for Ireland) and for the share of energy from renewable sources in transport (10 % for Ireland). It lays down rules relating to statistical transfers between Member States, joint projects between Member States and with third countries, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable sources. It establishes sustainability criteria for biofuels and bioliquids but not for green gas.

Important sections are Article 17 where sustainability criteria are defined, which have to be met by biofuels and Article 18 requiring mass balancing. Furthermore, it is mentioned in the introduction that the requirements for a sustainability scheme for energy uses of biomass, other than bioliquids and biofuels, should be analysed by the Commission, taking into account the need for biomass resources to be managed in a sustainable manner.

Article 4 of RED requires each Member State to adopt a national renewable energy action plan (NREAP) to be submitted to the European Commission. The NREAP sets out the Member State's national targets for the share of energy from renewable sources to be consumed in transport, electricity and heating and cooling in 2020, and demonstrates how the Member State will meet its overall national target established under the Directive. The Irish National Renewable Energy Action Plan has been submitted in 2010 (DCCAE 2010). The Department of Communication, Climate Action and Environment (DCCAE) of Ireland is the competent authority.

5.3.2 Renewable Energy Directive recast (RED II)

The proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast) – in the following referred to as RED II - was submitted to the Commission on 30 November 2016 and corrected on 23 February 2017 (European Commission 2016). On 13 December the Committee of Permanent Representatives COREPER submitted a compromise proposal to the Council. The European Parliament, in turn, adopted its proposal on 17 January 2018. Since February, the so-called trilogue, negotiation between the commission, the council and the parliament, has started and is supposed to come to an end in June 2018. **The agreed RED II will probably not enter into force before the end of 2018. Only then is it possible to derive finalized requirements for the registry.** Especially targets and GHG limits are likely to change slightly as might deadlines and timeframes for reports.

The analysis in this section is based on the corrected proposal for a recast of the RED by the commission of 23 February 2017. It contains the following points of relevance for the development of a green gas registry.

Guarantees of origin (GO) are defined as an electronic document and a means to prove to a final customer that a given quantity of energy was produced from renewable sources. Furthermore, it is said that this guarantee of origin can be traded independently of the energy to which it relates. In Article 19 aspects of the guarantees of origin are described. (see summary below for details). If a statement of the green gas registry should be used as a guarantee of origin for Irish green gas, the following aspects have to be observed.

It is obligatory for member states to guarantee the origin of renewable energy produced along objective, transparent and non-discriminatory criteria.

The issuance, transfer and cancellation of guarantees of origin have to be supervised by Member States or designated competent bodies. These designated competent bodies have to be independent of production, trade and supply activities. It has to be ensured via appropriate mechanisms that guarantees of origin can be issued, transferred and cancelled electronically and are accurate, reliable and fraud-resistant. Requirements have to be compliant with the RED standard.

It is obligatory for member states to guarantee the origin of renewable energy produced along objective, transparent and non-discriminatory criteria. A proposal for a RED compliant registry extract can be found in section 5.8

Further requirements can be derived from Article 25 (Mainstreaming renewable energy in the transport sector). There it is stated that Member States shall report on the aggregated information from the national databases, including fuels' life cycle greenhouse gas emissions. As the registry can be helpful in gathering information for the national database and green gas can be used as a fuel the registry should contain information on the life cycle greenhouse gas emissions of each MWh registered. Given that Article 25 names targets for advanced biofuels in transport and for fuels from part A annex IX. Furthermore, it limits the possible contribution of biogas from feedstock named in part B of annex IX. This information should be covered by the registry. Furthermore, Article 25 names minimum GHG savings for advanced biofuels. This information also needs to be captured by the registry. If these requirements are fulfilled, the registry can be used as a database enabling tracing of transport fuels that are eligible for counting or – if this database already exists – support this database with information.

Article 26 describes sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels. It is stated that to be counted towards the renewable energy targets, to measure compliance with obligations or to be eligible for financial support bioenergy must meet sustainability and GHG emission criteria. Thus, information on sustainability and greenhouse gas emissions savings has to be transported by the registry. How this can be realized is described in chapter 4.

Article 27 describes how the compliance with the sustainability and greenhouse gas emissions saving criteria can be verified. The key requirements are the usage of a mass balance system and standards of independent auditing. Voluntary schemes may be accepted by the commission and should at least once per year, publish a list of their certification bodies used for independent auditing and submit an annual report to the commission covering compliance with the sustainability and greenhouse gas emissions saving criteria.

Competent authorities of the Member States shall be allowed to supervise the operation of certification bodies that are accredited by the national accreditation body and are conducting independent auditing under a voluntary scheme.

RED II Requirements
Minimum size of a GO: 1 MWh
Complies with EN 16325
GO shall specify
– source of energy, start and end dates of production
– Whether or not GO relates to electricity, gas, or heating and cooling
– Location and type of installation producing energy
– Whether or not the installation has benefitted from investment support and
– Whether or not the unit of energy has benefited in any other way from a national scheme and the type of scheme.
– Date when facility became operational
– Date and country of issue for GO
– Gaseous biomass fuels must fulfil sustainability criteria if used in installations with an electrical capacity greater than 0.5MW.
– GHG emission savings
– Sustainability
For green gas used in transport, information are needed on
– life cycle greenhouse gas emissions of each MWh (Article 25, RED II)
– fulfilling part A annex IX and limits and whether or not the green gas has been produced based on feedstock named in part B of annex IX
Registry proof must be according to the mass balancing method (Article 18, RED/ Article 27 RED II)
Appling standards for independent auditing is necessary
Certification bodies need to be accredited by the national accreditation authority
The operator of the registry must be independent of production, trade or supply activities.
should be able to transport information on sustainability criteria from origin to the government authority

5.3.3 European Emission Trading System (EU-ETS)

Background

The European emission trading system caps emissions in the European energy sector at a certain level. To installations, which have to be part of emissions trading scheme according to the legislation, a defined number of emission allowances (from the cap) are allocated. The allocation rules are defined Europe-wide. One emission allowance equals one ton of CO_2. Once a year, each installation has to surrender enough allowances to cover all its emissions. If a company reduces its emissions so that it has more allowances than it needs, it can sell the remaining (not needed) allowances at the market. Alternatively, it has to purchase additional allowances to comply with its obligation. Those facing difficulty in remaining within their allowance limit can take measures to reduce their emissions such as using a less carbon intensive energy source. Installations or parts of installations used for research, development and testing of new products and processes and installations exclusively using biomass are not covered by these Regulations. “Units using exclusively biomass" includes units which use fossil fuels only during start-up or shut-down of the unit. The emission factor for biomass is defined as zero.

Biogas in natural gas grids

The guidance document on Biomass issues in the EU ETS (European Commission 2012) gives the following information. Where EU ETS operators want to claim a certain amount of that biogas as part of their purchased natural gas, there are two options:

- The operator determines the biomass fraction of the gas physically consumed. This would require either chemical analyses of the gas or an approved estimation method.
- Where an appropriate accounting system for biomass fractions is in place, it may be used under certain conditions. In particular a guarantee of origin system (in accordance with Articles 2(j) and 15 of the RED) might be considered appropriate. Where a guarantee of origin system is in place, laboratory analyses for the determination of the biomass fraction are not allowed for all installations connected to that grid in order to avoid double counting.

To make use of biogas in a natural gas grid and to make the benefits thereof easily accessible to operators of EU ETS installations, an appropriate accounting and verification system (e.g. using a biogas registry) has to be established which allows the accurate, transparent and verifiable identification of biogas amounts fed into the grid and consumed by installations, effectively avoiding double counting of biomass. The system also needs to make provisions for avoiding data gaps or double counting if the grid is connected to other grids, including in other Member States.

The ETS in Ireland

In Ireland, the ETS is administered by the Irish EPA. Accredited Verifier in Ireland is the Irish National Accreditation Board (INAB).

The EU emissions trading system (EU ETS) is implemented in Ireland under S.I. 490 of 2012 and amendments and S.I. No. 261 of 2010 and amendments.

ETS Requirements
– an appropriate accounting and verification system (e.g. using a biogas registry) is needed which allows the accurate, transparent and verifiable identification of biogas amounts fed into the grid and consumed by installations, effectively avoiding double counting of biomass. – Registry has to provide “accurate, transparent and verifiable identification of biogas amounts” – Registry needs to effectively avoid double counting of biomass

Examples, how the acceptance of green gas registry statements to fulfil the obligations is handled in other countries, are given in chapter 6.

Examples on the acceptance of green gas certificates in the EU-ETS trading system

Which requirements have to be fulfilled by green gas in order to be eligible for recognition by the Irish ETS-authorities? Examples from other countries:

- The German emission trading authority (Deutsche Emissionshandelsstelle, DEHSt) accepts certificates from the Biogasregister Deutschland as substitute for emissions certificates. It has to include the following information:

  - Substrates as defined by 601/2012/EU (represented by German Law “36. BImSchV”)
  - plausible quantity framework
  - feed-in quantity
  - mass balancing

- Denmark: The certificates in Energinet’s registry are recognized under the emission trading scheme. This means that enterprises covered by the emission trading scheme may use Green gasGas Certificates to offset CO_2 emissions in their emission trading scheme balance.

5.3.4 National schemes with possible impact on the registry design

The national schemes describe below address the so-called non-ETS sector. The EU ETS covers emissions of carbon dioxide (CO2) from power and heat generation (>20MW), a wide range of energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals and facilities that perform the capture, transport and geological storage of greenhouse gases. Non-ETS basically describes all other man-made sources of greenhouse emissions.

Biofuels Obligation Scheme (BOS)

The Biofuels Obligation Scheme (BOS) translates the standards for biofuels from the RED into Irish law. It places an obligation on suppliers of mineral oil to ensure that 8.695% (by volume) of the motor fuel (generally gasoline and motor diesel) they place on the market in Ireland is produced from renewable sources. Since 1 July 2010 a Biofuel Levy of 2.00 cent per litre is payable on the sales of all Biofuels into the market (DCCAE 2007).

The National Oil Reserves Agency (NORA) has been mandated to administer the Biofuels Obligation Scheme. NORA has engaged Consultants (a consortium of Byrne Ó Cléirigh and LHM Casey McGrath – with BÓC as the lead consultant – hereafter referred to as BÓC-CMG) to administer the Scheme. When submitting an application for BOS Certs, gas to liquid conversion factors apply which should be used when converting a unit volume of biofuel in gaseous form into a unit volume of road transport fuel in liquid form.

BOS Requirements
– the registry is required to state the amount of green gas in order to be able to convert a unit of green gas into a unit of liquid biofuels) – green house gas emission values – information on the compliance with sustainability criteria

If green gas should be used in transport an interface between the registry and the BOS would be helpful. In order to better match the statistics, the green gas registry would be required to issue account statistics quarterly.

Renewable Electricity Support Scheme (RESS)

The new RESS is being designed to contribute to Ireland's 2020 renewable electricity targets and to deliver Ireland's renewable energy ambitions out to 2030. The Public consultation on the development and design of a new Renewable Electricity Support Scheme (RESS), sought submissions on specific questions relating to the design principles and structure of the new RESS. These included models and pathways to deliver increased community and citizen participation in renewable electricity projects. On 4th September 2017, the Department of Communications, Climate Action and Environment released the consultation paper on the development of the new Renewable Electricity Support Scheme (RESS) for Ireland which will eventually be the successor to the current REFIT 2 & 3 schemes[13]. The deadline for submissions closed on Friday 10 November 2017. The recommended approach is a technology neutral auction resulting in the awarding of a uniform-price Floating Feed-in-Premium (FFiP). The length of the awarded FFiP contract will most likely be 15 years. Amongst the technology open for consideration are a number of Bioenergy technologies:

Biomass LFG, Large biomass combustion, Large biomass combustion repowering, Small biomass combustion, Large biomass CHP, Large biomass CHP repowering, Small biomass CHP, Large AD CHP, Large AD CHP (50/50), Small AD CHP, Sewage Gas, Biogas/green gas, Bio LPG CHP.

So far, no detailed requirements can be defined. If the new RESS should offer subsidies for green gas production or usage this scheme would have to be studied to derive requirements for the registry.

Support Scheme for Renewable Heat (SSRH)

The Support Scheme for Renewable Heat (formerly called Renewable Heat Incentive) was introduced at the end of 2017 after securing government approval.

So far, the scheme does not support green gas grid injection but it is said that this will continue to be under consideration for subsequent phases of the scheme.

The Minister for Communications, Climate Action and Environment has appointed the Sustainable Energy Authority of Ireland (SEAI) as the designated administrator.

Should green gas injection be part of the scheme in the future implications on requirements for the registry will have to be looked into.

5.3.5 Voluntary markets

Voluntary markets develop in the non-ETS sectors, relying on people of conviction – outside of the markets incentivized by subsidy systems.

[13] See *Public Consultation on the Design of a new Renewable Electricity Support Scheme in Ireland*, September 2017: https://www.dccae.gov.ie/en-ie/energy/consultations/Documents/28/consultations/Renewable%20Electricity%20Support%20Scheme%20-%20Public%20Consultation.pdf

Green House Gas Protocol (GHG Protocol)

The Greenhouse Gas (GHG) Protocol[14], developed by the World Resources Institute (WRI) and the World Business Council on Sustainable Development (WBCSD), sets a global standard for how to measure, manage, and report greenhouse gas emissions. The following information is obtained from the Green Gas Certification Scheme UK[15]. The GHG Protocol defines three scopes for reporting greenhouse gas emissions.

Scope 1 emissions address an organization's on-site fuel use or fuel use in vehicles they operate. The use of green gas delivered through the gas grid should be reported under a site's Scope 1 emissions. CO2 emissions of green gas consumption can be counted as zero under scope 1 but should be reported separately, outside the main emission Scopes, as a memo item in a company's GHG report. Fugitive CH_4 (methane) emissions and N_2O (nitrous oxide) emissions from green gas combustion must be accounted for under Scope 1. It is important that green gas use, and the associated emissions calculations and claims described above, are supported by appropriate evidence. The registry statement can provide such evidence.

Scope 2 emissions are generally related to consumption of electricity generated offsite. On-site or in-vehicle green gas use is unrelated to the reporting of Scope 2 emissions.

Scope 3 emissions relate to all indirect emissions due to the activities of an organization. In the case of green gas consumption the indirect emissions are related to the lifecycle greenhouse gas emissions arising from the production process of that green gas.

The registry statement will contain at least information on which criteria, such as defined for example by the RED II, are fulfilled. Based on this a default value for the lifecycle greenhouse gas emissions can be calculated and used for Scope 3 reporting. Furthermore, the registry statement could state the greenhouse gas emissions per megawatt hour of green gas.

Carbon disclosure project (CDP)

CDP[16], formerly the Carbon Disclosure Project, set up the global disclosure system that supports companies, cities, states and regions to measure and manage their environmental impacts. The CDP has gathered a comprehensive collection of self-reported environmental data.

The CDP issued a technical note on April 2017 on the use of green gas certificates for GHG and renewable energy (RE) usage claims:

- "Green gas certificates need to be legitimate and legally enforceable means of transacting property rights and claims to biogenic or renewable fuel attributes of gas production in a specific market;
- Green gas schemes based on robust tracking systems would help with assurance around data quality and double issuance of certificates;

[14] http://www.ghgprotocol.org/, last accessed 2018-03-14
[15] https://www.greengas.org.uk/certificates/emissions-reporting, last accessed 2018-03-14
[16] https://www.cdp.net/en/info/about-us, last accessed 2018-03-14

- The GHG Protocol's Scope 2 Guidance recommends considering and applying the Scope 2 quality criteria to green gas certificates;
- To make a renewable electricity usage claim valid for RE100, in addition to the above, a company still needs to produce and retain a renewable electricity attribute certificate".

CDP suggests that use of gas certificates be limited to users who can physically receive gas from gas plants via one closed gas network. Inside one gas grid certificates can be purchased from either the same supplier as the gas or a different supplier.

Existing schemes and verification

It is recommended that green gas certificates used for GHG or RE usage claims be verified by an independent third party against the Scope 2 quality criteria. This effort would have to be undertaken by the purchaser. The GHG Protocol Scope 2 Guidance requires that the emissions factors from Energy Attribute Certificates (certificates) that a company has retained or acquired be the first choice in market-based Scope 2 accounting. It is best practice to use certificates that rely on robust energy tracking and auditing systems that enable a link to be established between the energy production at a given source (with its specific attributes), and its sale through a network of suppliers, until it reaches the final consumer who will claim the specific characteristics of the original source. Reliable tracking systems are independent, transparent and robust. From a CDP perspective, there are four criteria that need to be fulfilled:

- There is an entity responsible for the instruments' generation (issuing body) that issues the instrument in a publicly available registry(ies) against renewable energy delivered by a generator. Only one instrument is issued per unit of energy (e.g. MWh) and this link is properly audited.
- A set of attributes are present in the instrument or can be legitimately inferred from it, namely:
    - Name of producer;
    - technology type;
    - year of installation;
    - year of production;
    - state support/aid; emission rate;
    - other environmental characteristics.

Properties should not be disaggregated, e.g. it is not allowed for one party to count for the GHG emission factor and another party to count for the fact that it is renewable in origin.

- There is an auditable chain of custody, that is, all information can be verified or audited by users in the system and the whole system is audited by external parties, guaranteeing that the link between generation, distribution and final consumption is effectively established and that there is a permanent retirement/cancelation mechanism within the system.
- The information in the system can be used to avoid the double counting of attributes.

To summarize, as long as the registry fulfils the requirements stated by the RED II, the requirements of the GHG protocol should also be fulfilled.

5.4 What data is relevant for the green gas registry (D2.3)

This section describes the entities which are involved inside and outside the green gas registry and the information they will provide. Entities in this context are actors or stakeholders which, in turn, could be persons, companies or agencies.

The setup of a green gas registry involves different stakeholders on the inside but also outside the registry. An overview of involved entities can be seen in Figure 12. These entities have different responsibilities and needs, at the same time offering different information to the registry (listed in subsection 5.41).

The central entity for the green gas registry is the registrar company, who manages and develops the registry according to national and EU-wide legislations and requirements from voluntary markets. The registrar needs, according to the RED draft, to receive a mandate from a government authority which will guarantee the recognition of the registry on a national and EU-wide level.

The other entities are the following ones: Producers and traders, auditors and also the registrar staff. It is assumed that the gas grid operator in Ireland can provide data for the registry, such as green gas amounts and further information about the production facility. The end user receives the registry statement which is issued by a production/trading company user [2] inside the registry.

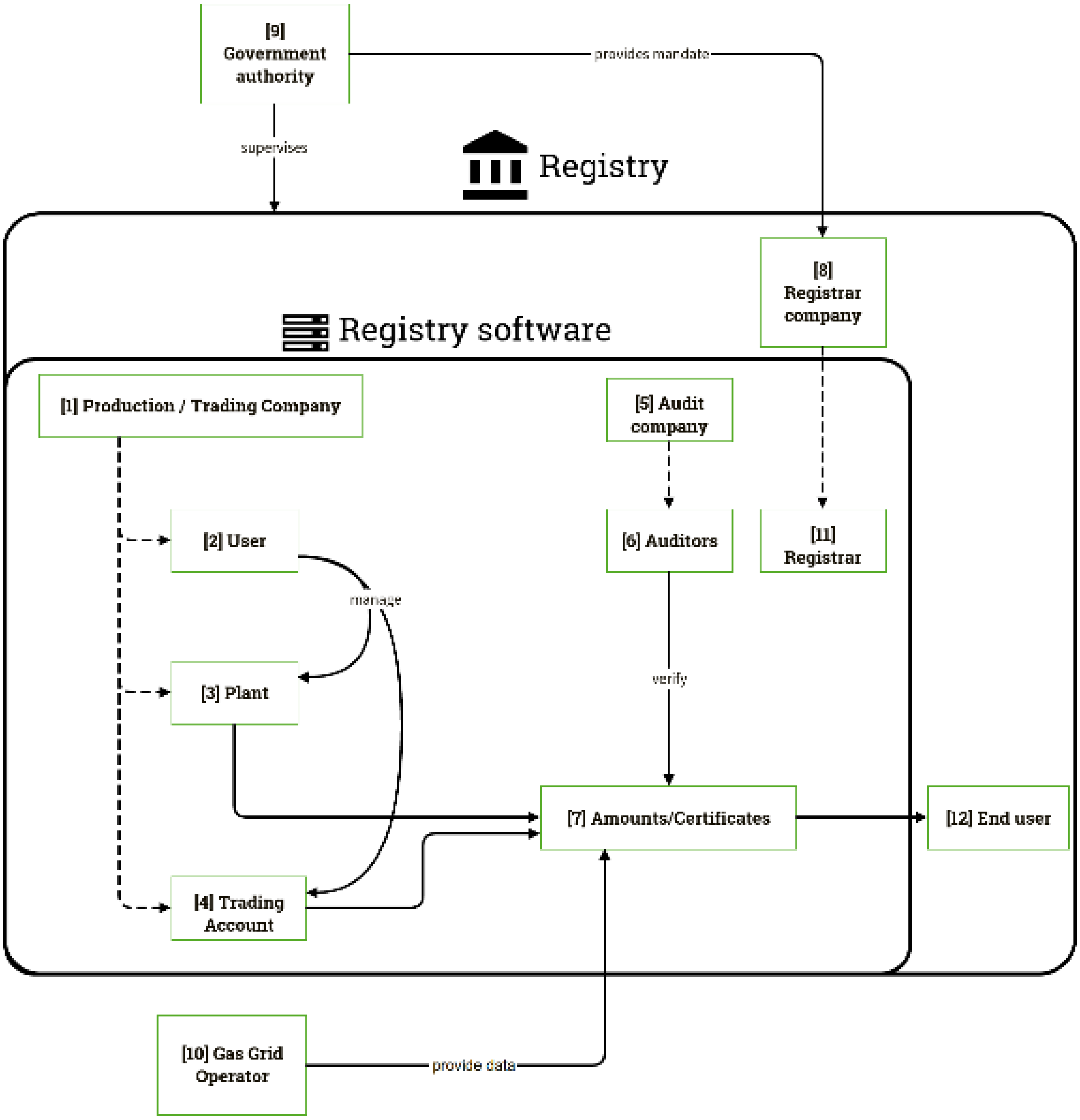


Figure 14: Entity model of the registry, entities are enclosed in green boxes

5.4.1 List of entities (D2.3)

The entities involved with the registry are listed in the following table. Furthermore, their most important attributes are indicated. This data set can be used as a starting point for the setup of the registry software. Within the software, it will be necessary to provide a comprehensive set of data in order to create a transparent and comprehensible registry.

One additional key entity inside the registry is the registry statement which is not listed here. The data defining the registry statement can be found in section 5.8.

Table 32 Registry statement data

Entity	Role for Registry		Data sets
Production / Trading Company	Register amounts, trade amounts, create/cancel certificates		Name of company
			Short name company
			VAT-Number company
			CRO-Key
			Name & contact info of authorized representative
			Contact info contact person operational business
			Contact info contact person billing
Application User	User of software system		Full name
			User name
			Contact info (phone, mail)

			Employer name & address
Green Gas Production plant	Registered in registry, basis for creating certificates		Plant name
			Plant address
			Plant commissioning date
			Injection point / meter point N°
			DAFM registration number
Trading Account	Basis for all trading activities		Account number
			Account name
Audit company	Officially registered and recognized by authorities		Name of company
			VAT-Number company
			CRO-Key

			Registration scheme
			Registration number
			Name & contact info of authorized representative
			Contact info person operational business
Auditors	Work for audit company, verify data from green gas producers		Full name
			User name
			Registration scheme
			Registration number
			Contact info
			Qualification
Green gas amounts/certificates	Are created and traded in the registry		Quantity

			Quality
			Origin
			Cancellation purpose (electricity, gas, heating and cooling)
			Period of injection
			Received subsidies
Registrar company	Manage registry		Name
			Address
Government institutions	Control registry, define standards (subsidies, sustainability,…)		Name
Gas Grid Operator	provide meter data		Name of production plant
			Meter data of production plants
			Injection point of production plant

Registrar	Employee of registrar company [8]		Full name
			User name
			contact info
End user	Receiver of registry statement		Full name

5.5 How to transfer data into the registry? (D2.6)

This section lists reference points for data collection of the future green gas registry in Ireland. All the data or information gathered and transferred by the registry relates to one of these reference points.

Any data registered inside the green gas registry refers to something in the real biomethane world, e.g. a production plant in operation or a traded green gas amount. This list includes relevant objects which are needed to enable a proper documentation for green gases in Ireland.

The list of reference points refers to objects outside the registry, while the list of entities (section 5.4) maps these objects inside the data base. The link of these two is described by the data collection process.

The registry issues a proof of origin as part of the final registry statement. This proof of origin, for example, refers to an existing production plant, which is operated by a company. For the green gas registry being able to provide a reliable proof of origin, the data behind needs to be collected in a well-defined way. These definitions have to be designed to enable back tracing to the origin for each proof. Thus, processing of proofs can be handled efficiently and potential fraud is discouraged. In cases of doubtful claims, further examination is done on a sound information basis.

The final registry statement also contains details on the proof of amount. It documents the green gas amount which was produced and has actually been used, e.g. in a CHP plant or in a heating unit. The exact gas amount within the registry is a result of a chain of production, trading, possibly splitting and, finally, cancellation. The registry may obtain these numbers from automatic meter readings. The value for green gas consumption in combination with the proof of cancellation is used for a number of purposes, for example, subsidy claim. Therefore, the registry has to be able lay open and to retrace step by step the chain of custody from withdrawal to injection if necessary.

5.5.1 List of reference points

The following tables list reference points for data collection necessary for a green gas registry in Ireland.

The table columns contain the reference point which is the entity defined in section 5.4, the “data collection” which defines where the information for the reference point comes from.

Companies along the trading chain

Different companies are part of the green gas chain of custody. The registry refers to these companies depending on their role, e.g. as a producing company or a trading company.

Table 33 Different companies and their roles in the registry

Entity/Object	(Possible) Reference point(s)	Involved persons or authorities
producing company	▪ application form ▪ data entry or confirmation inside software ▪ Companies Registration Office of Ireland	▪ authorised representative (e.g. CEO) ▪ registry users
trading company	▪ application form ▪ data entry or confirmation inside software ▪ Companies Registration Office of Ireland	▪ authorised representative ▪ registry users
importing company	▪ application form ▪ data entry or confirmation inside software ▪ Companies Registration Office of Ireland	▪ authorised representative ▪ registry users
Final consumer	▪ data entry during the cancellation process	▪ registry user of trading company

Table 34 Green gas production plants whithin the registry

Entity/Object	(Possible) Reference point(s)	Involved persons or authorities
Green Gas production plant with direct grid injection	▪ On first registration ▪ Data entry or confirmation inside software ▪ DAFM Certificate ▪ GNI meter	▪ producing company ▪ local DAFM Office ▪ GNI
Green gas production plant without grid injection	▪ On first registration ▪ Data entry or confirmation inside software ▪ DAFM certificate ▪ GNI meter	▪ by producing company ▪ local DAFM Office ▪ GNI

Table 35 Metered data for production and gas grid withdrawal in the registry

Entity/Object	(Possible) Reference point(s)	Involved persons or authorities
Gas grid meter for injection	▪ As produced batch from GNI meter reading (grid injection, land transport)	▪ GNI
Gas delivery contract (gas trade / certificate trade)	▪ Traded batch entered by user inside software	▪ Producing / trading company
Foreign registries cancellation statement referring to imported batch.	▪ Way of data collection needs to be developed	▪ cooperating registry ▪ Importing party
Gas grid meter for withdrawal	▪ As applied batch from automatic meter reading or ▪ entered by user inside software	▪ Trading company ▪ Final consumer ▪ From gas supplier ▪ From trader ▪ From SEAI

Table 36 Green gas quality information in the registry context

Entity/Object	(Possible) Reference point(s)	Involved persons or authorities
Certification results (sustainability, GHG-values, substrates…)	▪ From Certificate	▪ Auditor or ▪ Producing company
Mass balancing information along trading chain	▪ Companies involved in trading	▪ producing company ▪ trading company ▪ importing company ▪ Final consumer

Table 37 Application/Counting against targets within the registry context

Entity/Object	(Possible) Reference point(s)	Involved persons or authorities
Application of green gas	▪ Meter readings (from gas grid removal)	▪ Gas grid operator ▪ Final consumer
Counting against target	▪ Registry statement ▪ Authority verification	▪ Final consumer ▪ Competent authority

5.6 How is the registry data verified: Verification architecture (D2.8)

This section provides a suggestion for providing verification architecture for a green gas registry tailor-made for Ireland. On this basis, a trustworthy registry can be established.

The registry is designed to provide a system of proofs and guarantees in **compliance with a number of laws and directives** such as an Irish green gas support, EU-RED or EU-ETS (see section 5.3). The requirements posed by these regulations have to be met by the registry. Depending on the design of a possible future green gas support scheme, the registry may have a stronger or lighter focus on the proof of quality. This architecture assumes a registry that issues a tradeable proof of the green characteristic of a certain gas amount. The value of the green characteristic is remunerated based on a feed-in tariff for injection or for certain end uses, such as a transport fuel or as fuel for a CHP. If green gas is supported by a gas grid feed-in tariff (like in UK or Denmark), there will be still the need to issue a guarantee of origin according to the discussed RED II draft.

In addition, this section aims to

- provide an adapted verification architecture for an Irish green gas registry,
- suggest reasonable verification measures for an Irish green gas registry,
- suggest a robust data entry and verification process in order to enable an efficient registry, operation
- and indicate feasible options to the suggested process, whenever available.

5.6.1 Fundamental architecture issues

The RED II-draft requires the operator of the registry to be independent of production, trade or supply activities. In other European countries, e.g. in Denmark, France or Austria, the gas grid operator is in charge of the corresponding green gas registry. For the suggestions of this project, we only assume the registry operator to be government mandated, but run by an organisation under private law.

These aspects are the basis for the present system's architecture design.

For any private registry operator it is important to manage & reduce risks of liability. A database containing reliable information is therefore a key aspect of the registry.

Three Steps for data registration

The registry is intended as an electronic system. However, the registry cannot check the correctness of data itself, therefore verification steps are necessary. All the data needed for a registry statement has to be verified by an external actor or source. The registry remains a neutral actor, only providing the platform for registration.

The following basic principle for data registration is suggested:

1. Data registration (see also section 5.4)
2. Verification
3. Further data processing

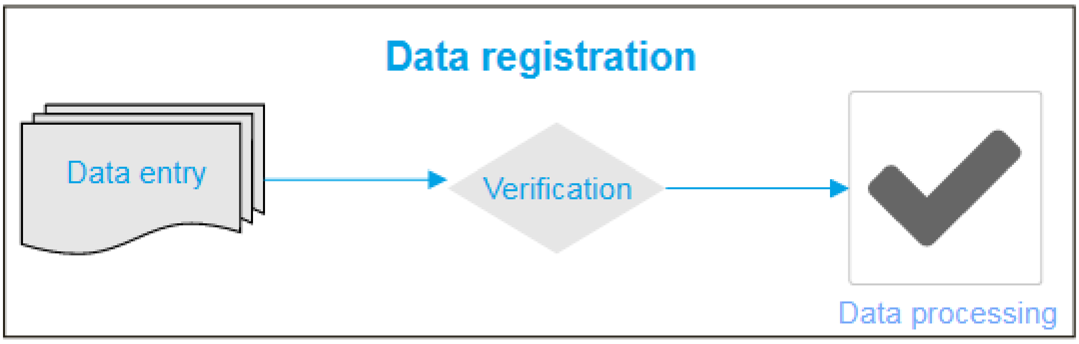


Figure 15 Steps of data registration

Fundamental principle: three types of proof

The architecture is based on the principle that REDs "guarantee of origin" is split into three parts. These parts are usually handled together, but with important differences in processing. The three parts are:

Proof of origin:	**Identification information about the production plant.**
Proof of amount:	**The produced and injected green gas amount.**
Proof of quality:	**For example, sustainability information and GHG value.**

Green gases for voluntary markets

It is assumed, that only green gases that comply with certain minimum standards are eligible for support schemes. However, green gases that fail to comply with support scheme or RED standards may be automatically registered. The registry therefore needs to be able to transport information on compliance with different support schemes or regulations.

Producers of non-compliant gases will thus not be able to have their gases recognized in the support schemes. However, their amounts are registered and they will still be able to sell their amounts on voluntary markets.

Who may register?

For mass balancing, as required by the RED the whole chain of custody needs to be considered. Therefore all relevant actors along the green gas trading chain, who contribute ort interact need to be registered. We assume that companies of the following will have to register

- Producers of green gases (for the registration of plants & amounts)
- Traders/Shippers of green gases (to register trading activities)
- Auditors for reporting of their certification results.

Options for other possible users may be:

- International Companies (in the future, also companies from abroad who import green gases to Ireland may be required to register)

- Government authorities or government mandated institutions may get an active role inside the registry for end-use-validation.

5.6.2 Handling of green gas amounts

The mode of handling green gas amounts is described in this subsection.

Amount registration

See also below for detailed procedure suggestions.

1. The reference point for amount registration is the meter at the feed-in point.
2. This meter is read electronically by GNI and transferred to MWh-units.
3. On a monthly basis, these readings are transmitted to the green gas registry.
4. According to this data a corresponding amount is credited to the producer's account as a monthly batch.
5. Amount transactions are done by registry users until cancellation.
6. After the expiry date of a registry certificate is reached (RED §19 Art. 2 3.) the registry redeems any amounts that have not been cancelled yet

Unit size for GoO

The RED defines a standard size of 1 MWh for guarantees of origin. In contrast, the unit used for the gas grid is 1 kWh (GNI 2017). The RED is not clear on which variations are possible and if units smaller than 1 MWh can be used for registry certificates.

Setting the standard size to 1 MWh, without allowing smaller units at the same time, may have unwanted consequences on the application side: A small CHP-plant may be forced to cancel a lot more energy certificates than needed. Thus these end-consumers may have to pay significant extra costs if the unit is set to 1 MWh in this case.

There are several options to bridge the gap between RED & gas grid accounting:

- Defining the registry's size to MWh, but allowing 3 decimal digits.
- Truncate the monthly kWh-value to get full MWh-values (and shift the difference to the following month).
- Allowing registration in kWh size but issuing only registry statements in MWh, if the end-use is subject to RED standards

Examples for green gas units from other countries

These units are used in other countries' registries:

Table 38: Green gas amount units in other countries

Country / Registry	Unit	Unit identification
Denmark / Energinet	MWh	Each MWh has an individual Certificate number No smaller units allowed In Denmark, Energinet's system issues certificates once a month. For each full 1 MWh, a certificate is issued. Remaining kWh are issued with the next month's certificates.
Germany / Biogasregister Deutschland	kWh	kWh are aggregated in batches. Only batches have individual numbers
Austria / Biomethane registry Austria	kWh	Each kWh has an individual number
United Kingdom / Green Gas Certification Scheme	kWh	Each kWh has an individual certificate number

5.6.3 External sources as a basis for registration

Before the first production site or amount may be registered, some verification steps could be facilitated by establishing direct or indirect cooperation with relevant authorities. In this section, the relevant connections are described.

Company registration

Only existing companies should be accepted to the registry. All Irish companies have to register with the companies' registration office of Ireland. Names and relevant data are publicly available on the CRO website.

Based on this, the registry may establish a simple but effective step as part of the application procedure for companies (see below). This step requires the registry staff to look up the company's name on the CRO website. Additionally, the name of persons authorized to sign in the name of this company can be verified via the CRO website and be compared with the signature on the application form.

On the basis of a personalized account for companies' staff members any operation in the registry can be assigned to a single person. All actions of these users are assigned to a certain company. The companies representatives have their own interest to appoint own personnel to the account as they will be held liable for their actions. This point should be clearly governed in the general terms & conditions of the registry.
Besides company staff, also staff of a service providing company should be able to get access to a company's account. In the German Biogasregister Deutschland, it is a common situation that the

trader provides the registry entry service for the producing company. This option should be considered in the registry software and in the application form.

Result: This step ensures that the registry only allows **existing companies** to register. These companies can be held liable for their documentation actions. A correct and reliable registration of the company is the very basis of all data entered into the registry.

Alternative options:

- It is also an option to skip this step. Company registration is then based on the signature on the application form only. The decision whether this step is required should be taken in respect to a risk assessment /liability considerations.
- If the registry is financed via registry's user fees, a billing process has to be established. This **billing process** is a small-scale but effective measure to keep the **list of companies** inside the registry clean & up to date. For example, when charging an annual fee, all companies are billed. If a company changes address or name, the motivation to pass on this information is based on the need to receive a correct bill. Thus, the database is refreshed on a regular basis (e.g. once a year).
- The registry could ask for an excerpt from the commercial register upon company registration.
- Along with the company registration, the registrar could create a special user-administration account that is available to the authorized representatives only. Any staff member of this company gets his or her own account through this administrative account. Access is granted or denied through this account. The drawback of this solution is that the administrative person is not easily replaceable in case this becomes necessary (e.g due to illness). Also, this requires a special skill set and knowledge.

Production plant registration: DAFM approval certificate for production plant registration

The Irish department of agriculture, food and the marine (DAFM) operates a number of regional offices (about 12 at present) to supervise compliance of agricultural companies with hygiene regulations. Before a biogas plant starts operation in Ireland, the operator needs a permission of DAFM. This permission is issued in a signed and embossed certificate by DAFM.

Building on this structure, we suggest to base the registry's proof of origin on the DAFM permission certificate. The following cooperation between the registry and DAFM and its regional offices could support this:

The green gas registry establishes cooperation with the regional DAFM offices. Only green gas production plants holding a valid certificate may be registered. In the process of registering a green gas production plant, the operator shows the DAFM certificate (in copy) to the registry operator (see procedure suggestion below). The registry and the central DAFM office each appoint a contact person for the other party.

Table 39 Obligations of registry and DAFM

The **registry**'s obligations	The regional DAFM office's obligations
▪ verify certificates and DAFM-registration ▪ compare operation periods and registered amounts ▪ clear questions regarding the proof of origin ▪ report irregularities in production plants to DAFM	▪ Provide DAFM registration certificates to the registry on demand ▪ report if DAFM is decommissioning a green gas production plant ▪ report if DAFMf takes a green gas production plant temporarily out of service

Result: Based on this, only green gas production plants, which are properly registered and certified by DAFM are eligible to the registry.

Options:

As there is no green gas support scheme at the time of writing, DAFM is not assigned to establish such cooperation. Therefore, the following options are mentioned:

- In Germany's registries, e.g. "Biogasregister Deutschland" or nabisy, the proof of origin is confirmed by independent auditors. The auditors act inside officially approved certification schemes and according to laws and regulations. On-site audits are elementary part of this procedure. The confirmation is renewed on a regular basis, e.g. annually. Thus, phases out of operation can be reported.
- Apart from DAFMs offices, other Irish offices (e.g. building control authority) may be able to confirm existence of green gas production plants. However, none of these are expected to check the production sites on a regular basis.
- In Denmark, Energinet's green gas registry is hosted by the gas grid operator. If Gas Networks Ireland (GNI) was the green gas registry's operator, the task of checking the plant may be also transferred to GNI.
- A software solution could be: production plants could be registered on a preliminary basis by the companies themselves. Handling of green gas amounts is restricted until full confirmation of plant.

Amount registration

The registration of amounts is a crucial point in the verification chain. The registered value is the basis for the proof of amount on the market. This proof also represents the monetary value which is linked to the green properties of the gas. Therefore, this is a potential entry point for fraud. Trust in the registry relies on a robust process, especially here.

This concept is based on the idea that green gas production is measured by automatic meter readings, and the registry operator obtains these readings from the gas grid operator. From this, the registry then establishes green gas amounts.

GNI as a potential registry operator has access to meter readings. Based on automatic meter readings of green gas injection, an efficient process for the registration of amounts can be established. GNI could do an electronic data transfer once every month.

Data for green gas amounts is obtained from meter readings. It is crucial that the meter readings are considering possible propane addition, e.g. by being placed before the addition of propane. In order to achieve this, the registry communicates with GNI's administrative system registry through a defined interface once per month. These amounts are credited to the registered production plants inside the registry. Gas Networks Ireland collect injection amounts by automatic meter readings (GNI 2017). These readings can e provided to the registry on a monthly basis via a digital interface (see below). In order to achieve this, the two parties have to cooperate in this area.

Table 40 Registry and GNI obligations

Registry's obligation:	GNI's obligation
▪ Provide contact person for cooperation issues and for technical issues ▪ Keep software compliant to interface standard, contribute to interface development ▪ Fetch monthly data within fixed time frame	▪ Provide contact person for cooperation issues and for technical issues ▪ Provide data interface standard to registry ▪ Include registry into interface development ▪ Provide data via a secure data transfer to registry, e.g. via server hub ▪ Report corrections to registry

Data can be processed automatically in this case. However, automatic meter readings may need to be manually corrected, e.g.

- in case of technical failures,
- software bugs,
- transmission errors or
- in order to subtract (fossil) propane addition
-

Therefore, the registry operator needs a **way to manually correct** the numbers if needed.

Propane adaption

Fossil propane is often added to the green gas before injection in order to meet the grid's gas quality requirements concerning the calorific value. Depending on the set-up, the meters sometimes do not detect the additive. In case of propane addition, the fossil propane share would then be counted as green gas.

Note: In this suggestion, only green gas measured by GNI meters is eligible to the green gas registry. Any other green gases need to find another way to prove their eligibility for support schemes.

Result: Registration of production plants is limited to feed-in plants which are in active cooperation with GNI.

Options to suggested procedure

- To further mitigate this risk, plausibility checks and random samples are appropriate.
- In dena's Biogasregister Deutschland (Germany), the amount is registered by a user and confirmed by an auditor. This procedure includes a plausibility check whether the amount measured matches to the substrate input of the production plant (mass balance verification).
- Denmark & Austria: The amount numbers are obtained by gas grid operator. The registries are operated by the gas grid operators (Denmark) or by a specialized daughter company (Austria). If the registry is operated by GNI itself, this cooperation may be reduced to an internal data interface.

Proof of quality: Compliance with relevant certification criteria

The sustainability certification scheme, resulting in sustainability certificate stating information on sustainability and GHG emissions, is described in chapter 4.

The certification system is in charge to supervise the verification process of the sustainability criteria; the registry transports the information. Therefore, a crucial point is interface between the auditing process and the registry. The options for this are described in section 5.9.

From the meta-position of the registry operator, it might be possible to conduct plausibility checks of the reported numbers every year on the basis of data reports and visualizations for all plants. This should be considered as an option for the registry.

Amount transactions and cancellation

The process steps for **amount splitting and transferring of amount** are based on delivery contracts, which details are only known to the trading parties. The registry provides the platform, on which the market participants document the actual trading chain (in order to comply with RED, for example). The two involved trading parties have to verify the data, and will do so in their own interest. Any discrepancy between registry transfers and delivery contracts is handled between the trading parties only.

The **registry software**, however, needs to make sure that only the registered and verified amount is processed. For all transactions the amounts have to correspond to the production. This verification must be guaranteed by the software, which has to be reliable and robust regarding all transactions in the registry. This can for example be controlled via the transaction log.

After final consumption, an amount is **cancelled** in order to close the mass balancing documentation. This transaction is based on a delivery contract; however, the exact amount delivered is determined by meter readings, e.g. on a fueling station or a CHP-plant. Both supplier and final consumer will confirm or correct the amount in their own interest. The intended end-use (e.g. transport, CHP) should be registered (see also section 5.8). This prevents that the same registry statement is used multiple times to apply for more than one subsidy.

Therefore, no external verification measures are required for amount transfers or cancellations.

International trade as future option

In the project's discussions, international transfer of proofs between registries has always been seen as an important future option. A transaction procedure between registries may facilitate import & export of green gas amounts between countries. The basis of such operations is a cooperation based on a contract between registries. Such contracts can be of bilateral or multilateral nature.

The multilateral ERGaR-initiative aims at establishing a European hub for the transfer of green gas proofs. An application for the recognition of the ERGaR scheme has been handed to the European Commission. As soon as the ERGaR scheme is accepted and the organization starts operation, the green gas registry could join this scheme once it is established. It would then be able to transfer proofs through the hub to all other participating registries, thus enabling cross border trade.

Registration of green gas imports from abroad need a different way of registration. Data entry and a verification procedure need to be elaborated in line with (multi-/bilateral) cooperation agreements. If green gas amounts from abroad are imported into the Irish registry, no origin for the production can be used as reference point for the data. In this case, the registry instead refers to the proofs of another cooperating registry.

Examples from other countries

- Bilateral agreements in Europe:
    - Denmarks Energinet cooperates with Germanys Biogasregister Deutschland
    - Austria's Biomethan registry cooperates with Germanys Biogasregister Deutschland
- Multilateral initiative: ERGaR

5.6.4 Verification during registry operation

This section describes registration and verification processes step by step from company registration to cancellation. The following figure 16 and table 41 summarize the data entry steps and the verification measures suggested above. The table picks up all major registration processes and considers for each step the following points:

- Data entry: Who enters which data?
- Verification measure: How can this data be verified (if necessary)?
- Procedure suggestion: A possible workflow including both data entry and verification.

Options to the suggested procedure are listed below the table.

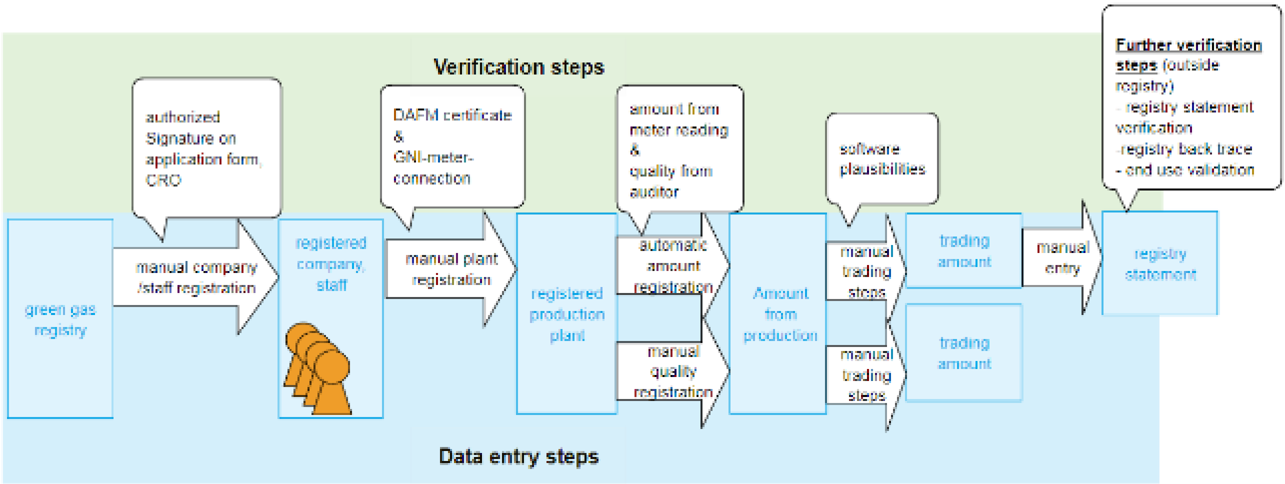


Figure 16 Data entry & verification steps

Table 41: Overview of verification procedures

Registra-tion	Data Entry	Suggested verification measure	Suggested Procedure
Company	Company registration is based on an application form (hard copy) signed by authorized representative. The registry staff enters company data into the registry.	The registry staff checks the data from the application form: Can the company data (name, address …) be found in the Companies Registration Office of Ireland (CRO)? Is the authorized signatory mentioned in the CRO database?	1. The companies' authorized representative fills in & signs the application form for company registration. 2. The Company sends the application to the green gas registry operator 3. The registry staff carries out verification measures The registry staff carries out the verification measures 4. The registrar sets up the account for the company.
Users	The authorized representative enters data (name, e-mail-address, …) of the company's staff inside the companies' administrative account	The software verifies the user's e-mail-address through e-mail-contact. Thus, only valid addresses are registered. They can be used for further communication (questions, password retrieval, newsletters…) Registration can also be managed only by the	1. The authorized representative of the company enters the staff members' personal data & e-Mail-address into the registry 2. After completion, the registry software sends an activation E-mail to the staff member including a link to activate the account. 3. The user follows this link, sets up a password

Registra-tion	Data Entry	Suggested verification measure	Suggested Procedure
		registrar (as for companies) and not by the means of the authorized person.	4. The registry software activates the account
Proof of Origin/ Produciton Plants	A user of the registered company enters the production plants data (Name, Address, meter number…) into the registry. A copy of the DAFM certificate needs to be uploaded in the process.	Registry staff verifies the plant data and plant ownership with the DAFM certificate. The registry staff checks the validity of the certificate and the DAFM-Number by communicating wit the point of contact at the regional DAFM office. The registry staff verifies master data of utilized meters with Gas Networks Ireland (GNI) for feed-in plants (meter number)..	1. A user of enters the plant's data into the registry and uploads a copy of the DAFM certificate. 2. The registrar performs the verification checks with DAFM office & GNI 3. The registry software establishes the connection to the GNI interface for the registered meters 4. Automatic meter readings can now start for this plant
Proof of Amounts	The registry software fetches values from automatic meter readings once per month from GNI through a software interface. The Registry software converts values into green gas certificates. If necessary, registry staff manually corrects values upon request.	No verification measures are needed for the regular process, here. The gas grid operator is an independent actor and has it's own interest in precise and correct data. The registrar performs plausibility checks of the numbers quarterly on the basis of data reports and visualizations for all plants.	1. The registry software obtains meter data from GNI's software once a month 2. The registry software converts meter readings into a green gas amount if necessary. 3. The software registers the amount and books it as certificates to the companies' account 4. Upon request by users/GNI/auditors, registry staff retroactively corrects amount

Registra-tion	Data Entry	Suggested verification measure	Suggested Procedure
Proof of Quality / Green Gas Properties	The producing company's user enters the desired quality information from the auditor's certificate into a registry form. The information is linked to the corresponding green gas amount (identified by production plant and production period). The responsible auditors name is assigned to this information.	Verification is done by the assigned auditor (optional: additional check by registrar) by confirmation of the entered data. A scan of the original certificate is uploaded by the auditor Optional: manual plausibility check by registrar (compare certificate & data)	1. A user of the producing company enters data for green properties for a specific green gas amount. 2. The user assigns the responsible auditor. 3. The auditor logs into the account and confirms the data inside the registry software 4. Optional: the registrar performs a manual plausibility check 5. The green properties are now registered with the amount. They can now be cancelled
Amount transactions: splitting, transferring	The owning company/user enters data for the desired transaction: Amount split: – User chooses the amount to be split and enters the size of the desired partial amount Amount transfer – User enters the recipient's account number an assigns the amount to be transferred	No manual verification measures are required Software verification – Amount splitting: Sum of the split amounts equals the precedent amount – Amount transfer: the transferred amount is deactivated on sender's account and activated in equal size on receiver's account	Amount splitting 1. User enters desired split value for specific amount 2. Registry software creates two new amounts or split certificates Amount transfer 1. User enters recipient's account 2. Registry software transfers amount to recipient's account Registry software transfers amount/certificate(s) to recipient's account
Cancella tion	Data entry by shipping companies' user	No verification by registry Later verification of registry statement needs to be possible	1. User enters end-use data, e.g. end-use classification (Optional: user enters competent authority / support scheme)

Registra-tion	Data Entry	Suggested verification measure	Suggested Procedure
		Later verification of validity of registry statement needs to be possible	2. Registry software cancels amount on the company's account 3. Registry software issues registry statement as digital document

For the suggested steps there are a number of options, which are summarized in the following table:

Table 42 Options to suggested procedures

Options for…	Options
Company registration	As an alternative option for company registration, the applicant could enter all data via an online registration form into a preliminary data base. After downloading the filled form, the applicant signs & sends in a hard copy of the print. After sending it in, the registry operator compares the data and transfers it into the actual registry base. This procedure may be more efficient with large numbers of company registrations.
Users registration	The way described above as suggested procedure reduces effort for the registry operator and gives responsibility for the data to the companies. However, other options are possible: – The user who applies for the account, enters his contact information online directly into the database – The registry operator enters data manually from the application form. – No further verification measures are necessary in these steps.
Registration of plants	Plant data and plant ownership (the link between company & plant, C1&P1/P2) is verified by an independent auditor. The auditor is appointed by the producing company. The verification of plant data andan ownership can also be done by a local authority, e.g. building authority
Registration of amounts	Options for the registration of amounts are presented here: – Green gas production with manual fiscal meter reading (e.g. land transport or fiscal meter at feed-in) – Green gas imports from abroad – Verification of amounts by auditors

Registration of proof of origin	All the data regarding the green gas' properties (see Q1 in D2.6 and 7.2 in D2.3 list of entities) can be entered either by The producing company (C1) An independent auditor, as part of the certification process The registry operator, based on the contents of a certificate Possible verification measures include Confirmation of the data by an independent auditor Certificate upload by the auditor Plausibility/Double check with data by registry operator
Cancellation	Further Verification measures inside the registry process could be the following: Registry operator compares data with a gas delivery: Cancellation data is compared with meter readings (obtained from GNI) or after upload of a gas delivery bill. In regard to a possible support scheme, plausibility tests based on SEAI meter information (heat measurement) for random samples seem appropriate. For this, a connection between the registry and SEAI need to be established A number of options to verify cancellation after the registry process ends are listed below in section 4.6.5.
Registration of proof of origin	All the data regarding the green gas' properties (see Q1 in D2.6 and 7.2 in D2.3 list of entities) can be entered either by The producing company (C1) An independent auditor, as part of the certification process The registry operator, based on the contents of a certificate Possible verification measures include Confirmation of the data by an independent auditor Certificate upload by the auditor Plausibility/Double check with data by registry operator
Cancellation	Further Verification measures inside the registry process could be the following: Registry operator compares data with a gas delivery: Cancellation data is compared with meter readings (obtained from GNI) or after upload of a gas delivery bill. In regard to a possible support scheme, plausibility tests based on SEAI meter information (heat measurement) for random samples seem appropriate. For this, a connection between the registry and SEAI need to be established

	A number of options to verify cancellation after the registry process ends are listed below in section 4.6.5.

5.6.5 Further verification steps to government recognition

The following procedures are suggested in order to enable further verification measures after registry processing has finished (when registry statement or proof of cancellation is issued). Starting point for all further verification measures is the registry statement (section 5.8).

Online Verification of the registry statement

The registry's proof of cancellation includes all relevant information to enable the final consumer to apply for possible support schemes, to prove compliance with obligations or to prove the gas quality. The suggestion is to issue the registry statement as a pdf file. This could be handled digitally and as printed paper. Those receiving a registry statement may want to check it for authenticity.

In Germany, the Biogasregister Deutschland offers the possibility to check all statements online for authenticity. This is done by either uploading the pdf-file or entering the statements individual number. Thus the person checking the registry statement can be sure to hold a valid statement that has been issued originally by the registry.

Another possibility would be to issue a pdf file which has to be hand-signed by a representative of the registry. In the Austrian biomethane registry, only signed statements are fully valid. This, of course, includes more paperwork than the pdf-option. It is, however an original document that may be accepted more easily by established legal procedures.

It is also conceivable to issue the registry statement only via a digital interface. This suggestion would include government authorities and end-consumers to be able to communicate with this interface in the course of accepting a registry statement.

Interface to existing schemes

A very powerful measure could be an interface between the registry and all potential government authorities. Through this interface, back tracing could be enabled to assign a registry statement to exactly one support scheme.

For example, after cancellation, the registry statement is handed in to NORA in order to apply for recognition within the biofuels obligation scheme. The staff then checks the application and, if granted, allocates the registry statement to the scheme. This is recorded inside the registry and the same statement cannot be used for any other purpose.

This would be the preferred option to enable the registry to give clear statistics on the distribution paths inside the registry, i.e. how much gas went into which support /obligation/ scheme.

In Germany, the nabisy registry has established such an interface to the German customs authority (Zollstelle). All applications for the German biofuels scheme have to pass through this way.

End-use verification

The degree of verification for a cancelled amount depends on further use. For the **voluntary markets**, we suggest that **no further procedures** are necessary because the verification will be done by the trading parties. For all government support options, verification measures depend on the definitions of the legal framework. Some options for end-use verification are discussed here.

In case the use of green gas is supported by a scheme, a government authority should be involved. If not verified by an interface (see above, section "Interface to existing schemes"), other verification steps are possible: The authority could ask the applicant to present the **gas delivery bill corresponding with the green gas certificate** from the registry. By this, the amount can be verified.

The **registration of end-use on the registry statement** is part of this concept. A government (mandated) authority could use a compilation of these details for end-use verification measures. For example, the authority employs auditors to visit sites to double check end-use. This could be done on a random sample basis, or with focus on the largest beneficiaries of the schemes.

In Germany, subsidies for biomethane are only granted when it is used in CHP (combined heat and power) units. In order to receive these subsidies, an auditor has to confirm on a yearly basis that the gas used in the CHP unit was renewable gas (e.g. by a registry extract from the dena biogasregister). However, this implies high costs for the end consumer and might not be feasible for private end consumers in renewable heat support schemes. Indeed, in Germany biomethane is used mainly in industrial sized CHP units.

End user could also be forced to monitor their heating unit by themselves which would be accompanied by high penalties if regulations of the support scheme are not respected. This should be combined with casual controls in order to make the penalties effective.

5.6.6 Examples from other countries

The following section gives an insight in the procedures and authorities in from other countries. The information is sorted by injection, withdrawal, and end-use-verification.

Table 43 Injection /Amount registration procedures in other countries

Country	Authority	Example
CH	Oberzolldirektion OZD (Customs authority) Defines procedures	Amounts injected into the gas grid are registered on a monthly basis by producers. Actual metering data is notified together with the amount of monthly production. Production facilities need to be registered and approved by OZD. All amounts of resale (not a delivery to final customers either as vehicle fuel, for heating purposes or for the production of electricity) are to be notified on a quarterly basis.
DK	Network Owner	For each Upgrading Facility, the Network Owner (usually DSO) establishes, operates and maintains a gas metering system for measuring the quality

		and energy of biomethane at the Metering Point. The Network Owner ensures the retrieval, registration and validation of metered supply. Each production plant has a unique GSRN number related to the metering point. The physical location of the metering point and GSRN appears from the Connection Agreement... Data are supplied to a central data base which is used as basis for issuing certificates.
NL	Dutch Emission authority	The biomethane data at the injection point is sourced at the grid operators and measurement parties all under the Dutch gas law. They provide the authority with the metering data, the calorific values of the gas and the amount of energy injected at that specific injection point. The same is done at the delivery point regarding biofuels, where the economic operator responsible for this physical delivery must provide meter readings to account for the deliveries made together with an equal amount of Vertogas (registrar) GoO's, this is than audited by an independent auditor and only after that is approved the delivered volumes are counted under the Dutch blending obligation a corresponding amount of Renewable Biofuel Credits are issued by the Dutch Emission authority.
DE	Auditor	Gas meter measuring is confirmed by an auditor and verified by the registrar. Furthermore, any other information (substrates, plant capacity, GHG emission etc.) can be confirmed by an auditor. Audits are usually done once a year for the production of the last year.
AT	Network owner	The Austrian biomethane registry is generating biomethane PoO based on network provider data which are the basis for the clearing of gas in Austria. The data are transmitted automatically once a month and therefore the biomethane PoO are also created for this period based on a published calendar in our registry.

Table 44 Withdrawal /Cancellation procedures in other countries

Country	Authority	Example
CH	Oberzolldirektion OZD (Customs authority) Defines procedures	All deliveries to final customers are also to be notified on a quarterly basis. By definition, this concerns all transactions that result in the physical withdrawal of the energy from the grid (be it for fueling, heating or electricity production).
DK	none	Energinet certificate system does not collect proof of physical withdrawal. Since 1 January 2017 accountholders must indicate the following upon cancellation: Cancellation Purpose, Location of Beneficiary, Usage

		Category, and Type of Beneficiary. But no measuring meter ID number or any collection of physical delivery data.
NL	Dutch Emission authority	In the Dutch system the economic operator who actually delivered the gas physically is responsible to provide this proof, at the moment to the Dutch Emission authority responsible for the Dutch biofuel blending obligation. This physical delivery must be combined with the Vertogas bio methane GoO's including the sustainability proof that is available on the Vertogas certificate also, if the bio methane producer has been audited to have such a valid proof of sustainability by NTA8080 a.o. So even if this trader/participant has no grid connection of his own, if he is the actual party claiming the physical delivery he must provide the verification documents needed. In practice it usually is the party who own the physical infrastructure, but the other possibility can also be facilitated within this process.
DE	none	There is no additional audit for the withdrawal of biomethane that is documented by the registry. Nevertheless, the registry statement (PoO) clearly indicates where (metering point) and from whom the biomethane is withdrawn from the gas network. Therefore, the PoO is only valid at defined metering point and for a defined amount of gas. Therefore, the PoO exactly describes from which point of time, where and from whom the gas is consumed.
AT	none	The withdrawal itself is not monitored but due to the fact that all participants need to have a valid gas supplier agreement in Austria, they are "able" to withdrawal.

Table 45 End-use verification procedures in other countries

Country	Authority	Example
CH	Oberzolldirektion OZD (Customs authority) Defines procedures	Notifications of withdrawal are cross-checked against production and trading data for the relevant parties. No party may trade or withdraw higher amounts of biomethane that it has previously sourced but no time-limit exists for consumption of amounts procured. Metering data are supervised under the authority of OZD.
DK	Danish Energy Authority	For the biofuel blending obligation it is the fuel supplier who delivers proof of withdrawal/delivery to refueling station to the Danish Energy Authority. For the use under Emission Trading Scheme physical delivery is documented to the Danish Energy Authority. For the use for heating, industrial processes, non-

		biofuel-quota transport fuel and power production it is a supplier/client relationship meeting the client's need for documenting physical delivery.
NL	Registry	For non bio fuel deliveries of bio methane within the Dutch grid the register saves the information at GoO cancellation where the certificate is used and the register is running an end consumers account with physical delivery points attached so the mass balance can be closed.
DE	Auditors (in case of EEG subsidies)	The Biogasregister Deutschland is fulfilling the mass balancing requirements according to the Renewable Energy Sources Act (EEG) and the Renewable Heat Act (EEWärmeG). In general the mass balancing rules require that the amount of biomethane withdrawn from the gas network is not more than the amount injected. Furthermore, there is no defined period to balance injection and withdrawal of biomethane.

5.7 How does the workflow of the registry look like? (D2.4)

This section describes the general process flow or cycle in the registry and reveals details about how the different entities defined in section 5.4 interact.

Regarding the workflow of the registry (see especially Figure 4) two different levels can be distinguished: The physical level, which includes the origin and production of the green gas, the route to market (the transport to the end consumer) and the application / end use of the green gas.

The second level regards the connected registry level, i.e. all the processes that are necessary to trace and verify the green gas properties from its origin to the application/use.

When having a closer look at the physical level, the production of green gas starts with the cultivation of energy crops or the collection of waste and residue streams (other substrates are also possible). These substrates are fed into a biogas production plant where anaerobic digestion leads to the production of biogas. In order to meet gas grid quality requirements, the biogas has to be upgraded by several measures (dried, filtered with activated carbon, rise CH_4 percentage) and is then injected into the gas grid by a feed-in station.

Once the gas is injected into the grid, the mechanisms of gas trade will deliver the gas to the end consumer at a gas withdrawal point. The possible applications (end use) for the natural gas can be power generation (gas turbine), heat (gas boiler), heat & power (combined heat and power unit), industrial use (e.g. for green industrial products), fuel (cars, trucks) and export (e.g. gas export to Scotland).

The registry level guarantees the verification of the green gas and allocates specific green gas to different uses. When biogas is produced, its substrates and the arrival of the substrates at the biogas production plant can already be certified and e.g. a GHG value can be assigned (see chapter 3). This information is confirmed by auditors and passed to the registry. Also, imported green gas can be registered in the green gas registry.

Once the registry certificates are registered in the registry, they can be traded, divided (split) and exchanged without restrictions. Once an amount of biomethane is sold to an end user this end user (or the trader) has to indicate whether the biomethane is used in transport, heat or the production of electricity.

In order to further illustrate the registry process, the most important ones are illustrated in the following paragraphs.

#Step 1: Registration of producers and traders

Once the registry is established, producers, trading companies and also energy supplier can enrol in the registry by submitting a (digital) application form and accepting the terms and conditions of the registry. The appointed registrar company will verify the applications forms and provide login information for the applying companies and their users.

#Step 2: Certificates are assigned to producers

In order to allow trade of green gas amounts in the registry, the produced green gas amounts have to be registered.

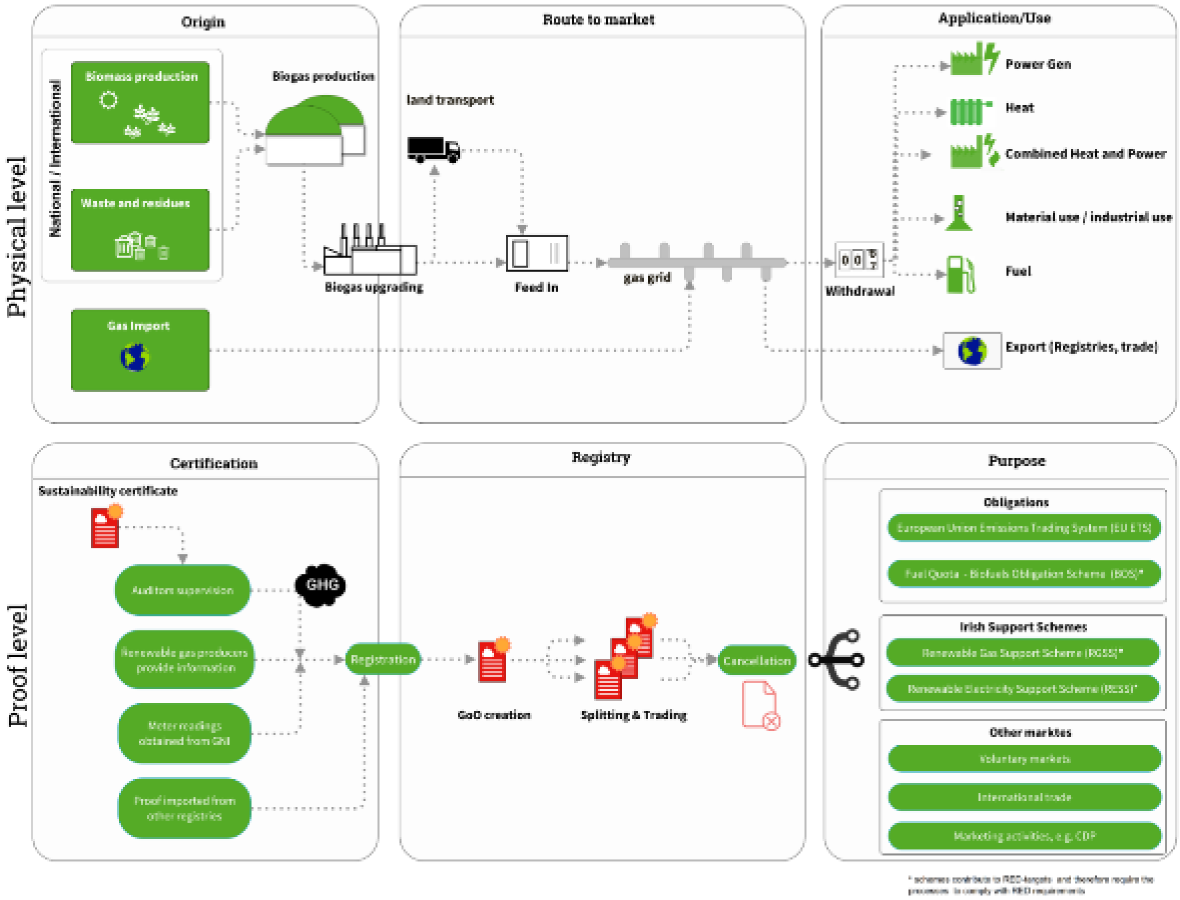


Figure 17: Workflow of the registry

At the moment, a creation of certificates is foreseen to be carried out on a monthly basis based on metering data provided by the grid operator.

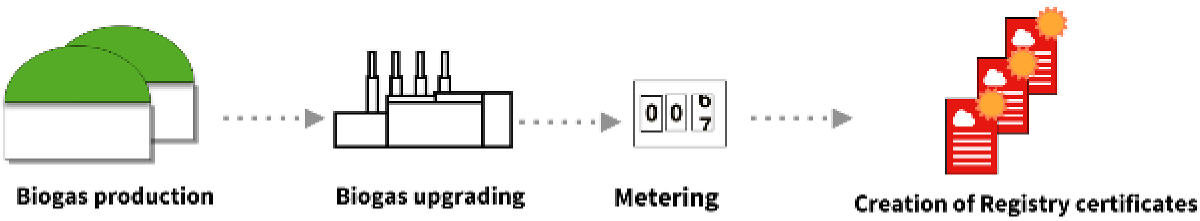


Figure 18: From green gas production to registry certificate creation

#Step 3: Registry certificates are traded between producers and traders

Once the certificates are filed inside the registry, they can be traded liberally between account holders in the system. Users can split certificates into smaller amounts and transfer them to other account holders. In the example in Figure 17, the producer transfers his certificates to Trader A. Trader A then splits the certificates and transfers one of the certificates to Trader B and one certificate to an energy supplier.

If an expiry date is implemented on the certificates (as currently foreseen by RED requirements, see section 5.3), the certificates will be automatically cancelled once the date of expiry is reached. Then, neither transfers nor the cancellation for a specific purpose are possible any longer. The green property of the gas cannot be sold any longer, if a gas amount was connected to the registry certificate, the gas can only be sold as natural gas.

An international transfer to a trader in a different biomethane registry is also possible when cooperation agreements are in place.

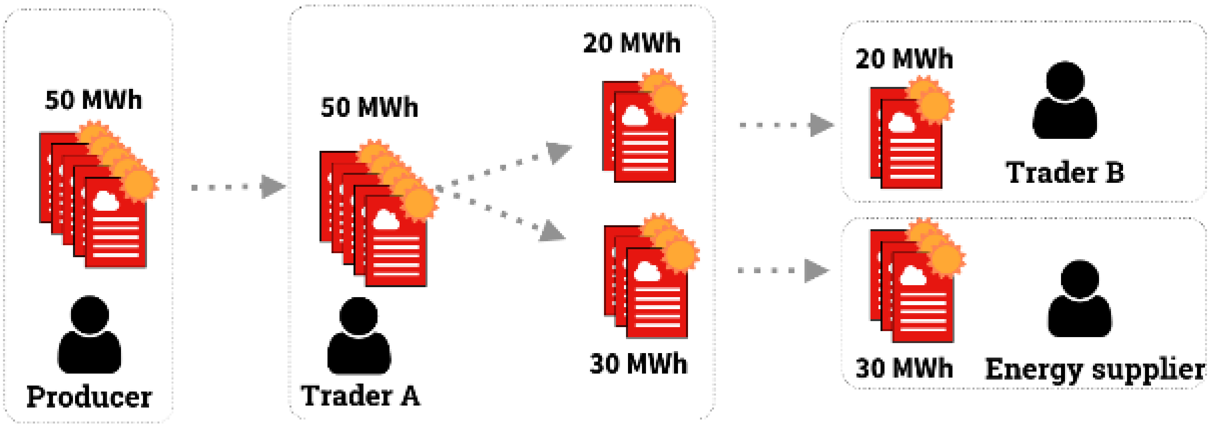


Figure 19: Trade possibilities in the registry

#Step 4: Supplier cancels amount when green gas is consumed

Figure 20: Final consumption of green gas

The process cycle ends with the cancellation of the registry certificate. This can be done by account holders when they want to use their certificates in a designated market (obligations, support schemes, other markets).

The proof of cancellation can then be used for the target markets, i.e. submitted to state authorities to claim a support scheme or as a proof for the use of green gas or GHG savings in the voluntary market.

5.8 The registry statement (D2.5)

This section illustrates the key elements and information which a registry statement has to contain in order to fulfil RED requirements and also to fulfil possible requirements derived from other target markets (e.g. voluntary markets).

The final product of the green gas registry, the registry statement, may be the basis for acceptance (or refusal) of a support scheme grant or for the decision, whether a specific green gas amount can be counted against the biofuels quota. In order to comply with this, all green properties (possibly) required green gas properties by authorities should be part of the registry statement. Green gas properties may depend on a wide variety of reference points, e.g. substrates used, GHG emissions of transport and many more. Any authority's decision is based on the results, rather than on input values, therefore an efficient registry requires only results of the precedent (sustainability) certification process. For the green gas registry it is sufficient to rely on the certificate issued by the certification scheme (WP 1) as reference point for green properties. This is, at least, possible for green gases produced within Ireland. For imported gases, other ways to obtain information on green properties need to be developed or a common standard is defined by schemes like ERGaR.

The registry statement is the most important product of the green gas registry and provides the end user with all information necessary to account for the use of its green gas. The main aim within the scope of this project is to comply with the criteria derived from the recast of the Renewable Energies Directive (RED II) by the European Union, so a registry statement can be used as proof of origin according to the RED II standard. Based on the draft of the recast document used (European Commission 2017) the following data has to be included in the draft registry statement.

Table 46 Data for the draft registry statement

	Data	Sample data	Reference RED	Content RED
1.	Date and country of issue	05.04.2017 - Ireland (IE)	Article 19, 7(f)	(f) the date and country of issue […] …
2.	Unique identification number	GGCS-IE-YYYY-MM-DD-XXXX	Article 19, 7(f)	(f) […]and a unique identification number
3.	Amount	1.000 MWh	Article 19, 2	A guarantee of Origin shall be of the standard size of 1 MWh.[…]
4.	Source of energy	Gas	Article 19, 7(a)	(a) the energy source from which the energy was produced
5.	Type of installation	Biomethane plant	Article 19, 7(c)	(c) the identity, location, type and capacity of the installation where the energy was produced;
6.	Name/Identity + Address	Green gas plant Dublin II, 222 Baker street, Dublin 4	Article 19, 7(c)	
7.	Capacity	200 m^3/h 2 MW	Article 19, 7(c)	

8.	Commissioning date	01.01.2019	Article 19, 7E	(e) the date on which the installation became operational; […]
9.	Investment support OR National scheme support granted	Yes | Yes	Article 19, 7(d)	(d) whether and to what extent the installation has benefited from investment support, and whether and to what extent the unit of energy has benefited in any other way from a national support scheme, and the type of support scheme;
10.	This GO relates to gas/electricity/heating and cooling	Gas	Article 19, 7(b)	(b) whether it relates to: (i) electricity; or (ii) gas, or (iiii) heating or cooling;
11.	GHG emissions savings	85%	Article 26	[…] Biomass fuels shall have to fulfil the sustainability and greenhouse gas emissions saving criteria set out in paragraphs 2 to 7 […] with an electrical capacity equal to or exceeding 0.5 MW in case of gaseous biomass fuels.

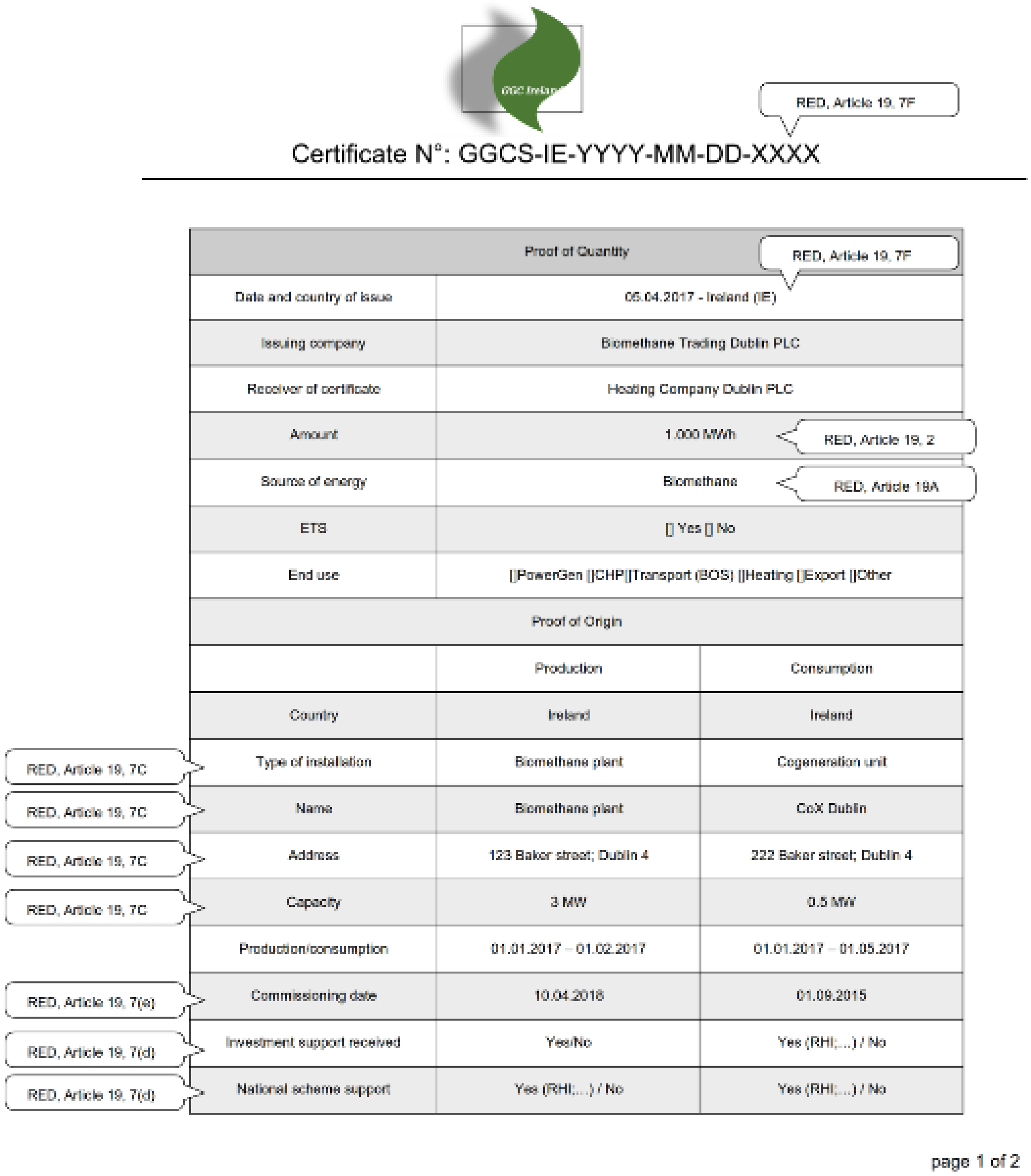
Beside the data requirements coming from the RED II, further data sets should be included in the registry statement in order to create a maximum of transparency and security.

One important bit of information is for example the issuing company, i.e. the company which created the registry statement should be named in the extract. Furthermore, information about the receiving company should be included on the registry extract. This provides useful information and also gives the possibility to receive further detailed information about the proof of origin by these companies.

The registry statement will also offer the possibility to indicate the target market (e.g. ETS) and end use of the green gas (PowerGen, CHP, Transport (BOS), Heating, Export, Other). The indication of a target market can also be set up as a mandatory field inside the registry. This can also be used in order to calculate final GHG emission savings as for example a use in CHP unit is more efficient than a use in a gas boiler.

Furthermore, the registry statement can be used to define the different qualities of the green gas. This can include the substrates that were used for the production of the biomethane, which criteria of different schemes are fulfilled (e.g. RED, fuel quota,…) and the total amount (percentage) of GHG emissions savings.

The final GHG emissions savings can only be calculated once the end use of the green gas is known.


GGC Ireland

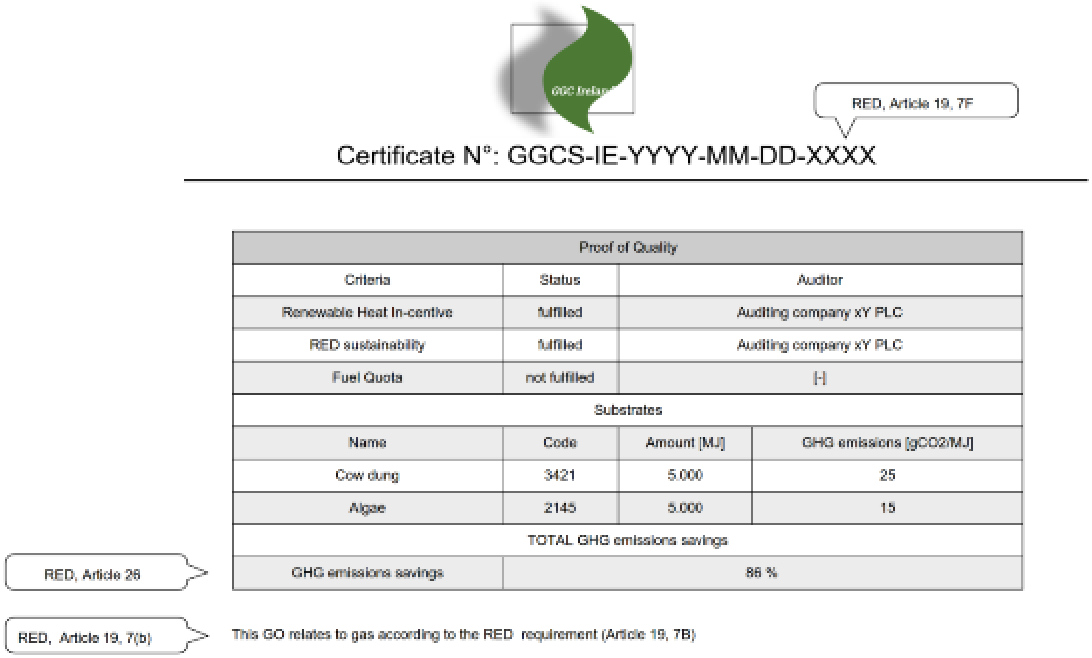
RED, Article 19, 7F

Certificate N°: GGCS-IE-YYYY-MM-DD-XXXX

	Proof of Quantity		
			RED, Article 19, 7F
Date and country of issue	05.04.2017 - Ireland (IE)		
Issuing company	Biomethane Trading Dublin PLC		
Receiver of certificate	Heating Company Dublin PLC		
Amount	1.000 MWh		RED, Article 19, 2
Source of energy	Biomethane		RED, Article 19A
ETS	[] Yes [] No		
End use	[]PowerGen []CHP[]Transport (BOS) []Heating []Export []Other		
	Proof of Origin		
	Production	Consumption	
Country	Ireland	Ireland	
Type of installation	Biomethane plant	Cogeneration unit	RED, Article 19, 7C
Name	Biomethane plant	CoX Dublin	RED, Article 19, 7C
Address	123 Baker street; Dublin 4	222 Baker street; Dublin 4	RED, Article 19, 7C
Capacity	3 MW	0.5 MW	RED, Article 19, 7C
Production/consumption	01.01.2017 – 01.02.2017	01.01.2017 – 01.05.2017	
Commissioning date	10.04.2018	01.09.2015	RED, Article 19, 7(e)
Investment support received	Yes/No	Yes (RHI;...) / No	RED, Article 19, 7(d)
National scheme support	Yes (RHI;...) / No	Yes (RHI;...) / No	RED, Article 19, 7(d)

page 1 of 2

Figure 21: First page of the registry statementdraft draft



RED, Article 19, 7F

Certificate N°: GGCS-IE-YYYY-MM-DD-XXXX

Proof of Quality			
Criteria	Status	Auditor	
Renewable Heat In-centive	fulfilled	Auditing company xY PLC	
RED sustainability	fulfilled	Auditing company xY PLC	
Fuel Quota	not fulfilled	[-]	
Substrates			
Name	Code	Amount [MJ]	GHG emissions [gCO2/MJ]
Cow dung	3421	5.000	25
Algae	2145	5.000	15
TOTAL GHG emissions savings			
GHG emissions savings	86 %		

RED, Article 26

RED, Article 19, 7(b)

This GO relates to gas according to the RED requirement (Article 19, 7B)

Figure 22: Second page of the registry statement draft

5.9 Suggestion for role of auditors (D2.7)

This section takes a look at how data can be verified by auditors in the context of a green gas registry. Regarding the sustainability criteria, the central interface in this case is the sustainability certificate (section 5.4), which contains the results from the certification process. As an additional analysis, suggestions for the role of auditors for end-use validation are made.

Figure 21 shows an overview of the full certification chain. In the sustainability certification step, auditors certify quality criteria according to their certifications' terms (see chapter 4). During the plant and amount registration step, the auditors confirm to the registry the results of their reports. Depending on possible support schemes requirements auditors may also play a role for the validation of end-use.

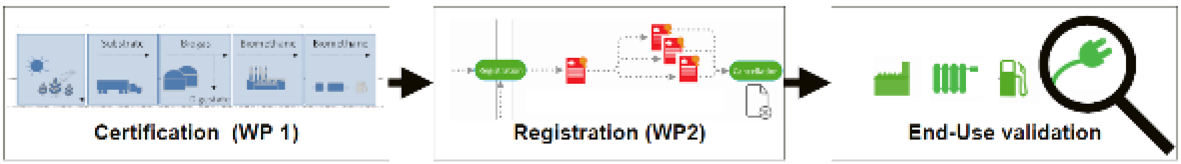


Figure 23 Possible Steps including Auditors

The registry itself does not supervise the certification activities of the auditors – this is the certification systems' task. However, based on the sustainability report transferred to the registry, support payments may be paid or certificates for obligation recognitions can be issued. Exchange of information between the certification system and the registry therefore improves documentation security and data quality.

It is thus recommended that the registry cooperates with existing and future auditing schemes. This is necessary to ensure that the certification systems' output (certificates, results, calculations…) can be correctly registered.

5.9.1 Proof registration tasks for auditors

The auditors have several tasks in the overall certification process. They should be employed where fraud possibilities are most probable. Figure 22 gives an overview over the most important steps in the certification process.

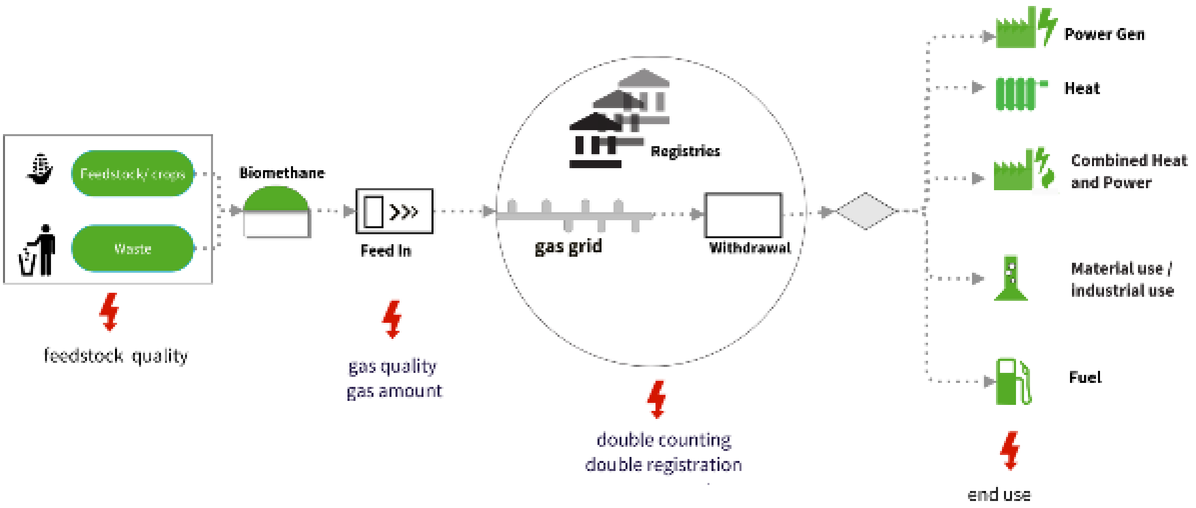


Figure 24: Critical points for certification of green gas

The main task would be to verify the running operation and report quality to the registry. In this task, the auditors e.g. calculate green house gas emissions from the substrate list and report them to the registry as part of their task. In Germany, the biofuels quota is calculated according to the individual green house gas savings of the particular amount when used in transportation. Therefore, the GHG-value of an amount has a strong influence on its price on the market. This makes the quality report a likely entry point for fraud. That is why an active role of auditors in the registry mitigates fraud risk.

Another potential task for auditors could be to check the amount production for plausibility. The amounts are automatically registered (see section 5.6) and every amount registered may be sold on the green gas market. The registration process based on GNIs meter readings seems very robust. However, as there is no manual step included, a systematic fraud could run for a long time if it is not discovered, e.g. injection of fossil natural gas or other ways of manipulations. Auditors could help, here: Any time they check the substrate list and quantities, they estimate if the produced and injected gas amount corresponds with the potential production from the used substrates. This will only be a rough equation, but still has the potential to uncover systematic fraud.

It may be allowed for green gas producers to register in multiple registries, depending on the legal background. This is the case in Germany, where biofuels registration and gas grid registration are separated in different registries. As a consequence, multiple registrations of amounts are allowed and daily routine for some market players. However, multiple registrations are prone to double selling. If a registration in several registries will become necessary in Ireland, auditors could supervise the registration in several registries and prevent double selling.

5.9.2 Plant registration

Auditors control a green gas production plant for compliance with minimum requirements before admitting plants to the registry. Complementing a general proof of operation by the DAFM offices (see above and in section 5.6), further minimal requirements can be checked by the auditor, e.g. green gas thresholds.

5.9.1 Proof registration

The auditors play an important role in transferring the sustainability certification safely into the registration process.

Auditors can be involved in all proof verification processes: The Proof of Origin, the Proof of Quality (e.g. sustainability), Proof of Quantity (amount of green gas). The less auditors contribute, the more the process relies on market players. The more they are involved, the higher will be the personal costs, which makes certification overall more expensive.

Different levels of involvement are possible for auditors, three main options are presented in table 47. The first option is that auditors are not involved in the data validation process and no verification of claims by producers are made. This would lead to a very fast process in the registry itself but would also bare a high risk of fraud.

The second option is that e.g. for the sustainability criteria, auditors can upload their results (sustainability certificate) to the registry and the registrar will allocate the data to the correspondent amount of green gas. With this option, data quality can be improved and the registrar can verify data in the registry.

The third option foresees an active role of the auditor in the registry software. Having its own account, he or she will be able to control the data which is provided by producers. This will lead to a very high data quality in the registry but also to high costs due to the necessary complicated implementation in the registry software and high additional personal costs (auditors).

Table 47: Levels of involvment

	No control	Certification upload, registry control	Data confirmation by auditors inside registry
Role of Auditors	▪ Auditors do not play a role inside the registry. ▪ All data is entered by users without further auditors' confirmation	▪ Auditors are involved briefly into the registration process for plants & amounts ▪ Auditors upload their results as the standardized certificate (for example see section 4.3 pilot certificate) into the registry	▪ Auditors have their own personalized account inside the registry ▪ Auditors confirm (certificate) content within the registry database ▪ Further compliance may be queried , e.g. amounts, ownership of plants, …
Examples	▪ Nabisy (Germany) ▪ AGCS Biomethane Registry Austria		Biogasregister Deutschland (Germany)
Rating	▪ very lean process ▪ no standard examination step to unveil wrong data ▪ no routine to compare certificate content and registry database ▪ Data quality in the registry will be lower	▪ The auditor will only upload own certificates. ▪ No routine to compare certificate content and registry database ▪	▪ Certification results are documented in highest quality ▪ Most elaborated process example
Costs	▪ Low	▪ Medium (integrate upload area in software, personal cost for registrar verification of certificates)	▪ High (integrate special role for auditors in software, maybe personal cost for final registrar verification of certificates and database data)

5.9.2 End-use verification

In the discussions of this project, the verification of end-use was an important subject. Details on the verification measures and their enforcement need to be defined by the corresponding support scheme regulation.

The registry itself can contribute to this, but will probably not to carry out any verification of end use. At the moment, when the registry statement is issued, the registry process finishes. The registry itself has no possibilities to control the end use after this point. The draft registry statement (see section

5.8) includes the documentation of end-use. On the basis of this, improved end-use verification may take place.

See section 5.6 for possible end-use verification measures. This section focuses on the role of auditors only.

Auditors could in this context check the application as part of the support schemes' recognition process. Furthermore, a final calculation of the exact total GHG-Emissions savings can only be done if the end-use is included into the calculation. The GHG emissions as documented on the registry statement would be the starting point for this calculation.

Table 48 Examples for end-use from other contries

Country	Example
Germany	In Germany, subsidies for biomethane are only granted when it is used in CHP (combined heat and power) units. In order to receive these subsidies, an auditor has to confirm on a yearly basis that the gas used in the CHP unit was renewable gas (e.g. by a registry statement from the dena biogasregister). This system avoids fraud and manipulation.
Denmark	In Denmark, the subsidies are granted for biomethane injection. Therefore, no problems with end use validation exist. Certificates are issued for production units but can only be used in the voluntary market.
United Kingdom	In the United Kingdom, the subsidy system is based on the Renewable Heat Incentive (RHI). For biomethane producers, a feed in tariff for the injection of biomethane is applied (see Link, p.41).

6 Policy and dissemination

6.1 Introduction

This section summarises the work completed in Work Package 3 “Policy and dissemination” of the GreenGasCert project. The aims of this work package were:

- To engage key stakeholders and ensure that their requirements are addressed by the design of the scheme;
- To disseminate information about the project to stakeholders and the wider community;
- To review and collate Irish research and data to provide an evidence base for the benefits of biogas and of a certification system;
- To ensure that the results of the work completed in the work package contribute to the design of the scheme in Work Packages 1 and 2.

The work package was led by MaREI. Due to resource constraints at MaREI, IERC took over responsibility for the delivery of elements of the work package in October 2017.

6.2 Stakeholder engagement

A series of one-to-one meetings were held with representatives of key stakeholder organisations during the course of the project. At the meetings the goals of the project were outlined and the need for a renewable gas certification scheme for Ireland was explained. Input was sought and organisations were given the opportunity to express any requirements that they would have of such a scheme. Key public bodies and government departments engaged with included:

Department of Communications, Climate Action and Environment (DCCAE);

- Sustainable Energy Authority of Ireland (SEAI);
- Department of Agriculture, Food and the Marine (DFAM);
- Teagasc Agriculture and Food Development Authority;
- National Standards Authority of Ireland (NSAI);
- Department of Jobs, Enterprise and Innovation (DJEI);

Stakeholders representing the renewable gas industry, including producers, end-users and energy service providers, were also engaged through the activities and meetings of the RGFI.

The level of one-to-one stakeholder engagement with government organisations was not as intensive as planned in the original proposal for a number of reasons. Firstly, the availability of some important contacts among the key stakeholder groups was limited initially. Secondly, policy developments, in particular the rollout of support scheme for renewable heat, were slower than anticipated and didn’t favour grid-injected biomethane (see *Section 6.7.2*). However, an increased willingness among stakeholders to engage with the project team was clearly discernible towards the latter stages of the project. This was due to the ongoing stakeholder engagement efforts of the project team leading to improved awareness of the project work and increased recognition of the need for a renewable gas certification scheme.

In addition to one-to-one meetings with key stakeholders an important element of stakeholder engagement was the promotion of the work of the project team to the wider community through presentations and networking at relevant national and international conferences and workshops. Included below is a list of some of these events:

- IERC Conference 2017, Presentation by Daniela Thraen, DBFZ. 30th March 2017.
- Energy in Agriculture 2017. 'An argument for using green gas as a biofuel in Ireland' Presentation by Prof. Jerry Murphy, MaREI. 22nd August 2017.
- DCCAE/RGFI workshop with biogas industry. 'GreenGasCert: A certification scheme for renewable gas in Ireland' Presentation by Prof. Jerry Murphy, MaREI. 17th January 2018.
- Irish Renewable Energy Summit 2018, 'Developing renewable gas in Ireland' Presentation by Ian Kilgallon, GNI. 31st January 2018.
- RGFI representation to the Oireachtas Joint Committee on Communications, Climate Action & Environment by PJ McCarthy, RGFI. 20th February 2018.
- Bioenergy Future Ireland Conference 2018. Presentation by Ian Kilgallon, GNI. 21st February 2018.

Stakeholder engagement is an ongoing process. After the end of this project there will still be a need to inform and discuss with stakeholders and to ensure that their requirements are met. Proactive engagement with all stakeholders will need to continue during the roll-out of the certification scheme.

6.3 Stakeholder workshops

Central to the stakeholder engagement process was the hosting of two formal stakeholder workshops. The workshops provided an ideal forum for providing project information to the stakeholder community, for gathering inputs and requirements from stakeholders and for ensuring that these are addressed in the design of the scheme. In the original proposal only one workshop, to be held at around the mid-way point in the project, was planned. Ultimately, at the beginning of the project, it was decided that it would be best to hold two workshops; one at the start to provide information about the project and its goals, and another at a later stage to update stakeholders on progress and seek their guidance and inputs before the final design was agreed upon.

6.3.1 First stakeholder workshop

The first stakeholder workshop was held at the Radisson Blu Hotel, Golden Lane, Dublin 2 on 26th April 2017. The workshop coincided with the official launch of the project. The purpose of the project was to introduce the project, generate interest among stakeholders and understand their initial requirements of a renewable gas certification scheme. It was attended by 65 people representing academia, policy makers, and all parties involved in the production, supply and use of biogas.

The first part of the workshop consisted of a number of presentations. Professor Brian Ó Gallachóir and Professor Jerry Murphy from MaREI gave an academic perspective on the potential for biogas in Ireland. Simon Shannon of Diageo presented on the importance of biogas to Irish industry. A guest presentation from Massachusetts State Senator Marc Pacheco gave a view on biogas from a U.S. perspective. Stefan Majer, DBFZ, presented the German biogas certification system. Then Stefan Majer and Aoife Long, MaREI, introduced the GreenGasCert project.

Figure 25: Presentation by Massachusetts State Sen. Marc Pacheco at the first stakeholder workshop

In the second part of the workshop the group was briefed on five discussion questions formulated by the GreenGasCert project team. Delegates were divided into groups and asked to address each question and assign a rapporteur to give feedback at the end. There was approximately 5 minutes allowed for discussion of each question. Representatives from each group presented the key points from their discussion in the plenary session at the end. The five questions discussed and the main responses from the groups are summarised below:

1. <u>What are the green gas customer needs from a certification scheme?</u>
   - Secure and reliable supply of renewable gas
   - Safety specifications considered and met
   - Clear statement of values to the customer e.g. trading credits or link to incentives
   - Scheme should not add significant cost to the customer
   - Certification scheme is consistent with incentive schemes and the ETS
   - Certification scheme should be consistent with schemes in other countries
   - Transparent accounting system, using measured values instead of standard values
   - Independent verification of GHG savings
   - Renewable gas is 'seen to be green'
   - Independent oversight and certification
   - Both large and small customers should be considered, also consider both ETS and non-ETS customers

2. <u>What are the green gas supplier needs from a green gas certification scheme?</u>
   - Suppliers need assurances of a market with price certainty for investment
   - Cost and value of certificates and ability to trade and market certificates
   - Carbon credits may be more sought after than the energy consumed
   - Certification scheme is consistent with incentive schemes
   - Policy stability from government to support investment

- It should be possible to sell certificates to other countries
- Divided perspective on emissions accounting, default values recommended for small producers, also recognition that these can cause difficulty and are hard to verify
- Full Life Cycle Analysis should be undertaken so carbon capture and use of digestate as fertiliser is considered
- Low administration cost and minimum audit oversight, scheme should be approved by government, should also be easy to use.
- Lead times for acquiring certificate and legal status should be considered.
- Need to distinguish between producer, shipper and supplier as all have different needs
- In Germany there are three separate schemes, aim to have a single scheme for Ireland

3. What are the regulator/policy maker needs from a green gas certification scheme?

- Engage with stakeholders, minimise complexity and administration, consider security of data, minimise burden on small producers
- There should be inputs from the EPA
- The certificate value should be based on sustainability
- Government support for renewable heat should be set at the right level
- Compatible with other certification schemes, international trading possible, accepted by other countries, compatible with requirements of recast Renewable Energy Directive
- Use Life Cycle Analysis (LCA), transparent methodology, clear Measuring, Reporting and Verification process
- Include biogas, syngas and hydrogen
- Independent auditing body: Environmental Protection Agency, World Resources Institute, Irish National Accreditation Board suggested
- Regulator responsible for vetting and licencing
- Is there a requirement to audit the auditors?
- Review scheme regularly as in Denmark and Austria, avoid errors of Northern Ireland Renewable Heat Incentive

4. What are the key issues for a green gas certification scheme?

- The price of green gas
- Clearly defined production pathways: feedstock and production methods to be included mixed feedstock to be included, needs to accommodate mix of renewable and fossil fuel
- Quantifying green gas and emissions: How can the methane produced be metered? Use LCA to determine emissions savings. Needs to link to national targets
- Must be consistent with EU requirements and allow cross-border trading of certs
- Credibility of the system: Buy-in from industry and policy makers needed. Accounting methodology must be transparent. Training on the process must be provided. The scheme should be regularly reviewed
- Clarity of the scheme: Rules of qualification. Simple system with single scheme for Ireland. The scope of the scheme is understood and clear
- The scheme should be weighted to favour local supply. Some suggested that it should be weighted to favour non-ETS sector end use, no agreement on this

- Needs to capture end use
- Should have a lower auditing burden for smaller producers
- Are there any benefits for those who produce and use their own gas?
- It needs to be future-proof and adaptable to changes in technology or policy

5. Are there any other questions we should be asking?

- What is the impact of Brexit and gas interconnector on the gas market between Ireland and UK?
- What are the benefits to society and how much should we pay?
- What support will aid the scheme?
- How will the value of certs be scaled against the natural gas price?
- Should the system be open to new technology and feedstock types?
- How can the system support the reporting of Ireland's GHG emissions targets in different sectors?
- Can the system support a fair comparison between the different renewables with regard to GHG mitigation?
- Can biomass resources be allocated to sectors of end use which allow the highest emissions savings?
- Is the end use necessary, and is there a duty on suppliers to ensure the product will not be wasted on non-productive uses?
- Can the scheme encourage better early community engagement and improve the planning and consent process?

6.3.2 Second stakeholder workshop

The second stakeholder workshop was due to be held on Month 7 of the project (ca. November 2017). Due to the lower level of one-to-one stakeholder engagement than planned in the first half of the project, however, it was decided to defer the second workshop to a later stage. It was felt that this would give time to the team to discuss the project with key stakeholders in more detail.

The second stakeholder workshop was held on 1st February 2018 at the Crowne Plaza Dublin Airport hotel in Dublin. Around 55 people attended, representing developers, network operators, academics, government bodies and energy consumers.

The first part of the workshop was a series of presentations from stakeholders. These included a presentation from MaREI on the opportunities for biomethane in Ireland, a presentation on the recovery and use of biogas from process waste at Dairygold, and a presentation from the Department of Agriculture, Food & the Marine (DAFM) on inspections of anaerobic digestion plants.

In the second part two key elements of the GreenGasCert project were presented. Stefan Majer of DBFZ presented the methodology for calculating the GHG emissions associated with biogas and the sustainability criteria that could be included in the assessment. Stephan Bowe of DENA presented on the operation of the green gas registry.

Figure 26: Presentation by Stefan Majer, DBFZ, at the second stakeholder workshop

Two parallel breakout sessions were then held dealing with the two elements presented in the previous section. The presentations given and summaries of the breakout sessions can be found on the www.greengascert.ie website. The main points examined and the outcomes of the breakout sessions are summarised below.

6.3.2.1 Breakout session 1: Sustainability criteria and greenhouse gas calculation tool

The session was chaired by Stefan Majer of DBFZ. He introduced the mandatory sustainability criteria in the RED and said that these would be included in the design. The goal of the first part of the session was to work out a set of further criteria to be considered for inclusion in the scheme. The session participants broke into groups to discuss. The following is a summary list of potential sustainability criteria proposed:

- Rural/community development
- Community involvement
- Quality assurance in farming, manure management in particular
- Air quality
- Water quality
- Soil quality
- Biodiversity
- Transport efficiency (min. Euro standards for vehicles, use of biomethane as fuel)
- Min. waste proportion in feedstock
- Traceability
- Covered manure storage
- Indirect land use change (ILUC)

In the second part of the breakout session Stefan Majer introduced the GHG calculation tool. He explained how data can be entered, how the calculations are done for each step in the process and the most important parameters for each element in the supply chain. The participants broke into groups again to discuss three topics relating to the tool. The questions and the main responses from the groups are given below:

Are there any features and requirements regarding the methodology missing?

- Inclusion of case studies/example calculations
- Possibility to account for digestate displacing artificial fertilizer
- Inclusion of carbon capture and storage and carbon capture and replacement
- Carbon sequestration in grassland
- Differentiation between open and closed manure storage tanks
- Credits for the use of food waste, consideration of emissions of alternative uses (e.g. composting, landfilling)
- Variation of volatile solids content and dry matter content
- Inclusion of digestate transport
- Gas quality
- Forced input of actual values where necessary

Do the included pathways cover the Irish situation?

- Consider extension of the database to more feedstock etc.
- Range of data for feedstock
- Regular revision of background data and default values needed

Which data is easy to provide and at which points should the tool provide support?

- Co-digestion of feedstock
- Compression/injection-> uncertainties/losses
- Further breakdown of food waste into the different types of food waste

6.3.2.2 Breakout session 2: Operation of the biogas registry

The session was chaired by Christine Kuehnel of DENA. The goals of the breakout session were:

- To give an understanding of the complexity of green gas certification and of how the registry can reduce this complexity;
- To address any related questions that arose during the morning session.

In the first part of the session three use cases for the application of biomethane were examined (EU-ETS participant, Voluntary market and Cross-border trade), and the needs for each and their interactions with the registry assessed.

EU-ETS participant

- End user owns installation covered by European emissions trading (for example gas turbine > 20 MW)
- The user wants to claim a certain amount of biogas as part of their purchased natural gas
- Needs to use appropriate accounting and verification system (e.g. green gas registry) which allows the accurate, transparent and verifiable identification of biogas amounts fed into the grid and consumed by installations, effectively avoiding double counting of biomass

- Needs 'proof of origin' and 'proof of amount', which means an electronic document which has the sole function of providing proof to a final customer that a given share or quantity of energy was produced from renewable sources as required by Article 3(6) of Directive 2003/54/EC;

Voluntary market (i.e. the GHG protocol developed by the WRI)

- CDP, formerly the Carbon Disclosure Project, runs the global disclosure system that enables companies, cities, states and regions to measure and manage their environmental impacts.
- End user wants to report GHG emissions inside CDP
- Reliable tracking systems are independent, transparent and robust. From a CDP perspective, there are four criteria that need to be fulfilled:
- There is an entity responsible for the certificate generation (issuing body) that issues the certificate in a publicly available registry against renewable energy delivered by a generator. Only one instrument is issued per unit of energy (e.g. MWh) and this link is properly audited.
- A set of attributes are present in the instrument or can be legitimately inferred from it, namely: Name of producer; technology type; year of installation; year of production; state support/aid; emission rate;
- Auditable chain of custody: all information can be verified or audited by users in the system and the whole system is audited by external parties, guaranteeing that the link between generation, distribution and final consumption is effectively established and that there is a permanent retirement/cancelation mechanism within the system.
- The information in the system can be used to avoid the double counting of attributes

Cross-border trade

- End user would like to have possibly cheap biomethane, e.g. for his marketing activities,
- Only minor requirements for the proof: Needs proof only of amount for his/her natural gas driven bus fleet, book & claim is okay
- User looks all over Europe to find the cheapest biogas possible. Needs a registry that can import proofs from as many countries as possibleThe participants asked a series of questions relating to the use of the registry. The questions and summary answers are below:

Which actors are involved in the use of the registry?

- Producer of green gas,
- Regulatory authority,
- Independent auditor,
- Registry operator,
- Grid operator,
- Trader / shipper
- End user (corporate entity, large ETS),
- Government authority,
- EPA,
- Accrediting agency,
- NSAI,

- DAFM,
- WRI (GHG standards)

What steps are necessary to fulfil regulations or obligations with biomethane?

- Complete verification procedure
- Registry provides proof of gas quantities and quality
- Software prevents double-selling of certificates

What attributes will a registry statement need?

- Proof of origin – the gas comes from renewable sources
- Proof of quantity – the green gas quantity was verified
- Proof of quality – the properties of the green gas were verified

A role play was organised in which participants in the session played the roles of key users of the registry focussing on the three roles of Producer, Shipper and End user. The following main phases in the registry process were identified:

Phase 1: registration of company, user and biomethane plant

- Producer applies for registration of company and employees of biomethane producer
- Producer registers biomethane plant
- Producer registers amount injected into the grid
    - Monthly reports by GNI on injected amounts
    - Proof of quality by auditor (interface to GHG calculation tool)

Phase 2: Trade of biomethane

- Application for registration of company and employees of biomethane trader/shipper
- Producer and shipper agree on a supply contract
- Producer sells shipper biomethane and hands over registry excerpt. Possible actions of shipper in the registry: buy biomethane amount, divide quantity, sell part, cancel certificate.

Phase 3: Biomethane end use

- Shipper sells biomethane amount to end user
- End user verifies quality and quantity via registry

A number of questions arose relating to the registry during the session. These questions were answered either during the session or subsequently in the documentation circulated to the participants after the workshop. Below is a summary of the main questions and corresponding answers.

Q: Can the certificates be transferred in Europe and what is needed to allow this to happen?

A: To be able to trade green gas certificates cross-border, first an Irish registry has to be established and accredited by the national accreditation authority. This registry can then set up cooperation agreements with other registries. The EU initiative for a European Renewable Gas Registry (ERGaR) works towards enabling cross-border trade of biomethane certificates among all member registries.

The Irish registry can become part of ERGaR and profit from standardised and easy international trade. The ERGaR scheme still has to be finalised and accredited.

Q: In the case of the ETS currently do the EPA subcontract auditors need to be accredited to a certain level? Does this accreditation need to be agreed / set by NSAI?

A: The EPA/NSAI should be contacted and asked for their needs regarding the recognition of biomethane certificates.

Q: Will the registry operate in real-time? What time lags are associated due to data verification before a MWh of Green Gas produced can be certified?

A: The registry will not operate in real time and this is not necessary. Most existing registries are available online, though. The time lag depends on the final registry set-up. The current proposal foresees a registration of bio-methane amounts once per months. Other registries only register once per year. With the upcoming RED II regulation, certificates will only be valid for 12 months (see below) and a monthly registration is recommended.

Q: How long will a certificate remain valid for?

A: The RED II proposal restricts the “life time” of a certificate to 12 month (RED II, §19 (3)).

Q: What is to stop double counting of certificates?

A: One of the main goals of the registry is to prevent double counting. Once a Megawatt hour of Biomethane is registered and the corresponding information on origin and quality (i.e. GHG emissions etc.) is approved by an auditor the biomethane can be traded with the matching registry statement. The whole chain of custody is tracked inside the registry as well as the final consumption and cancelation of the registry statement. It is thus impossible to sell the same amount of biomethane twice.

Q: How will the certification scheme account for end usage of the gas (i.e. if used in electricity @ 30% efficiency as opposed CHP, how would this be differentiated?)

A: To account for end usage of biomethane the end user would have to be required to report end use to the registry and independent auditors would be needed to at least randomly check for correctness of the information and additional data such as efficiency of end use appliances. It is also possible to implement standard values for different consumption types. If the use of biomethane is incentivised via subsidies addressing end use the support scheme will need to define a control mechanism that could be coupled with the registry. Should biomethane be incentivised by a feed-in tariff end use might not be of relevance and could be assessed on a voluntary basis and without auditors.

Q: Does the scheme account for emissions saved through the avoidance of methane slippage from Slurry to make the outputs carbon negative?

A: The GHG-calculation tool is part of work package one. The information about GHG savings can be saved and transmitted in the registry.

6.4 Stakeholder consultation period

A key element of the GreenGasCert project is ensuring that the requirements of stakeholders are accounted for in the design of the scheme. At the end of the second stakeholder workshop a stakeholder consultation period for the project was launched. All workshop participants were invited to provide any input or feedback on the contents of the workshop or on any aspects of the certification scheme generally. A total of over 80 stakeholders including all workshop participants were also informed by email about the consultation period. Stakeholders were requested to provide inputs by Friday 2nd March 2018. The deadline was needed to ensure that any potential changes to the design arising from any submissions could be addressed before the end of the project in April.

A total of five submissions were received. A summary of the submissions is given below.

Table 49 Stakeholder consultation: summary of submissions

Organisation	Contact	Submission summary
DCCAE	Robert McGuinness	• The consideration in the scheme of the RED requirements including the latest draft recast RED • The treatment of grid-injected biomethane in the national statistics • The use of grid-injected biomethane in high efficiency applications • The operation and financing of the scheme
DCCAE	David Dodd	• The handling of ammonia emissions in the Green Gas Certification Scheme
SEAI	Matthew Clancy	• The need for a robust certification scheme to support any future exchequer support scheme • The need to ensure that default values used in the calculation tool are conservative
Adesco	Sean O'Hare	• The potential availability of the calculation tool for testing
Alchemy Utilities	Eanna Tiernan	• The suitability of grass as a feedstock for AD in Ireland

Each submission was addressed and responded to individually. Detailed submissions, and the team response to each, are presented in this document in Appendix A: Stakeholder consultation – submission and responses

6.5 Review and collation of Irish research

A primary objective of Work Package 3 was to ensure that the blueprint design was suitable for implementation in Ireland. To achieve this it was necessary that the design be informed by Irish research into anaerobic digestion by related areas of Irish research. MaREI have extensive experience in the area of bioenergy research and in particular in anaerobic digestion in Ireland. Aoife Long of MaREI has liaised with colleagues in DBFZ and DENA and provided Irish research data where this data is available. The data has been used in the development of the GHG calculation tool in Work Package 1 and the registry blueprint in Work Package 2.

An output of this activity was a research paper submitted in January 2018 by MaREI to the academic journal Renewable and Sustainable Energy Reviews. The paper was titled '*Can green gas certificates allow for the accurate quantification of the energy supply and sustainability of biomethane from a range of sources for renewable heat and or transport?*' It outlines the need for a green gas certification scheme but details a number of challenges associated with it. It shows that the sustainability criteria in the draft recast RED are much more difficult to fulfil for biomethane used for renewable heat than for biomethane used for transport. It also highlights an issue, explained in more detail in *Section 6.7.5* below, relating to the treatment of grid-injected biomethane in national statistics.

6.6 Project website

A project website was established in the early stages of the project. The website, www.greengascert.ie, provides high level information about the project. It has also been used to promote the stakeholder workshops and stakeholder consultation and to make workshop proceedings available online.

6.7 Policy developments

It is generally agreed that the biogas industry in Ireland, and thereby the green gas certification scheme, needs a favourable policy environment in order to thrive. This section outlines some national and international developments and issues relevant to biogas and biomethane, and thereby to the certification scheme, that arose during the course of the project.

6.7.1 Assessment of cost and benefits of biogas and biomethane

In June 2017 a report titled '*Assessment of Cost and Benefits of Biogas and Biomethane in Ireland*' was published by SEAI [17]. The report, prepared by Ricardo Energy and Environment, fulfilled the commitment in the Draft Bioenergy Plan from 2014 to conduct such a study[18].

To conduct the cost benefit analysis the report developed and examined four deployment scenarios:

- *Waste-based AD*: Maximum use of food and animal wastes, i.e. resources with the lowest cost and highest carbon savings;
- *Increased Biomethane*: Increased injection of biomethane into the gas grid utilising the most accessible and least cost injection points;
- *All AD Feedstocks*: Maximum use of all AD resources, including the potential surplus grass silage resource;
- *Exploratory*: Using gasification technology to produce renewable gas from wood chips/ pellets and energy crops.

In the *Waste-based AD* scenario animal and food wastes are often available at low cost or even command a gate fee. The study found that this scenario results in a net benefit to society across the range of price sensitivities examined. Similarly, it found that increasing production to inject gas at easily accessible points on the grid in the *Increased Biomethane* scenario showed a net benefit.

In the *All AD Feedstocks* scenario additional grass silage is a key feedstock accounting for 86% of energy potential. A net benefit was found only under favourable conditions including a reduction of the cost at which silage is produced. In the *Exploratory* scenario the study did not find a net benefit at current cost levels.

Key findings of the report overall included:

- By 2050 biogas and biomethane output could reach 28% of current gas supply;
- This could realise savings of 2 Mt CO_2 per annum by 2050;
- 900 new AD plants could be needed to deliver the savings;
- Financial incentives will be needed to encourage growth of the industry as few plants currently exist;
- Policy must also address other non-financial barriers to development.

6.7.2 Government support for renewable heat

A financial support scheme for renewable heat has been anticipated for a number of years. Ireland's 2014 Draft Bioenergy Plan committed to an 'Exchequer-funded incentive scheme for larger non-ETS industrial and commercial renewable heating installations' to be operational by 2016.

17 https://www.seai.ie/resources/publications/Assessment-of-Cost-and-Benefits-of-Biogas-and-Biomethane-in-Ireland.pdf
18 Draft Bioenergy Plan. October 2014. Department of Communications, Energy & Natural Resources.

On 22nd August 2017 at an Energy in Agriculture event in Roscrea, Co. Tipperary, Denis Naughten, Minister for Communications, Climate Action and Environment, announced the rollout of a 'Renewable Heat Incentive' scheme that would stimulate growth in the domestic bioenergy sector. He said that his proposal to the Government would include support for biomethane injected into the grid.[19]

In early December Minister Naughten met with RGFI and representatives of the biogas industry and explained that support for biomethane would not be included in the renewable heat support package, now renamed Support Scheme for Renewable Heat (SSRH), within the timeframe of Budget 2018.

In light of the decision not to include support for biomethane in the SSRH initially, DCCAE organised a workshop with the biogas industry to discuss how grid-injected biomethane could be supported by Government in future. The workshop was held at the Camden Court Hotel, Dublin on 17th January 2018. The workshop was addressed by Minister Naughten. He stated his commitment to biomethane and to supporting the industry in the future. A number of presentations were made by industry including a presentation on certification by Professor Jerry Murphy on behalf of the GreenGasCert project. A group discussion was then held with the participants during which ideas were sought and recorded for how support for grid-injected biomethane could be supported in future. At the end of the workshop Kevin Brady, Principal Officer at DCCAE with responsibility for heat and transport said that the inputs would be compiled and that a submission would be prepared by his department for consideration in Budget 2019.

An important feature of the green gas certification scheme is that it can complement any support scheme envisaged. Certification allows us to trace each unit of biomethane from producer to end-user and provides a means of ensuring that sustainability criteria are met. These aspects would be requirements of a state-sponsored support scheme for grid-injected biomethane. Also, independent auditing and verification can be designed into system and the registry can be used to record end-use applications. These points have been highlighted to key decision makers by the GreenGasCert team at various stages during the project.

6.7.3 Proposed Renewable Electricity Support Scheme

In September 2017, the Government launched a public consultation on a proposed Renewable Electricity Support Scheme (RESS)[20]. The stated objective of the RESS is to incentivise the introduction of sufficient renewable generation to deliver national and EU-wide renewables and decarbonisation targets. The RESS will eventually replace existing REFIT 2 and 3 programmes. It is proposed that the RESS will have technology-neutral auctions. All generators who are successful in one auction will earn the same strike price for electricity generated regardless of technology used. If the reference market price is below the strike price the generator receives a top-up payment, i.e. a 'Floating Feed-In Premium'. If the reference market price is above the strike price the generator pays back the

[19] https://www.dccae.gov.ie/en-ie/news-and-media/speeches/Pages/Speech-by-Denis-Naughten-T-D--Minister-of-Communications,-Climate-Action-and-Environment-at-Energy-in-Agriculture-2017-Even.aspx
[20] Department of Communications Climate Action and Environment, Public Consultation on the Design of a new Renewable Electricity Support Scheme in Ireland, September 2017. https://www.dccae.gov.ie/en-ie/energy/consultations/Documents/28/consultations/Renewable%20Electricity%20Support%20Scheme%20-%20Public%20Consultation.pdf

difference. An important component of the RESS will be the provision of opportunities for community ownership and benefit sharing of renewable electricity projects.

The consultation document lists all technologies that were assessed and that remain open for consideration in the scheme. Included in the list is 'biogas/biomethane'. This would appear to open the possibility of electricity generators using natural gas participating in the RESS auction process. An appropriate guarantee of origin mechanism would be required to prove the quantity of electricity that was generated using grid-injected biomethane. A green gas certification scheme, as proposed in this project, would provide the necessary verification. The proposed RESS thereby provides further impetus to establish a biogas certification scheme.

6.7.4 Proposed recast Renewable Energy Directive

The Renewable Energy Directive (RED) sets a target of 20% of RES in EU final energy consumption in 2020. It sets binding targets for each EU Member State including a 16% target for Ireland. In November 2016 the European Commission launched the Clean Energy Package which included a proposal for a recast of the RED with a binding target of a 27 % share of RES in EU final energy consumption by 2030 The draft recast RED proposes that existing national RES targets for 2020 given in Annex I be extended out to 2030. Elements of the draft recast RED that relate specifically to biomethane include:

- Article 2: Biomethane is now covered in the definition of 'biomass fuels'.
- Article 7: The contribution of food and feed crops can be no more than 3.8% of final consumption in transport in 2030.
- Article 19: Defines requirements related to Guarantees of Origin (GOs) to provide information to the final consumer have been extended to cover gas. The Article also introduces a time limit to GOs.
- Article 23: Member States will endeavour to increase the level of renewables used in heating and cooling by a non-binding 1% every year.
- Article 25: Member States will be required to increase the share of advanced biofuels and biogas for transport from at least 0.5% in 2021 to at least 3.6% in 2030. A definitive list of feedstocks used to produce advanced biofuels is given in Annex IX. The GHG savings associated with the use of these feedstocks must be at least 70% by 2021.
- Article 26: The sustainability and GHG emission requirements have been extended to cover biogas.
- Article 27: clarifies the mass balance system and adapts it to cover biogas co-digestion and injection of biomethane in the natural gas grid.
- Annex VI: Defines typical and default GHG emission reduction values for biomethane produced from a number of substrates and defines the fossil fuel comparators for electricity, heating/cooling and transport.

On 18th January 2018 the European Parliament adopted proposal for a more ambitious binding 35% target for the share of RES in EU energy consumption in 2030[21]. According to their proposal the target would be achieved by means of new binding national targets that are much higher than the 2020 targets listed in Annex I of the existing RED. For each Member State it proposes that a formula be used to calculate the 2030 target. The calculation will take into account the existing 2020 target, national per-capita GDP, renewables potential, interconnectivity, and a flat rate percentage contribution that is the same for all Member States.

The design of certification scheme has been based on the requirements of the existing RED and on those of the latest draft of the European Commission's proposal for a recast RED. At the time of writing, trilogue discussions regarding the final text of the recast RED between the Commission, the Parliament and the Council are ongoing. The certification scheme design delivered by this project will need to be assessed against the final compromise text, once that text is available. It is acknowledged that the final text may necessitate further modification of the blueprint.

6.7.5 Statistical handling of grid-injected biomethane

At a national level calculation of progress towards Ireland's renewables targets is done with an Excel-based tool developed by Eurostat called SHARES (Short Assessment of Renewable Energy Sources). This tool is used in Ireland and in other EU Member States to calculate overall RES penetration in accordance with RED obligations, as well as RES-E, RES–H and RES-T progress. In Ireland responsibility for calculating the figures and submitting to Eurostat lies with SEAI.

With SHARES, biogas/biomethane is fully attributed to the sector of its consumption (transport, industry, households) if is consumed directly, without injection in the natural gas grid. However, if biogas/biomethane is injected into the grid, it is attributed pro-rata to all sectors that consume natural gas, including electricity and heat generation, based on proportion of overall gas consumption of each sector. Although a certification system such as the one proposed may attribute a quantity of grid-injected biomethane to a specific end use, for instance heat, the Eurostat approach causes the quantity of gas to be diluted across all gas uses when calculating its contribution to national sector-level renewables targets.

Italy made a submission to the European Commission requesting that biomethane injected into the gas grid and used for transport should be fully attributed to transport in SHARES if backed up by an appropriate accounting mechanism and data. Ireland supported the Italian submission and pointed out that Ireland is 'currently beginning a project for a Green Gas Certification Scheme which could allow Ireland to accurately record where bio-methane injected to the grid is eventually consumed'[22].

In February 2018 a clarification was received from Eurostat[23]. It points out that the recast RED has provision for traceability measures that will allow the allocation to the transport sector of the entire amount of biomethane injected into the grid. It clarifies that a recent European Court of Justice ruling confirmed that a mass balance system can be applied to biomethane injected into the grid and that

[21] Epropean Parliament 2016/0382(COD)http://www.europarl.europa.eu/oeil/popups/summary.do?id=1519347&t=d&l=en
[22] SEAI, 'Biomethane Statistical Accounting', Biomethane stakeholder engagement, January 2018
[23] email from M.Howley, SEAI on 16th February 2018

this approach should already be applied to calculate the contribution of biomethane to the 2020 RES-T target. It states that the next version of the SHARES tool will be adapted from year 2017 onwards to allow the allocation of biomethane to the transport sector. The clarification focuses on the transport sector and does not deal specifically with the allocation of grid-injected biomethane to heat or electricity generation.

Further clarification was received in March 2018 from the office of Sean Kelly, MEP, lead negotiator for the European Parliament in the trilogue negotiations for the recast RED. It states that "*the new Renewable Energy Directive … will foresee for the accounting of biomethane injected in the grid based on administrative certificates (for example, 100% consumed in one specific sector, like transport). After internal discussions between Eurostat and EC, it was decided that the SHARES tool will start applying this system as from the next reporting year.*"[24]

[24] email from Niall Goodwin, office of Sean Kelly MEP, to PJ McCarthy RGFI. March 2018

7 Case Study

This case study shall illustrate the entire certification process based on a fictitious example, beginning with the application for certification and ending with issuance of the certificate and sustainability information transfer to the database. In this example, a typical case of biomethane production and consumption is presented and critical points are emphasized.

A biomethane plant owner (Mr White), producing biogas from grass silage and residues from the nearby dairy product manufactory, receives subsidies for the injection of his upgraded biogas (biomethane) and has a contract to sell his additional certificates to a trading company (Green Trading Ireland Ltd.).

The sustainability of the biomethane production, up to the point of grid injection is ensured by sustainability certification according to the GreenGasCert standard. The certification involves a check of compliance with the sustainability criteria as defined by the GreenGasCert standard. A certification company (IRCert Ltd.) coordinates the certification process, where Mr. Red is the responsible auditor for Mr White.

The contact point at the trading company for Mr White is Ms Brown. Ms Brown herself sells the certificates to different customers, one of them is the owner of a CHP plant (Heat & Power Cork, 2 MW_{el}), which has committed itself to a voluntary share of green gas use. The second customer of Ms Brown is a power plant with a capacity of 30 MW which uses the registry certificates for the EU-ETS.

Mr White and Ms Brown use the Irish biomethane registry in order to transfer and cancel their certificates.

7.1 Registration of market actors

Mr. White and Ms. Brown both have successfully registered with their companies in the Irish green gas registry. The plant owner Mr. White had to send in his DAFM registration documentation and his GNI grid access point information in order to finalize the registration of his plant. Both companies have further submitted their CRO numbers in order to verify their company status.

7.2 Biomethane production until grid injection

Mr. White operates a biomethane production facility, sourcing feedstock from a number of farmers as well as from a dairy farm. The feedstocks are being transported to the biomethane production facility. Mr. White is responsible for all process steps starting with the receipt of the feedstock, the production of biogas, the biogas upgrading, and finally, the grid injection of biomethane. Mr. White wants to certify the annual production of his biomethane, using the GreenGasCert standard. This concerns the complete value chain of biomethane production, including all upstream processes involved. In this case, this includes two farmers selling grass silage and Mr. White as operator of the biomethane production facility. Furthermore, Mr. White receives a certain amount of manure/slurry from a nearby diary farm.

To receive a sustainability certificate, the sustainability criteria of the GreenGasCert system need to be checked and fulfilled by the different market actors involved in the value chain for biomethane production. Compliance with the criteria will be checked by an auditor, working for an independent auditing company (IRCert Ltd.), which is recognised by the GreenGasCert system. Mr. Red works as an auditor for IRCert Ltd. He has attended different trainings from the GreenGasCert system and has been recognised as a qualified auditor. Mr Red is responsible for the auditing process of the Mr Whites biomethane facility.

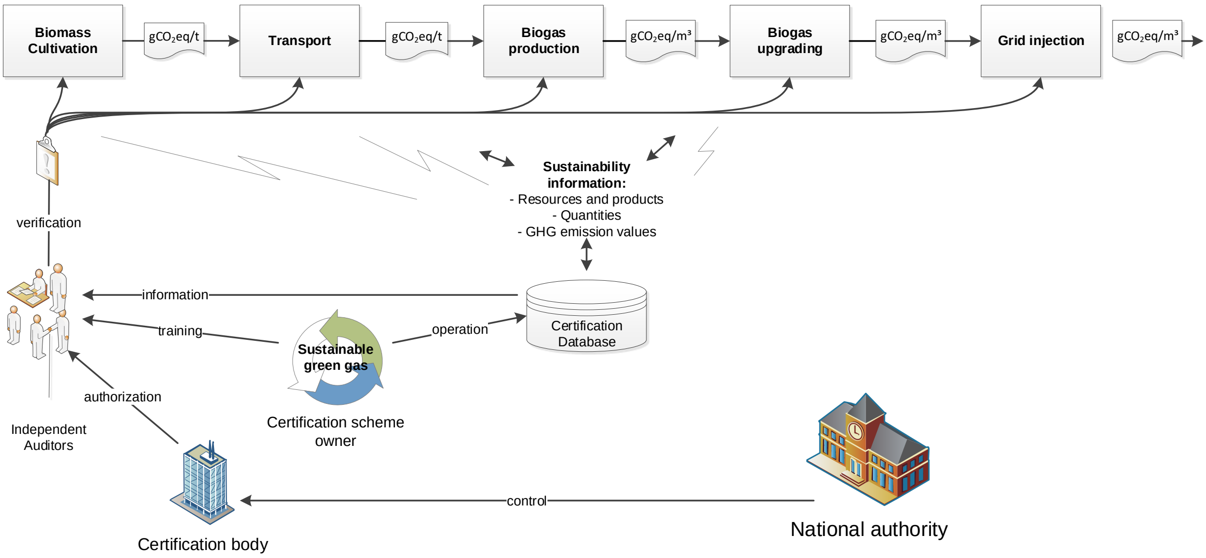


Figure 27 relevant process steps for the sustainability certification

Mr Red checks compliance with the GreenGasCert criteria at all relevant process steps (see figure 25). The general procedure for the auditing process (from contracting Mr Red to the final certificate) is described in figure 26.

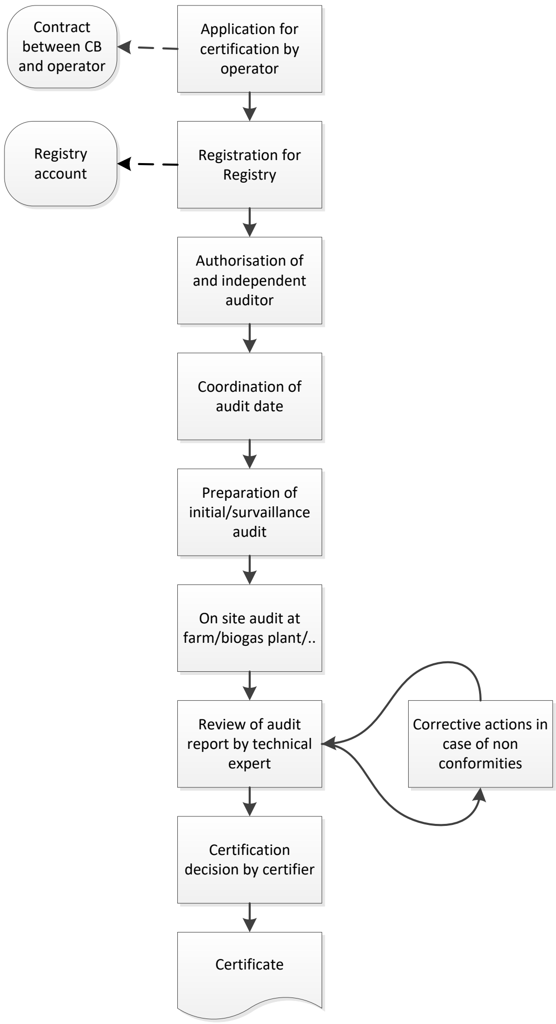


Figure 28 Auditing procedure within the certification process of the GreenGasCert sustainability scheme

For the process of biomass cultivation, the GreenGasCert system criteria are in line with requirements for good agricultural practice according to the existing EU requirements (e.g. cross compliance regulations). Farmers usually already need to show compliance with these requirements in order to receive EU subsidy payments. In this case, the check for the process of biomass production can be notably simplified. The two suppliers of grass silage need to sign a self-declaration, referring to the documentation procedures for the EU subsidy payments.

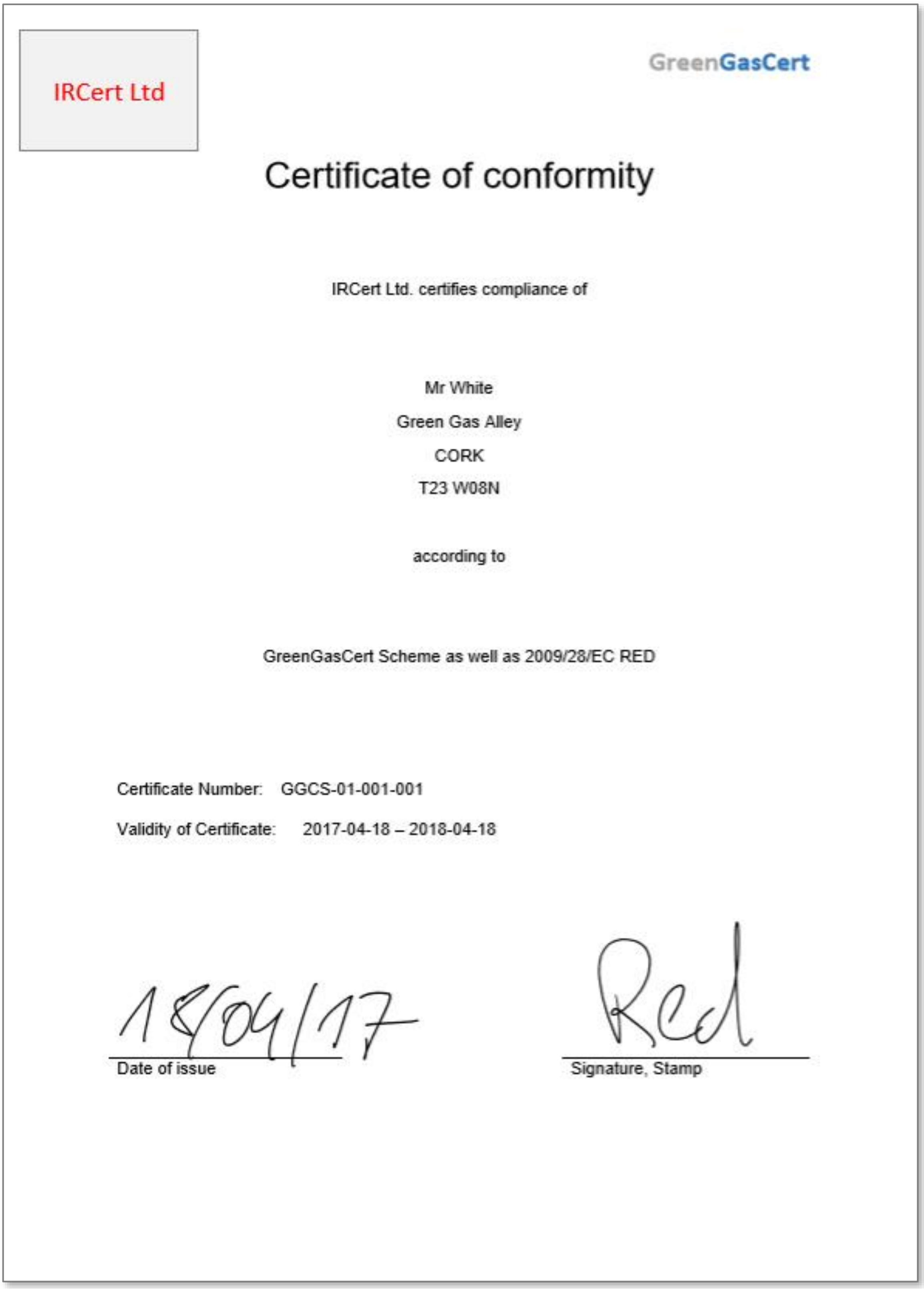
A copy of this self declaration has been send to Mr White who has received the grass silage from both farmers. Furthermore, Mr White receives a documentation regarding the origin of the manure which is supplied from a nearby diary farm. Mr Red checks both document types during the audit at Mr White's biomethane facility.

Amongst the sustainability criteria of the GreenGasCert scheme, the GHG mitigation criteria is of special nature because this criteria involves information from all process steps of the value chain. Mr White, as operator of the Biomethane facility calculates the GHG emissions of the biomethane produced, up to the process of grid injection. In order to conduct this calculation, Mr White uses actual data from both farmers supplying grass silage to the biomethane facility. The parameter relevant for the calculation of GHG emissions from Biomass production have been identified from the

GreenGasCert GHG calculation tool. Mr White uses the GreeGasCert tool to calculate the GHG emissions per MJ of biomethane produced.

Mr Red checks the compliance of the GHG calculation with the methodological requirements defined in the GreenGasCert system. Finally, Mr Red calculates the GHG mitigation value of the biomethane by comparing the GHG emission factor calculated by Mr White to the fossil comparator value as defined in the EU RED and the GreenGasCert system. Mr White's biomethane has a GHG mitigation potential of 75%. This value will be included on the certificate from the GreenGasCert system which is filed to Mr White. Furthermore, Mr Red checks, if the mass balance is compliant with the requirements defined in the scheme. Quantities of ingoing material and outgoing product are checked, by sampling delivery notes and invoices and their assignment in the mass balance. Also the conversion factors and their derivation are evaluated.

The certificate filed to Mr. White is illustrated in the following figures.



IRCert Ltd

GreenGasCert

Certificate of conformity

IRCert Ltd. certifies compliance of

Mr White

Green Gas Alley

CORK

T23 W08N

according to

GreenGasCert Scheme as well as 2009/28/EC RED

Certificate Number: GGCS-01-001-001

Validity of Certificate: 2017-04-18 – 2018-04-18

18/04/17

Date of issue

Signature, Stamp

Figure 29 Example sustainability certificate (page 1/2)

IRCert Ltd

GreenGasCert

Annex to certificate

Certification scope:

The certified company is a Biomethane producer
Wählen Sie ein Element aus.
Wählen Sie ein Element aus.

Year of initial operation of the interface: 24.03.2017

Product(s) and origin

Product	Biomass	Biomass origin	Quantity		Mass balance period	Lower heating value	
Biomethane	Grass silage	Ireland	1000	t	18.04.2017 to18.04.2018	36	MJ/m³
Wählen Sie ein Element aus.	manure, cattle	Ireland	200	m³		36	MJ/m³

GHG emission	
20.95	gCO2eq/MJ

The final use of the biomass/biofuel is/will be
☐ Heat and Electricity from CHP
☐ Heat
☐ Vehicle fuel
☒ unknown

The biomass within the scope of this certificate complies with 2009/28/EC Article 17, 2-6

Figure 30 Example sustainability certificate (page 2/2)

7.3 Creation of certificates and trade

After the biogas is produced and upgraded to natural gas quality, it is injected into the gas grid. Mr White has also registered its plant with the Irish Biomethane registry. Every month, he receives the equivalent of his injected biomethane as certificates on his account in the registry.

The plant was verified by the registry and receives information from the gas grid operator about the injected amount of biomethane.

Every month, after receiving the certificates for the last month, Mr White transfers his new certificates to Ms Brown. For achieving this, he logs into the web platform of the registry and transfers the certificates to the account of Ms Brown by using the registry account number of Ms Brown, which is GTI001.

Ms Brown receives an automatically generated mail for every incoming transaction so she immediately knows when Mr White transfers his certificates to her.

7.4 Cancellation of certificates / Target markets

Ms Brown wants to provide the necessary documents for her clients and therefore logs into the web platform of the registry and creates proofs of cancellation or registry extracts according to her contractual commitments. For the CHP plant, she issues a registry statement with an amount of 500 MWh and for the Power plant a registry statement about 2.000 MWh.

The owner of the CHP plant will then transfer this registry statement to the authorities of the voluntary scheme or to its financial auditor in order to get its green gas use verified and accounted. The registry statement for the CHP unit is shown in Figure 28.

The Power Plant also receives the registry extracts from Ms Brown and passes the information on to the national authority for the ETS trade in Ireland, the EPA. EPA accounts the used Biomethane as “zero emission” and accounts it to the Power Plant owner.

Green Gas Certificate

Certificate N°: GGCS-IE-YYYY-MM-DD-XXXX

Please verify the state of the certificate under ggcs.ie/verify.

Proof of Quantity	
Date and country of issue	22.05.2017 - Ireland (IE)
Issuing company	Green Trading Ireland Ltd.
Receiver of certificate	Heat & Power Cork
Amount	500 MWh
Source of energy	Biomethane
ETS	☐ Yes ☑ No
End use	☐PowerGen ☑CHP ☐Transport (BOS) ☐Heating ☐Export ☐Other

Proof of origin		
	Production	Consumption
Country	Ireland	Ireland
Type of installation	Biomethane plant	Cogeneration unit
Name	Biomethane plant Mr White	Cogeneration unit 34, Heat & Power Cork
Address	Camolin street, Co. Wexford	222 Baker street, Cork
Capacity	3 MW	2 MW
Time period	01.03.2018 – 31.03.2018	01.03.2018 – 31.03.2018
Commissioning date	10.04.2017	01.09.2015
Investment support received	No	No
National scheme support	Yes	No

Proof of Quality		
Criteria	Status	Auditor
RED II	fulfilled	IRCert Ltd
Fuel Quota	not fulfilled	[-]

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16.04.2018

Figure 31: Registry statement for CHP plant of "Power & Heat Cork" (page 1/2)

GGC Ireland

Green Gas Certificate

Certificate N°: GGCS-IE-YYYY-MM-DD-XXXX

Please verify the state of the certificate under ggcs.ie/verify

Substrates			
Name	Code	Amount [MWh]	GHG emissions [gCO2eq/MJ]
Grass silage	#3421	200	25
manure, cattle	#2145	300	18
Overall			20.95

Following EUROSTAT regulations the produced biomethane can only be accounted for the national goals of Ireland.

This GO relates to gas according to the Renewable Energies Directive, Article 19, 7B.

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16.04.2018

Figure 32: Registry statement for CHP plant of "Power & Heat Cork" (page 2/2)

8 Conclusion and recommendations

The GreenGasCert project has delivered a blueprint for a biogas certification scheme for Ireland. Key deliverables have been produced and important milestones have been met in accordance with the original project plan. Through successful stakeholder engagement and information dissemination the work of the team is now widely recognised. There is an increased understanding and widespread acceptance among the stakeholder community of the need for a renewable gas certification scheme.

By producing a blueprint design and achieving greater commitment from key stakeholders, the GreenGasCert project has provided an ideal starting point for the implementation of a working renewable gas certification scheme for Ireland. Considerable effort will still be needed, however, to deliver a working scheme. This section examines some of the open questions at the end of the project and makes recommendations regarding the next steps that should be taken to implement a green gas certification scheme for Ireland.

8.1 Open questions

8.1.1 Which organisation could manage the registry?

An organisation which will be responsible for the management of the registry has to be appointed. The registry can be managed by a private organisation or a state owned agency. Both options are attractive for several reasons. Both options offer different advantages.

The current proposal for the revision of the EU states that every member state has to appoint one national registry which will be responsible for issuing Guarantees of Origin according to RED standards (§ 19). To fulfil the requirements of the RED proposal, the register management has to be independent of production, trade or supply activities.

Private company/organisation as registrar

For a private company to be responsible for the management, a RED mandate (according to § 19) has to be granted to it. Furthermore, the private company may need to charge fees for the use of the registry or the state will reimburse them for the costs connected to the registry.

One of the possible candidates for the management of the registry is the Irish gas grid operator GNI (Gas Network Ireland, www.gasnetworks.ie). The most important advantage of having GNI as operator of the green gas registry is, that GNI will have direct access to injection data from green gas production plants. Thus, this data can be transmitted directly into the registry. As a market actor, GNI has expertise and experience regarding the gas market and its procedures and regulations.

Furthermore, GNI can be seen as a neutral actor, as they are not involved in any gas trade activities. There would also be no need to create a new state agency for the registry. A department of GNI could take over the responsibility for the registry. Further private actors like the World Resource Institute could also be a possible manager for the registry.

State agency as registrar

A state agency (e.g. the Environmental Protection Agency, EPA, www.epa.ie) could also manage the registry. This would have the advantage for the Irish government that the registry can be controlled easily and efficiently. It will also be easier to grant a RED mandate to a state agency than to a private company. However, the state agency will probably lack technical expertise regarding the gas grid and its operation. This could lead to a slower start-up of the registry and less efficient processes. Because often public offices need more time to acquire staff and build up new departments, as they have to follow strict regulations a slower start-up process may result.

The following table shows some examples for registrars in different member states.

Table 50 Registrars in different member states

Member state	Registrar	private/state agency
Denmark	ENERGINET	Independent public enterprise owned by the Danish state
Germany – dena registry	German Energy Agency	Private (stakeholders of dena are German ministries)
Germany - nabisy	Federal Office for Agriculture and Food (BLE)	state agency
France	GRDF (Gas grid operator)	private
UK	GGCS	private

8.1.2 Which organisation could manage the certification scheme?

In general, the certification scheme could be operated by a private entity or by a public institution or authority. As for the operation of the registry, both options offer different advantages and disadvantages.

An operation of the certification scheme by a private entity would follow the example of most sustainability schemes currently acknowledged by the EU Commission within the EU RED framework. Also, this approach would allow opening a market for competing sustainability certification schemes in Ireland. This could be relevant in the future if the installed capacity of green gas facilities increases.

An example for a centralised approach, in which a national institution or authority operates the certification scheme (and is also responsible for the certification processes) can be found in Austria. Such an approach might reduce the level of complexity for market actors (e.g. regarding the choice of the certification system) but it also hinders any competition between certification systems.

8.1.3 What is the frequency for issuing registry certificates?

On several occasions in the project, it was discussed on what frequency registry certificates shall be issued. If a connection between GNI and the registry is established, a monthly frequency would be recommended.

However, it is also possible to issue certificates on a quarterly or annual basis. This can be helpful if sustainability criteria have to be transferred to the registry but will probably lead to issues with the lifetime for proofs of Origin foreseen in the RED proposal (section 5.3)

8.1.4 How can the registry be financed?

General business plan

A crucial point for the future setup of the registry is the financing of the registry. Especially if a private stakeholder manages the registry, the financing must be guaranteed. If the registry is managed by a state agency, state institutions will guarantee the financing. *Figure 33* shows different financing options for set-up and maintenance costs.

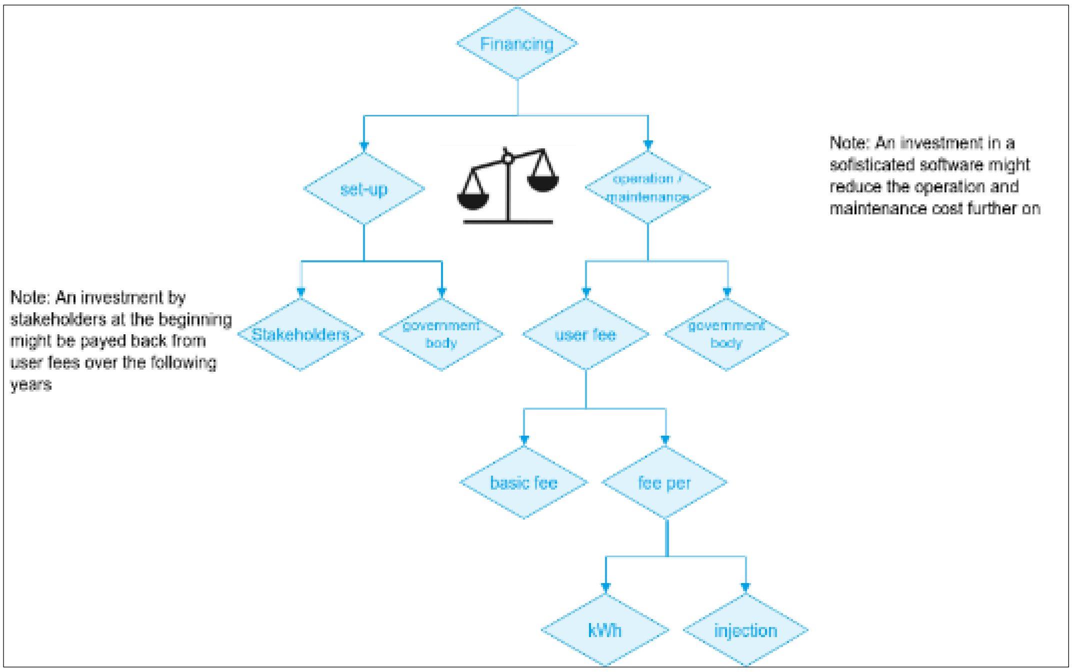

Figure 33: Registry financing options for set-up and maintenance costs

In order to illustrate possible solutions for the financing issue, examples from different member states are presented below:

- Germany: 14 companies from the green gas and gas industry helped with the initial financing. The registry is financed by the users' fees. The initial financing has also been was paid back over a few years once the system was up, running, and economically successful.
- Denmark: The registry is incorporated into the national TSO. The grid operator is a non-profit enterprise owned by the Danish Ministry of Energy, Utilities and Climate and has no commercial interest. The grid operator holds a government mandate for running the registry. The registration in the Danish register is free of charge.
- UK: In the UK two registries exist. GGCS-UK (https://www.greengas.org.uk) was founded by a variety of organizations with an interest in the green gas sector. It operates on a not-for-profit basis and fees are calculated to cover running costs.

- The Biomethane Certification Scheme (BMCS) (http://greengastrading.co.uk/) is run by Green Gas Trading Limited (GGT). Producers buy a dividend paying plant share of £7,500 and pay 4 pence per MWh as a certification fee.

Fee structure

There are different options for setting up a fee structure in a registry. The following main options exist:

- Annual inscription fee:
  - Every company that is registered has to pay the annual registration fee (e.g. 890 € in the dena registry).
- Fee for amount registration:
  - When amounts are registered in the registry, a fee has to be paid per energy amount (e.g. 140€/GWh in the dena registry).
- Fee for registry certificate cancellation:
  - When a certificate is cancelled in the registry, a fee per energy amount (10 pence/ MWh) applies.
- Fee for certificate transfer:
  - When a certificate is transferred to another account holder in the registry, a fee per transaction or energy amount has to be paid.

8.1.5 A few remarks on cross-border trade

Trade between Austria and Germany as well as Denmark and Germany is enabled through bilateral cooperation agreements between the registries.

The association ERGaR seeks to establish an independent, transparent and trustworthy documentation scheme for mass balancing of green gas on a European level. Once this is achieved and GGCS Ireland is participating, international trade of green gas will be possible without further cooperation agreements.

8.2 Recommendations

During the course of the project considerable progress has been made to prepare for an operational renewable gas certification scheme for Ireland. It is important that the momentum achieved through GreenGasCert is maintained and that plans are put in place as early as possible for the rollout of the scheme. In this regard this report recommends that the following activities be undertaken in the coming months:

8.2.1 Project implementation plan

As an immediate priority a project implementation plan needs to be put in place. The plan should detail the work needed to develop an operational renewable certification scheme from the GreenGasCert blueprint. It should identify all necessary main work packages and provide a schedule for the delivery of the certification scheme. Skills required to deliver the scheme will need to be identified and a consortium of suitable project partners organised. The plan will need to assess the costs for delivering the certification scheme and identify the funding sources to meet the setup costs.

8.2.2 Advocacy and policy developments

In order to foster and grow a sustainable biogas industry in Ireland a favourable policy environment will be needed. An important part of that environment will be an Exchequer funded financial support mechanism for grid-injected biomethane. It will be necessary to continue to promote the benefits of grid-injected biomethane among key decision makers to encourage favourable policy development and ensure that an adequate support mechanism is realised.

The SSRH is currently being designed and rolled out by SEAI. Although the scheme does not currently support grid-injected biomethane, a commitment has been made by Minister Naughten to consider a support mechanism in Budget 2019. Close cooperation is needed with SEAI in the coming months so that any potential requirements of the SSRH can be addressed by the green gas certification scheme.

Similarly, opportunities for grid-injected biomethane presented by the proposed RESS scheme for renewable electricity and potential synergies between RESS and the certification scheme will need to be explored.

At the time of writing the trilogue process to agree the final text of the recast RED is ongoing. Once the compromise text is available the blueprint will need to be assessed against it and any necessary modifications to the design will need to be made.

8.2.3 Stakeholder engagement and information dissemination

The GreenGasCert project team has successfully promoted the green gas certification scheme over the course of the project. There is now general acceptance among the wider stakeholder community that a scheme will be rolled out imminently and that it will be based on the blueprint designed by the project team. In order to maintain the profile of the work completed the ongoing and intensive consultation with all stakeholders and the dissemination of information will need to continue in the coming months.

As part of the implementation process, an oversight committee should be established. The committee should comprise representatives of the renewable gas industry (producers, suppliers, network operators and consumers) and of relevant government departments and state agencies, as well as members of the implementation team. The committee should be tasked with ensuring that the rollout of the scheme continues to meet the requirements of stakeholders.

8.2.4 Establishment of a framework for operating the scheme

The entity or entities responsible for operating the scheme has to be decided upon. If these don't already exist, they need to be established. The necessary authority, structures and resources to carry out their duties needs to be allocated to them.

While an objective of the scheme would be that it be self-financing, it is recognised that the set-up costs and the costs of running the scheme in the beginning will need external funding. A business plan for the operation of the scheme needs to be developed that outlines how it will be financed in the longer term. An approach to auditing the scheme needs to be agreed upon and auditors need to be appointed. The implementation team will need to continue to work with DAFM to explore synergies between the existing inspection processes for AD plants in Ireland and the auditing requirements of the certification scheme.

As part of the project implementation a technical assessment of suitable software platforms for the operation of the registry needs to be undertaken and the appropriate one for the Irish case identified. The assessment will need to take into account the set-up costs and the ongoing operational costs associated with registry operation.

8.2.5 Accreditation and recognition

The scheme will need to be accredited by a national accreditation body. It has been difficult to identify and discuss with the appropriate contacts and to find information about the accreditation process during the course of the GreenGasCert project. The accreditation process needs to be fully understood, the requirements for accreditation clarified and the appropriate accreditation body identified.

Critical to the acceptance of the scheme by end-users is its recognition by voluntary global disclosure schemes, in particular the CDP and the WRI. It may be necessary have the scheme in operation and accredited by the national accreditation body before it will be recognised by international voluntary schemes. More work needs to be done to understand the route to its recognition.

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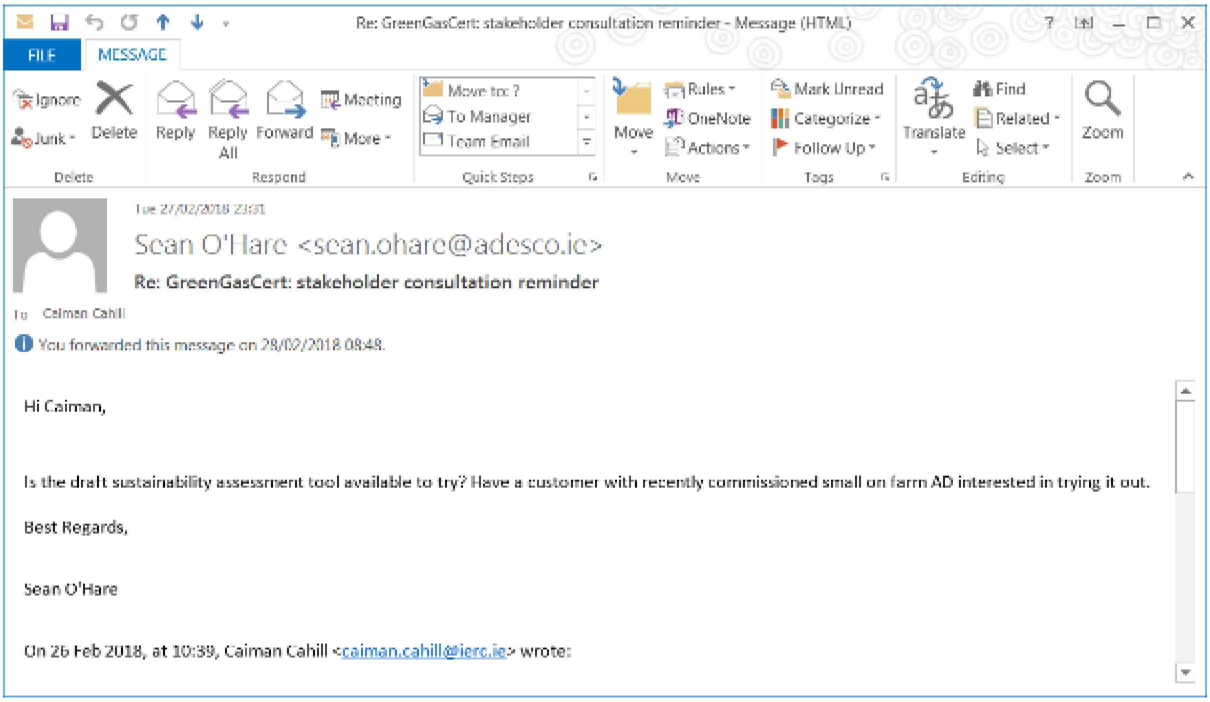
Appendix A: Stakeholder consultation – submissions and responses

Submission from Adesco Nutricines and team response:



Re: GreenGasCert: stakeholder consultation reminder - Message (HTML)

Tue 27/02/2018 23:31

Sean O'Hare <sean.ohare@adesco.ie>

Re: GreenGasCert: stakeholder consultation reminder

To Caiman Cahill

You forwarded this message on 28/02/2018 08:48.

Hi Caiman,

Is the draft sustainability assessment tool available to try? Have a customer with recently commissioned small on farm AD interested in trying it out.

Best Regards,

Sean O'Hare

On 26 Feb 2018, at 10:39, Caiman Cahill <caiman.cahill@ierc.ie> wrote:

GreenGasCert
www.greengascert.ie

International Energy Research Centre
Tyndall National Institute
Lee Maltings
Dyke Parade
Cork, T12 R5CP
Ireland

23rd March 2018

Seán O'Hare,
Adesco Nutricines,
Dungarvan Enterprise Centre,
Lower Main Street,
Dungarvan,
Co. Waterford.

Dear Seán,

Subject: GreenGasCert stakeholder consultation

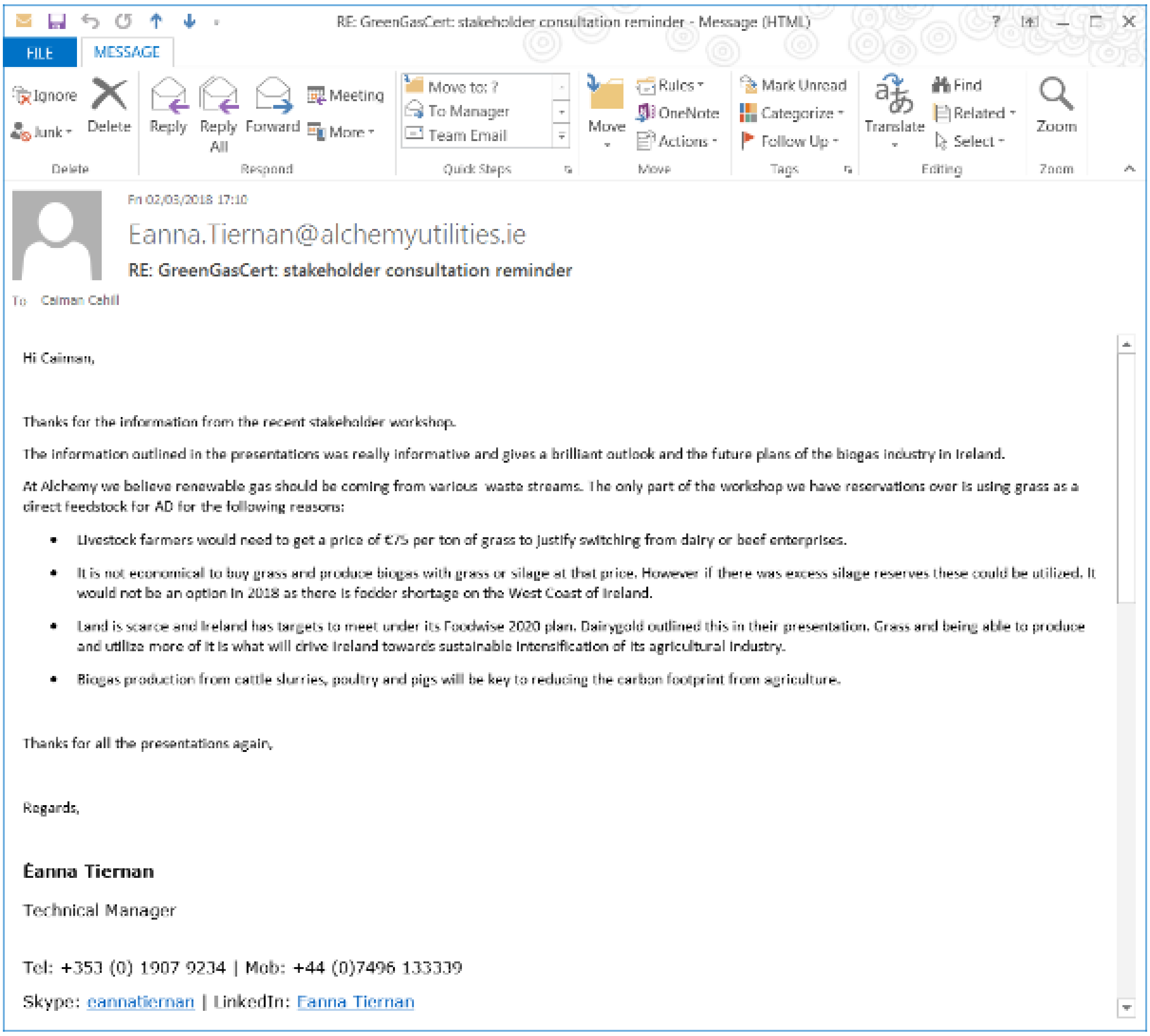
Thank you for participating in the stakeholder consultation for the GreenGasCert project and for your query relating to the draft sustainability assessment tool that has been developed as part of the project. Unfortunately due to issues relating to the protection of the intellectual property of the project partners we are unable to provide you with a copy of the software tool at this stage.

We would like to thank you again for your input. The GreenGasCert project aims to deliver a blueprint for the certification scheme and by doing so will support the growth of a sustainable biogas industry in Ireland. There is still considerable work to be done to implement the scheme once this project is complete. We hope that at a later stage in the process the current IP constraints will be lifted and project deliverables will be available for distribution among the wider stakeholder community. We would be grateful for your continued support and helpful input as certification scheme is rolled out.

Yours Sincerely,
On behalf of the GreenGasCert team

Caiman Cahill
Senior Researcher, International Energy Research Centre

Submission from Alchemy Utilities and team response:



Fri 02/03/2018 17:10

Eanna.Tiernan@alchemyutilities.ie

RE: GreenGasCert: stakeholder consultation reminder

To Caiman Cahill

Hi Caiman,

Thanks for the information from the recent stakeholder workshop.

The information outlined in the presentations was really informative and gives a brilliant outlook and the future plans of the biogas industry in Ireland.

At Alchemy we believe renewable gas should be coming from various waste streams. The only part of the workshop we have reservations over is using grass as a direct feedstock for AD for the following reasons:

- Livestock farmers would need to get a price of €75 per ton of grass to justify switching from dairy or beef enterprises.
- It is not economical to buy grass and produce biogas with grass or silage at that price. However if there was excess silage reserves these could be utilized. It would not be an option in 2018 as there is fodder shortage on the West Coast of Ireland.
- Land is scarce and Ireland has targets to meet under its Foodwise 2020 plan. Dairygold outlined this in their presentation. Grass and being able to produce and utilize more of it is what will drive Ireland towards sustainable intensification of its agricultural industry.
- Biogas production from cattle slurries, poultry and pigs will be key to reducing the carbon footprint from agriculture.

Thanks for all the presentations again,

Regards,

Eanna Tiernan

Technical Manager

Tel: +353 (0) 1907 9234 | Mob: +44 (0)7496 133339

Skype: eannatiernan | LinkedIn: Eanna Tiernan

GreenGasCert
www.greengascert.ie

International Energy Research Centre
Tyndall National Institute
Lee Maltings
Dyke Parade
Cork, T12 R5CP
Ireland

23rd March 2018

Eanna Tiernan,
Alchemy Utilities,
2 Harmony Court,
Harmony Row,
Dublin 4

Dear Eanna,

Subject: GreenGasCert stakeholder consultation

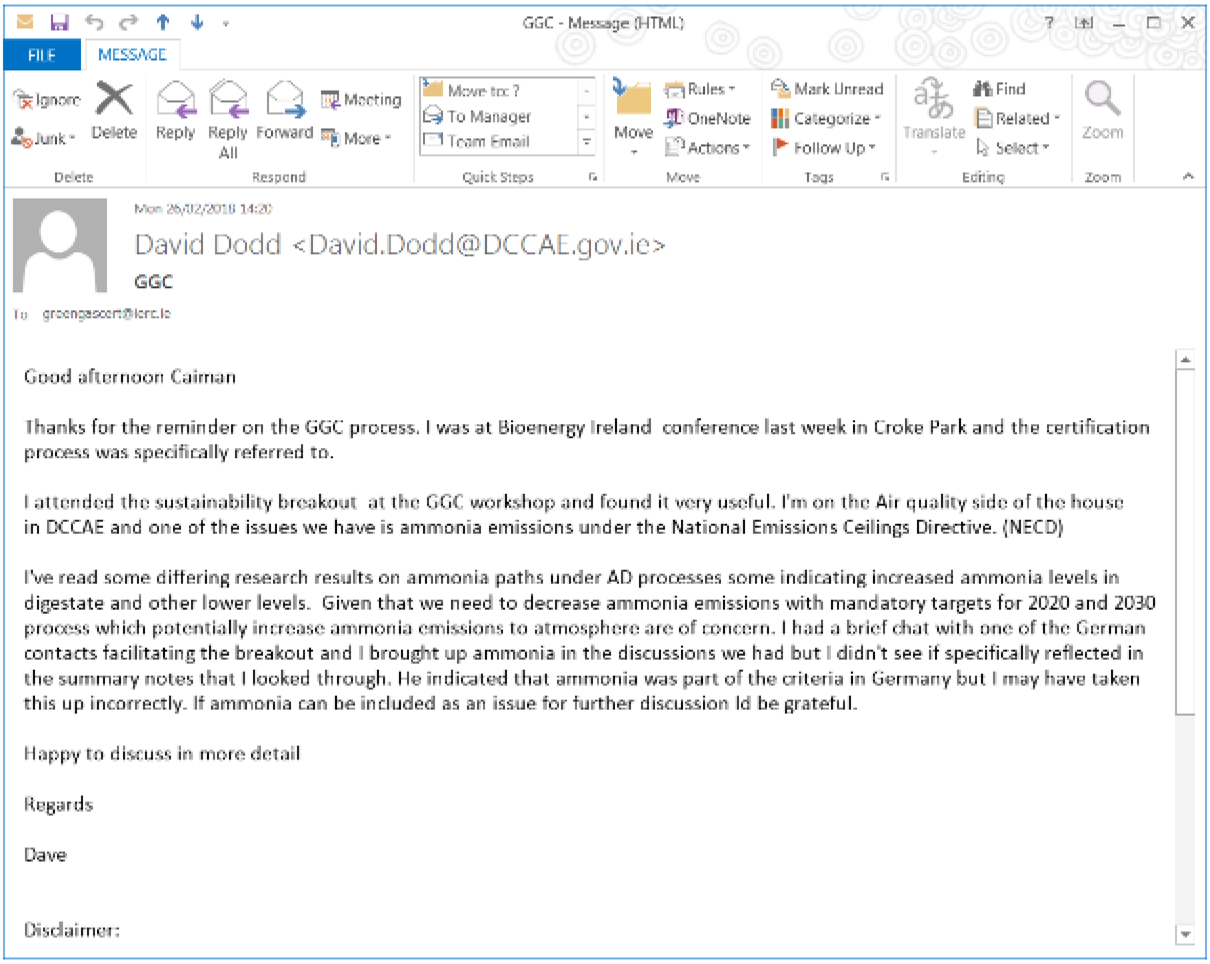
Thank you for participating in the stakeholder consultation for the GreenGasCert project and for your input on the issue of the suitability of grass as a feedstock for anaerobic digestion. I would like to clarify that the GHG calculation methodology and sustainability assessment will accommodate all substrates likely to be used in AD plants in Ireland. The certification scheme will not promote the use of any particular feedstock for digestion but will reflect the sustainability of each in the assessment and in the certificate for the biogas produced. Although much research has been done by some members of the team on the sustainability of different substrates and their potential in Ireland, that work is outside the scope of the GreenGasCert project. Therefore the suitability of grass as a feedstock for anaerobic digestion will not be addressed in the current project.

We would like to thank you again for your input which was considered and helpful. We will endeavour to address all feedback from stakeholders insofar as this is possible in the GreenGasCert project. We would like to remind you that although the project delivers a blueprint for a certification scheme there is still considerable work to be done to implement the scheme once this project is complete. We would be grateful for your continued support and helpful input as certification scheme is rolled out.

Yours Sincerely,
On behalf of the GreenGasCert team

Caiman Cahill
Senior Researcher, International Energy Research Centre

Submission from DCCAE (David Dodd) and team response:



Mon 26/02/2018 14:20

David Dodd <David.Dodd@DCCAE.gov.ie>

GGC

To greengascert@ierc.ie

Good afternoon Cairnan

Thanks for the reminder on the GGC process. I was at Bioenergy Ireland conference last week in Croke Park and the certification process was specifically referred to.

I attended the sustainability breakout at the GGC workshop and found it very useful. I'm on the Air quality side of the house in DCCAE and one of the issues we have is ammonia emissions under the National Emissions Ceilings Directive. (NECD)

I've read some differing research results on ammonia paths under AD processes some indicating increased ammonia levels in digestate and other lower levels. Given that we need to decrease ammonia emissions with mandatory targets for 2020 and 2030 process which potentially increase ammonia emissions to atmosphere are of concern. I had a brief chat with one of the German contacts facilitating the breakout and I brought up ammonia in the discussions we had but I didn't see if specifically reflected in the summary notes that I looked through. He indicated that ammonia was part of the criteria in Germany but I may have taken this up incorrectly. If ammonia can be included as an issue for further discussion Id be grateful.

Happy to discuss in more detail

Regards

Dave

Disclaimer:

GreenGasCert
www.greengascert.ie

International Energy Research Centre
Tyndall National Institute
Lee Maltings
Dyke Parade
Cork, T12 R5CP
Ireland

23rd March 2018

David Dodd,
Department of Communications, Climate Action & Environment,
29-31 Adelaide Road,
Dublin, D02 X285

Dear David,

Subject: GreenGasCert stakeholder consultation

Thank you for participating in the stakeholder consultation for the GreenGasCert project. You raised the issue of ammonia levels in digestate and their impact on national ammonia emissions and asked that the issue be included for further discussion in the project. I have discussed this with our German partners at DBFZ who are responsible for developing the sustainability criteria for the certification scheme and they have clarified the following:

> Livestock production and the storage and application of digestate from anaerobic digestion can be significant sources of ammonia emissions in the agricultural sector. The magnitude of ammonia emissions from biogas production and digestate handling are subject to various influencing factors.
>
> From our perspective, there are two ways to include this aspect in the GreenGasCert certification scheme. Firstly, the GHG calculation approach developed in our scheme will allow for the calculation of GHG emissions from the application of digestate in agricultural systems. However, it is important to mention that this will be based in literature values.
>
> Secondly, to address mitigation measures to reduce ammonia emissions, the GreenGasCert sustainability criteria set could include a "best practice" criteria for digestate handling. We know from other parts of the EU that ammonia emissions from digestate application can be decreased by appropriate application techniques (and timeframes).
>
> Obviously, because of the strong regional character of the drivers and influencing factors for ammonia emissions, the best practice guidelines should be developed by national Irish experts (we are happy to provide more insights from the "lessons learned" in Germany).

I would like to point out that although the project delivers a blueprint for a certification scheme there is still considerable work to be done to implement the scheme once this project is complete. As part of

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that implementation we would like continue to work with you to explore how best practice criteria for the spreading of digestate could be included in the sustainability criteria. We would like to thank you again for your input which was considered and helpful and we look forward to your continued collaboration.

Yours Sincerely,
On behalf of the GreenGasCert team

Caiman Cahill
Senior Researcher, International Energy Research Centre

Submission from DCCAE (Heat and Transport) and team response:

Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

IERC GreenGasCert Project - Stakeholder Consultation

Department of Communications, Climate Action and Environment

9th March 2018

With reference to the GreenGasCert Project stakeholder consultation, managed by the International Energy Research Centre (IERC), the Department of Communications, Climate Action and Environment (DCCAE) suggests the following points be noted:

1. **European Directives**

   The design of the renewable gas certification system blueprint (the Blueprint) should recognise relevant provisions in the Renewable Energy Directive (RED). In particular, the Blueprint should recognise Article 15 of RED, which relates to Guarantees of Origin (GoOs) and safeguards against double compensation.

   In designing the Blueprint, the changes being proposed for the recast of the Renewable Energy Directive (REDII) should also be noted. For instance, the recast of the Directive proposes extending GoOs to renewable gas in order to prove the origin of renewable gas to final customers and to facilitate greater cross-border trade.

   The recast of the Renewable Energy Directive is not yet finalised. The trilateral negotiations between the European Commission, the European Parliament and the Council of the European Union are underway in order to agree on a compromise text.

2. **Statistical Treatment**

   If biomethane grid injection is to be supported by Exchequer funding, it is of paramount importance that the supported product is directed to the most efficient applications. This direction must be recognised for statistical reporting purposes to the EU in order to maximise the contribution towards our national energy and climate target.

   The Blueprint should note that Ireland's renewable energy target is based on energy consumption (i.e. after losses that occur in the generation of electricity). Currently, c.50% of natural gas consumed from the Irish grid is used in relatively low-efficiency electricity production; therefore it would currently be considered that c. 50% of each unit of biomethane injected is consumed in electricity generation. Given that OCGT and CCGT plants generally operate with efficiency levels in the range of 35%-60%, this relatively low efficiency application is not considered desirable for support from a policy perspective.

However, Eurostat recently stated that traceability measures such as certification will facilitate the direction of biomethane injected to the gas grid towards the transport sector. This change is expected to be included in the next iteration of the SHARES statistical reporting tool. The Department understands that this principle, once established, may also allow the accounting of biomethane towards the heat sector, high-efficiency heating and Combined Heat and Power (CHP).

3. **Efficiency**

Following from the above, the design of the Blueprint should include options to allow preferential access to purchase green gas certificates for high-efficiency applications or other selected applications such as transport.

This may be achieved by requiring certificate purchasers to declare their intended use of biomethane, ranking consumers applications into a modifiable hierarchy (e.g. 1- transport, 2-high efficiency heating etc.) and including an audit process to verify that stated application of gas aligns with actual use. Where practical, applications may be split further into efficiency bands, e.g. high efficiency heating may be split in to >90%, 86-90% etc.

4. **Registry Operation**

The Blueprint should include options for the ownership and operation of the green gas certification registry. These options should include reference to international best practice.

The options proposed should all include means for the proposed registry to be self-financing, via a commission on the trade of certificates or by other appropriate means.

Heat and Transport Energy Policy Division
9th March 2018

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International Energy Research Centre
Tyndall National Institute
Lee Maltings
Dyke Parade
Cork, T12 R5CP
Ireland

23rd[nd] March 2018

Robert McGuinness,
Department of Communications, Climate Action & Environment,
29-31 Adelaide Road,
Dublin, D02 X285

Dear Robert,

Subject: GreenGasCert stakeholder consultation

Thank you for participating in the stakeholder consultation for the GreenGasCert project. We will endeavour to reflect your inputs in the final blueprint. With regards to specific points raised in your submission I would like to clarify the following:

- The registry blueprint will be designed in accordance with the sustainability requirements of the latest draft of the Commission's proposal for a recast Renewable Energy Directive, while acknowledging the proposals of the Parliament and the Council. We recognise that the final compromise text, whenever it is available, may necessitate further modification of the blueprint.
- We welcome the recent clarification from Eurostat regarding the statistical treatment of grid-injected biomethane. We believe that the certification scheme will allow the attribution of biomethane to specific end-uses in line with the next version of the SHARES tool.
- We acknowledge your point that efficient end-use will be a prerequisite for any future Exchequer support for grid-injected biomethane. For the certification scheme to complement any such support programme it will require that particulars of the end-use application be recorded in the registry. We recognise that such records may require independent verification.
- The certification scheme will support multiple end-uses. The scheme itself as currently envisaged, however, will not determine the end-use application or prioritise purchasers in a particular end-use category. This could only be done in conjunction with supporting legislation or policy instruments.
- The blueprint will include options for the ownership and operation of the scheme. While it is desirable that the scheme be self-financing in future there is recognition among the project partners that industry may have to provide financial support to the operation in the initial stages.

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Analysis of the costs of setting up and operating the scheme is not within the scope of the current GreenGasCert project.

We will endeavour to address all feedback from stakeholders in the final deliverables of the GreenGasCert project. We would like to remind you that although the project delivers a blueprint for a certification scheme there is still considerable work to be done to implement the scheme once this project is complete. As part of that implementation process we would like to establish an oversight committee. The oversight committee will ensure that the certification scheme rollout meets the requirements of the stakeholders. We would be grateful if you would consider proposing a DCCAE representative to sit on the committee. This would ensure that current and future needs of the Department are addressed. We would like to thank you again for your input which was considered and helpful and we look forward to your continued collaboration.

Yours Sincerely,
On behalf of the GreenGasCert team

Caiman Cahill
Senior Researcher, International Energy Research Centre

Submission from SEAI and team response:

RE: GreenGasCert: stakeholder consultation reminder - Message (HTML)

FILE MESSAGE DEVELOPER

Tue 06/03/2018 14:15

Clancy Matthew <Matthew.Clancy@seai.ie>

RE: GreenGasCert: stakeholder consultation reminder

To Caiman Cahill

Click here to download pictures. To help protect your privacy, Outlook prevented automatic download of some pictures in this message.

Thanks Caiman,

We will consider how best to approach this then in the context of the SSRH,

Best rgerads,

Mathew

From: Caiman Cahill [mailto:caiman.cahill@ierc.ie]
Sent: Tuesday 6 March 2018 11:36
To: Clancy Matthew <Matthew.Clancy@seai.ie>
Subject: RE: GreenGasCert: stakeholder consultation reminder

Hi Matthew,

Thanks for your mail. I hope your trip to the US went well. We set a time limit on consultation submissions simply to give a chance to make any necessary changes to the proposed GHG calculation methodology or to the registry blueprint before the end of the current IERC project next month. In reality the work on the scheme will need to continue beyond that date. In that regard we would welcome any further input and feedback from SEAI on the proposed scheme at any stage. Please feel free to respond more fully if you get a chance. Thanks again.

Regards,

Caiman

From: Clancy Matthew [mailto:Matthew.Clancy@seai.ie]
Sent: 06 March 2018 10:06
To: Caiman Cahill
Subject: RE: GreenGasCert: stakeholder consultation reminder

Dear Caiman,

I have been out of the office for the last while so apologies for not replying to this sooner. I am happy that much of the issues are being addressed by the project team but would be keen to add some comments on the record if the opportunity is still there.

If not, the main SEAI comment is to reiterate the need for such a scheme and the need for robust certification to allow integration of biomethane and biogas with government support schemes. Also, any default values for feedstock and pathway combinations should have conservative estimates and follow the precautionary principle.

Let me know if the opportunity to respond more fully is still available,

Thanks,

Matthew

GreenGasCert
www.greengascert.ie

International Energy Research Centre
Tyndall National Institute
Lee Maltings
Dyke Parade
Cork, T12 R5CP
Ireland

23rd March 2018

Matthew Clancy,
Sustainable Energy Authority of Ireland,
Wilton Park House,
Wilton Place
Dublin 2, D02 T228

Dear Matthew,

Subject: GreenGasCert stakeholder consultation

Thank you for participating in the stakeholder consultation for the GreenGasCert project and for your support for the work done so far. With regards to specific points that you have raised I would like to clarify the following:

- We acknowledge your point that default values for feedstock and pathway combinations should have conservative estimates and should follow the precautionary principle, and we will endeavour to reflect this in the design.
- We agree that the certification scheme will need to be robust in order to integrate with any future support scheme for biogas and biomethane. The GreenGasCert project members would be happy to continue to work with SEAI to ensure that the scheme is aligned with Support Scheme for Renewable Heat and addresses any other requirements. We recognise that this work may need to continue beyond the finish date for the current project.

Although the project delivers a blueprint for a certification scheme there is still considerable work to be done to implement the scheme once this project is complete. As part of that implementation process we would like to establish an oversight committee. The oversight committee will ensure that the certification scheme rollout meets the requirements of the stakeholders. We would be grateful if you would consider proposing an SEAI representative to sit on the committee. This would ensure that current and future needs of the SEAI are addressed. We would like to thank you again for your input which was considered and helpful and we look forward to your continued collaboration.

Yours Sincerely,
On behalf of the GreenGasCert team

Caiman Cahill
Senior Researcher, International Energy Research Centre