GREEN GAS

WHAT IS GREEN GAS?

Green Gas is a form of energy derived primarily from biomass; biological material that includes energy crops (such as wood, grasses, and seaweed), animal slurries, and municipal wastes, as well as from non-biological origins such as electricity. It is a form of renewable energy that can be injected into the existing natural gas network and used as a substitute for natural gas for renewable electricity, heat, and transport.

MaREI
Centre for Marine and Renewable Energy

Why Green Gas?

Ireland's target for 2020 is to have 40% of electrical, 12% of heat, and 10% of transport energy coming from renewable sources. These are binding targets and as of 2015 we have achieved 25.3%, 6.5%, and 5.7% respectively. A simplified breakdown of total final energy consumption in Ireland shows that electricity accounts for ~20% of energy. The heat and transport sectors combined constitute the remaining ~80%. However, to date the production of renewable electricity has been the primary focus in Ireland with the majority of effort going to ramping up green electricity production from wind turbines. Unfortunately, Ireland is not on track to meet its emission reduction targets for 2020 as the decarbonisation of the heat and transport sectors has not occurred to the extent that it has occurred in electricity. Green Gas is a commercially available indigenous solution to satisfy renewable heat and transport, and to avoid large incoming fines for neglecting EU targets in these sectors. It can also help meet the growing demand for green energy from multinationals.

What's the Potential?

GREEN GAS FROM ANAEROBIC DIGESTION:

Anaerobic digestion (AD) of wet organic biomass can provide an indigenous renewable energy supply for Ireland. AD is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. AD is a mature technology, with ~14,000 digesters now operating throughout Europe. It produces biogas which is approx. 60% methane (CH_4) and 40% carbon dioxide (CO_2). Biogas was traditionally combusted to generate combined heat and power (CHP). Recently however an industry in upgrading biogas through removal of CO_2 and impurities to biomethane with greater than 95% CH_4 (similar quality to natural gas) has emerged. This Green Gas may be injected to the existing natural gas grid.

In many ways Ireland is suited to AD technology. The extensive agricultural industry can be exploited for its vast resources of slurries, slaughterhouse wastes, dairy slurries, and surplus grass silage, which are principal feedstocks for AD. Previous studies have indicated that Ireland can achieve 10% renewable energy in transport by digesting just 1.1% of grassland in Ireland with dairy slurry. The concept would also contribute to the overall ideology of "greening agriculture" and diversifying the rural economy, which faces many challenges. Ireland is unique in Europe in having such a large proportion of our population living in rural areas. This coupled with an aging population, high levels of farm subsidies, and the need to reduce emissions from agriculture, indicates the need for a plan of action. Growing energy crops for biomethane offers many potential benefits to rural communities as an alternative to beef farming where over 60% of farmers are considered part-time, and almost two thirds of farms are considered unprofitable. Coupled with the fact that the Irish agricultural sector is populated by a large number of small farms, Green Gas production through cooperative movements could provide valuable income for many families while contributing to Ireland's renewable energy needs and emission reduction targets. Ireland's active ecosystem and grass availability offer low indirect land use bioenergy, something that is strongly promoted as a future fuel by the European Commission in recent revisions of the Renewable Energy Directive.

Additionally, waste streams outside of agriculture can be targeted such as household food waste. Brown bin waste may even attract a gate fee for acceptance to an AD facility making the project more economically feasible.

GREEN GAS FROM WOODY CROPS:

In the longer term, gasification could provide an additional significant quantity of Green Gas. Gasification is a low-carbon pathway to produce energy, fuels, chemicals, and fertilisers. A large variety of biomass or waste feedstocks, agro-forestry residues, black bin waste, indigenous energy crops grown on marginal land, and sewage sludge can be used in this process Gasification involves the "partial combustion" of carbonaceous feeds to produce a synthetic gas that is further converted into valuable products. In the case of Green Gas, methanation is used to create synthetic natural gas (bio-SNG) with a 95% CH_4 content. The valuable by-products of gasification such as fertilisers and chemicals improve its environmental and economic performance.

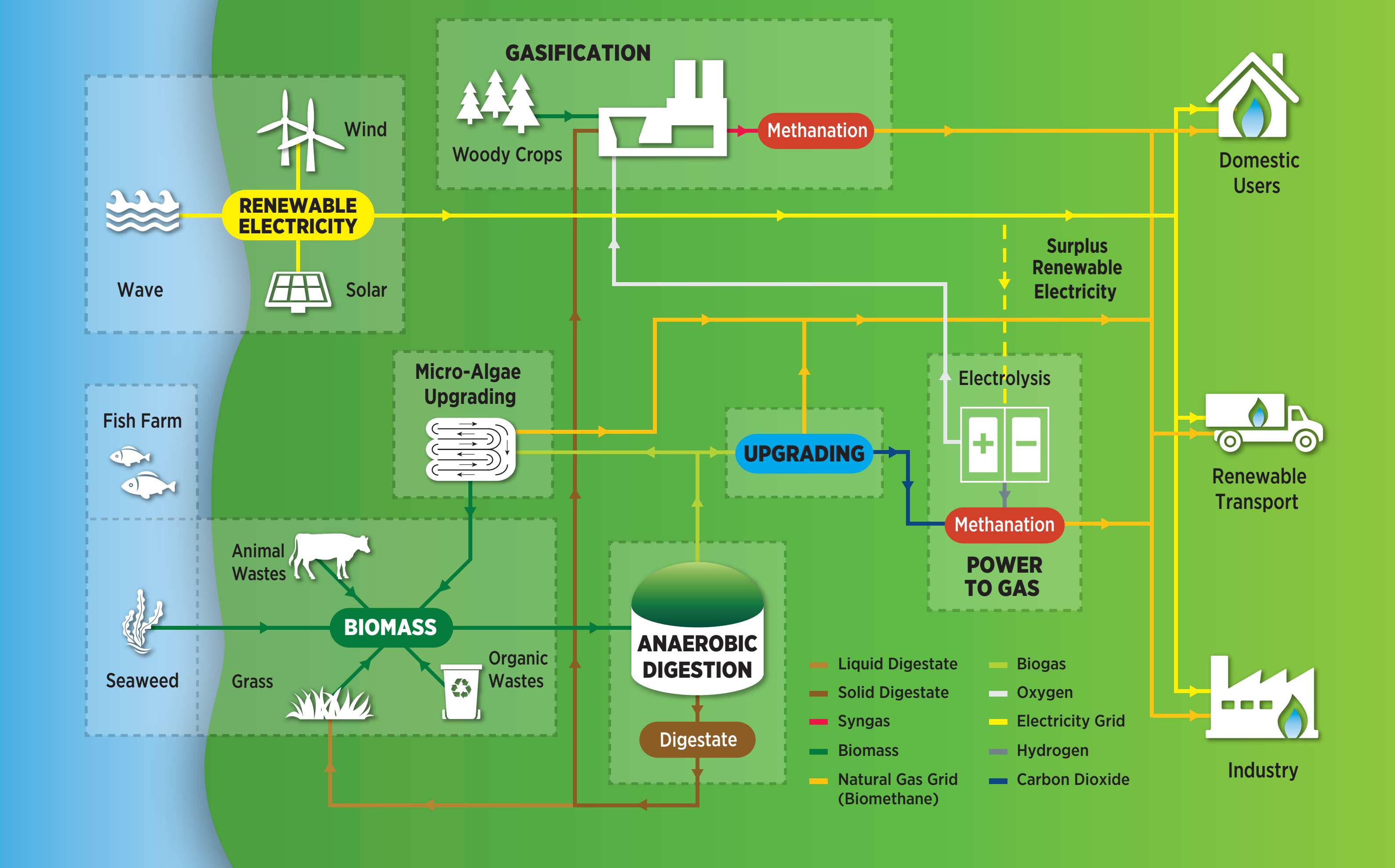
Several commercial biomass gasification-methanation plants operate in Sweden, Austria, and France. Studies indicate that Ireland can achieve 5.2% renewable energy in transport through gasification-methanation of only the existing waste streams from forestry, agriculture, black bin waste, sewage sludge, and digestate. Given the lack of public support for incineration in Ireland, this technology offers a useful alternative. An additional 5.5% could be met through gasification-methanation of energy crops such as short rotation coppice willow on 75,000 ha of otherwise marginal land. The planned expansion of forestry will further increase the viability of gasification as in other countries like Sweden.

GREEN GAS FROM ALGAE:

In terms of a future outlook, advanced biofuel substrates like seaweed and micro-algae can lessen the requirement of land based feedstocks for renewable gas production. Research investigating the seasonal variation of seaweed, combined with effective ensiling methods, will enable the provision of a year round supply of high quality biomass.

Potential exists to expand the resource of seaweed available in Ireland through innovative cultivation techniques. An example of this is integrated multi-trophic aquaculture systems whereby seaweed is cultivated adjacent to fish farms utilising the fish excrement as a nutrient source, increasing growth yields, whilst cleaning the waters. Research suggests that if advanced biofuels from seaweed are to satisfy 1.25% of energy in transport in the EU, the EU would need 13 million tonnes (Mt) of salmon, generating 168Mt of seaweed that would need 2603 anaerobic digesters. The world harvest of farmed fish was 66.6Mt in 2012 and aquaculture contributed ~23Mt of seaweed in 2012. Micro-algae can also contribute significantly to Green Gas, not only as a substrate with very high growth rate but also as a novel biogas upgrading method by capturing CO_2 in its growth.

RENEWABLE GAS SYSTEM



POWER TO GAS:

Future opportunities are seen in power-to-gas (P2G) systems, which offer significant potential to expand the Green Gas sector. By 2020, Ireland is expected to spill 7-14% of its renewable electricity production when capacity exceeds demand. This is a by-product of the successful implementation of wind power to an extent where 40% of electricity is expected to be renewable by 2020. Considering wind power has a capacity factor of ~30%, the installed wind capacity may be of the order of 133% of maximum demand, leading to periods of curtailment. Thus, a method of storing this surplus electricity is crucial.

Where electricity storage is challenging and current infrastructure does not support long-term management of this problem, the P2G process converts the energy vector from electricity to gas (methane) which can be injected into the grid. This is achieved through electrolysis, powered by electricity, to produce hydrogen, which is then combined with CO_2 to produce Green Gas, creating a carbon neutral gas.

The synergies of P2G processes with existing energy systems offer significant advantages. First, P2G offers an alternative storage solution for electricity and has significant capacity to balance and facilitate high levels of variable renewable electricity. Second, the use of CO_2 present in biogas and synthetic gas presents an opportunity for offsetting the costs for traditional upgrading units for AD and gasification facilities, greatly increasing the potential methane output from a digester or gasifier. Third, O_2 produced in electrolysis can be used to vastly improve the quality and efficiency of gasification derived Green Gas. Although the technology is in its infancy the potential of P2G is significant.

DEMAND DRIVEN GREEN GAS

Beside conversion of surplus electricity to gas, bioenergy systems can facilitate periods of low production of electricity through demand driven Green Gas. When for example wind and solar resources are low, intermittent renewable electricity is sparse. Bioenergy can be made dispatchable on demand. For example, stored Green Gas can provide renewable electricity at times of significant electricity demand compensating for a shortfall in wind. Green Gas plants can also be fed intermittently leading to a ramp up in Green Gas supply. Thus there are two instruments to facilitate intermittent renewable electricity: Power to gas when electricity demand is less than power supply; and demand driven Green Gas when electricity demand is greater than intermittent renewable electricity supply.

Green Gas Roadmaps

Renewable "Green Gas" can play a vital role in contributing to the heat and transport sectors in both the short and long term. Six European gas grids have committed to supply 100% Green Gas by 2050. Gas Networks Ireland have concluded that up to 20% of natural gas demand could be met by Green Gas from existing sources if market barriers were removed. A roadmap for Green Gas in Ireland will originate with existing mature technologies such as AD. It is then expected that gasification-methanation, algal biogas, and power-to-gas technologies will develop sequentially eventually leading to 100% substitution of natural gas. Green Gas is a facilitator of intermittent renewable electricity and an excellent vector for renewable heat and renewable transport fuel. **Green Gas represents a low carbon energy pathway that can support future energy security for Ireland.**

The MaREI Centre is a world leader in Green Gas research. Our research facilitates the development of roadmaps that define how Ireland can initiate a Green Gas industry, which would contribute to meeting mandatory renewable energy targets for renewable heat and transport fuel.

The Bioenergy research group investigates a range of digestion applications at lab scale for innovative technologies such as P2G, demand driven biogas, and novel biogas upgrading technologies. Fundamental and applied aspects of biomass gasification, pyrolysis, combustion and methanation are also investigated.

MaREI's collaborations with industrial partners, such as Gas Networks Ireland who fund work related to the production and grid injection of Green Gas, strengthen the expertise on bioenergy and energy systems with mutual knowledge transfer.

In 2016 MaREI researchers published 23 peer reviewed journal papers and previously authored a number of International Energy Agency Reports on Green Gas including: Energy from Crop Digestion (2011); A perspective on the role of biogas in Smart Energy Grids (2014); A perspective on algal biogas (2015); and the 2016 State of Technology Review – Algae Bioenergy.

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