CARBON ASSESSMENT

Enfield Farm AD Facility

Prepared for: **Gorst Energy Ltd**

Client Ref: 06679

SLR Ref: 416.06679.00006
Version No: FINAL
August 2021

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1.1 Introduction

A carbon footprint represents the total quantity of greenhouse gases emitted to atmosphere associated with an economic activity.

Greenhouse gas refers to those gaseous compounds that are known to contribute to the warming of the atmosphere, the so called 'global warming' effect. The most common greenhouse gas is carbon dioxide (CO_2) however other species, primarily methane (CH_4) and nitrous oxide (N_2O), can be equally significant in waste management[1].

Methane is formed by the biological reaction of carbon under anaerobic conditions and is most commonly associated with landfill gas emissions. Nitrous oxide (N_2O) is formed by the biological breakdown of nitrogen containing material and is therefore closely associated with composting processes. To a lesser extent nitrous oxide may also be formed in combustion processes. Nitrous oxide is distinct from other oxides of nitrogen such as nitric oxide (NO) and nitrogen dioxide (NO_2) which are formed in combustion processes but do not contribute to global warming.

The degree to which a greenhouse gas contributes to global warming is measured by its Global Warming Potential (GWP). This is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is, by definition, 1)[2]. A GWP is calculated over a specific time interval and the value of this must be stated whenever a GWP is quoted or else the value is meaningless. Life cycle analysis convention dictates that the GWP is commonly measured over a 100-year timespan and considers abiotic (manmade) sources only; results are therefore reported as GWP100a.

The carbon footprint is expressed in the form of mass carbon dioxide equivalency (CO_2e or CO_2eq), a concept that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential, when measured over a specified timescale. The carbon dioxide equivalency for a gas is obtained by multiplying together the mass and the GWP of the gas.

1.2 Biogenic and Fossil Carbon

Fuels derived from waste, contain both biogenic and non-biogenic (fossil carbon), both of which are released to atmosphere during combustion. Fossil fuels, on combustion, release carbon that has been locked up in the ground for millions of years, while converting biomass to energy emits carbon that is part of the biogenic carbon cycle.

In other words, fossil fuel use increases the total amount of carbon in the biosphere-atmosphere system, while bioenergy systems operate within this system.

Consequently use of biogas either for power generation or as replacement for natural gas in heating systems simply returns to the atmosphere the carbon that was absorbed as the plants grew.

With the exception of material and energy inputs which may derive from fossil fuel sources, the growing of biomass to feed an anaerobic digestion (AD) plant to produce biogas, which is then converted to power or heat and digestate which is used to provide nutrients to the growing biomass is the ultimate example of a net zero carbon system. Further benefits can be derived from treating wastes that would other wise be disposed of to landfill albeit this is not the case at Enfield Farm AD facility.

[1] The latter species should not be confused with nitric oxide and nitrogen dioxide, both commonly referred to as NOx, and which play no part in global warming but, instead, are powerful contributors to acid rain.
[2] The GWP for methane and nitrous oxide is 25 and 298 respectively.

1.3 Methodology

Carbon Footprints are evaluated on a lifecycle basis comprising the following elements:

- **Direct Burdens –** defined as emissions from the process itself, for example carbon dioxide as result of a consequence of combustion or methane from anaerobic degradation;
- **Indirect Burdens –** associated with the supply of energy and materials to the process, for example construction materials, electrical energy for motors and fans, and chemicals for pollution abatement equipment; and
- **Avoided Burdens –** associated with the recovery of energy and materials from the waste stream resulting in the avoidance of primary energy production and mineral extraction.

Each quarter Gorst Energy is required to submit to the Government an evaluation of the carbon footprint of the gas generated from the biogas plant. Reporting is carried out using the Biomethane AD and Heat Calculator Tool (Carbon Tool) which has been developed by Ricardo Energy & Environment to assist biogas facilities, like Enfield Farm AD, to satisfy RHI sustainability reporting requirements.

The model works on the basis of life cycle principles and for each different feedstock type provides an evaluation of the lifecycle carbon impacts associated with converting crops and animal manures/slurry to biomethane including growing, harvesting, biogas generation and upgrading steps.

The data is presented to below to illustrate the overall carbon footprint of the AD process.

1.4 What is included in an AD carbon footprint?

As described above, the carbon footprint is made up of a number of direct, indirect and avoided burdens which, for an AD plant, incorporate the following:

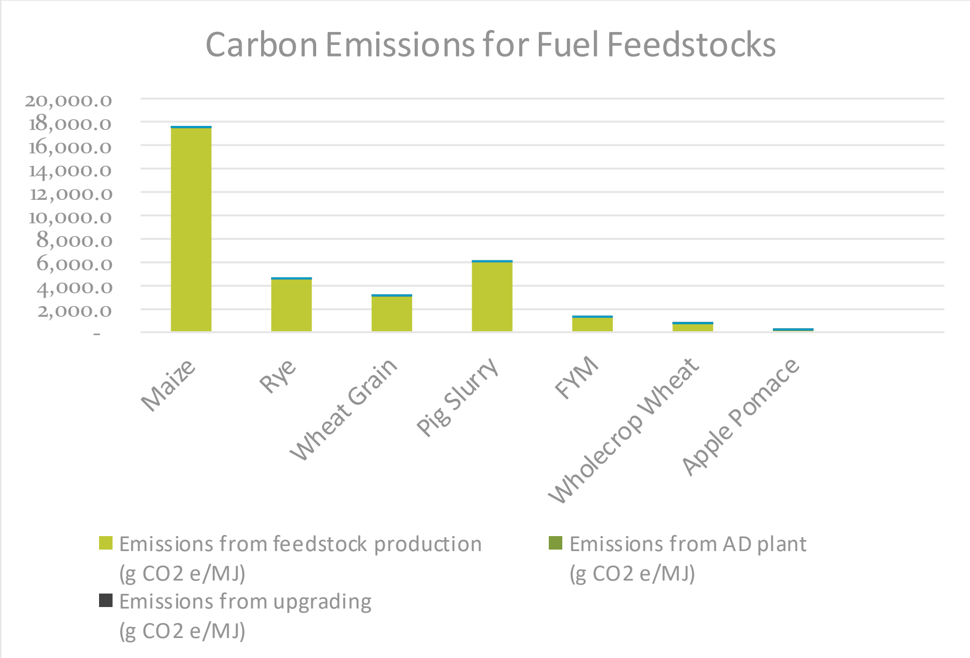
Burden Category	Type of Burden	Consideration	Carbon Tool reference
Direct	Emissions from the AD plant	The process will release very small amounts of methane to atmosphere normally referred to as fugitive emissions through pressure relief valves and flaring	AD plant
	Emissions from vehicles	Combustion of fuel in mobile machinery on the AD plant produces carbon dioxide	AD plant
	Emissions from feedstock cultivation and harvesting	Combustion of fuel in tractors mobile machinery produces carbon dioxide	Feedstock
	Onsite electricity generation	Where the CHP plant uses biogas the carbon emissions are classified as biogenic and not included.	AD plant
	Transport emissions	From the transportation of feedstocks to the plant and residues to final destinations	Feedstock

	Emissions from upgrading	The process will release very small amounts of methane to atmosphere normally referred to as fugitive emissions	Upgrading
Indirect Burdens	Supply of consumables	Chemical consumables as well as fuel all exhibit their own carbon impact which is accounted for in the carbon footprint	AD plant
	Supply of electricity	Unless the plant uses all renewable electricity to operate, any electricity supplied to the plant will have a carbon footprint	AD plant
	Supply of fertiliser	Where the growing of feedstocks includes artificial fertilisers this is included in the footprint.	Feedstock
	Digestate to land	Where digestate is deployed to land for growing crops this is included as an indirect burden.	Feedstock
Avoided Burdens	Injected Biomethane	Biomethane is assumed to displace natural gas and is included as a carbon saving.	Not reported
	Digestate to land	The use of digestate will reduce volumes of artificial fertiliser with a subsequent net carbon benefit	Not reported

The purpose of the Carbon Tool is to report the emissions associated with the production of biomethane against a maximum target carbon figure to secure ongoing renewable energy payments. As such, the savings associated with displacing conventional natural gas are not reported in the carbon tool but are calculated separately below.

1.5 Results

For each feedstock consignment, the Carbon Tool determines the carbon impact at three different stages of the process; emissions from feedstock production, emissions from AD, emissions from biogas upgrading. Results for the specific feedstock consignments are shown below.



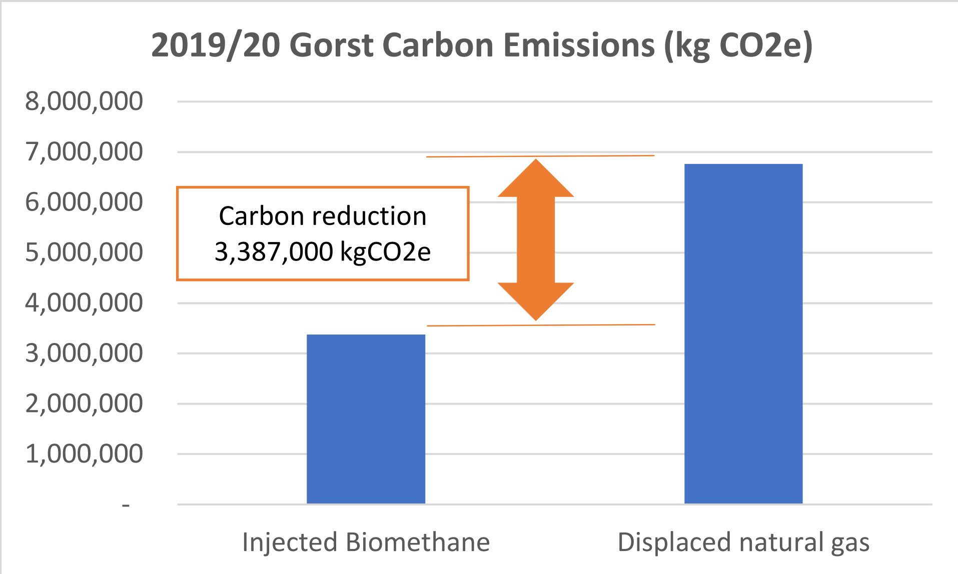
Accounting for the tonnage of each material and the contribution to biogas volumes, the average carbon emission factor is 25.4 gCO2 per MJ.

To determine the overall carbon saving it is necessary to consider the carbon footprint for the fuel being displaced by the injected biomethane i.e. conventional natural gas.

The Department for Business, Energy & Industrial Strategy publish carbon emission factors for company reporting with the most recent figures published in June 2021[3]. For natural gas, the carbon emission factor is 0.18316 kg CO2e per kWh[4] or 50.88 gCO2e per MJ

Between October 2019 and September 2020, Gorst Energy injected 10.26 million MJ of biomethane into the gas network which would have displaced an equal quantity of natural gas as well as nearly 3 million MJ of electricity exported from the site. The carbon benefit associated with this displacement is illustrated below.

[3] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021
[4] Reporting of emission factors is based on gross calorific value / higher heating value



Through operation of the AD plant and injection of biomethane to grid to displace natural gas, Gorst Energy has contributed to a carbon saving of 3,387 tonnes CO2e for the year 2019/20. In 2021/22, assuming the proposed feedstock increase is permitted, annual carbon savings will increase to 6,774 tonnes CO2e per year.

Accounting for a typical 20 year operational life of the AD plant, overall carbon savings of 135,500 tonnes CO2e will be delivered by the AD plant.

1.6 Summary

This carbon assessment has shown that through the production of biogas and injection of biomethane into the distribution grid as a direct replacement for natural gas, Gorst Energy currently delivers carbon savings, annually of 3,387 tonnes CO2e. This figure would be doubled to 6,774 tonnes CO2e per year if the proposed feedstock changes are made.

To put these figures in to perspective, carbon emission calculations conducted by Exeter University to determine Devon's carbon footprint[5] estimate that the management of Exeter's waste emits over 41,000 tonnes CO2e per annum. At 3,387 tonnes CO2e, Gorst Energy delivers a carbon saving equivalent to 8.2% of the carbon emissions associated with managing waste in the City, increasing to 16.4% post expansion. And against Exeter's total carbon footprint, Gorst Energy achieves a 0.62% saving in carbon emissions, increasing to 1.2% post expansion.

[5] https://www.devonclimateemergency.org.uk/studies-and-data/devons-carbon-footprint/

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