



IEA Bioenergy
Technology Collaboration Programme

Case Story

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Towards carbon neutrality in on-farm biomethane production from break crops



Figure 1 Overview of Apsley Farms biomethane plant

Apsley Farms biomethane plant

Apsley Farms, operated by Yelspa Ltd, is a pioneering enterprise located in Hampshire UK which combines traditional practices with innovative technologies to optimise bioenergy production, reduce carbon emissions and enhance sustainability. It is the UK's third-largest biomethane plant, and has been supplying renewable natural gas to the UK gas grid since 2014. It operates one of the world's largest crop-based digesters which, at 89 m long and 9 m deep, holds 18,000 m³ of digestate in an innovative lagoon design.

The size and location of the plant have allowed key decisions to be made on its mode of operation with the goal of moving towards carbon neutral on-farm biomethane production. Through innovation around crop ensilement, pre-hydrolysis, long retention, low downtime and operational resilience, the plant has achieved 385 Nm³ CH₄ per tonne of organic solids, making it one of the most efficient farm-based biomethane and CO₂ facilities in Europe.

Low carbon farming techniques tailored to biogas production

Feedstock is around 90,000 tonnes per year of Maize, Rye, Barley, Oats or Grass grown in rotation on the 465-hectare estate or at local farms. Apsley Farms uses a range of techniques to improve agricultural sustainability, including:

- Minimum tillage and use of cover crops to reduce soil disturbance and carbon emissions
- Effective digestate utilisation to maintain soil health and reduce synthetic fertiliser needs
- Precision farming with real-time control of nutrient addition and monitoring of crop growth through to harvest
- On-field storage and ensiling using the AgBag™ system to reduce crop losses, minimise the size of silage clamps and decrease vehicle movements for transport



Figure 2. 'AgBagging' Crops

DIGESTION PROCESS

A 250 m³ hydrolysis stage is followed by two small and one large circular primary digesters with a combined digestion capacity of 17,000 m³ (Fig. 1). Secondary digestion is in two rectangular digesters with a total capacity of 22,000 m³. The large digesters are lagoon-style structures of the company's own design (Fig. 3) and are mixed and maintained at 44-47 °C. The full system allows retention times of up to 160 days to maximise substrate bioconversion.

Digestate is then separated and a proportion of liquid is returned to the hydrolysis stage to maintain solids content in the preferred range, while avoiding water addition. The nutrient-rich liquid fraction is applied as a fertiliser and the solids are used directly.

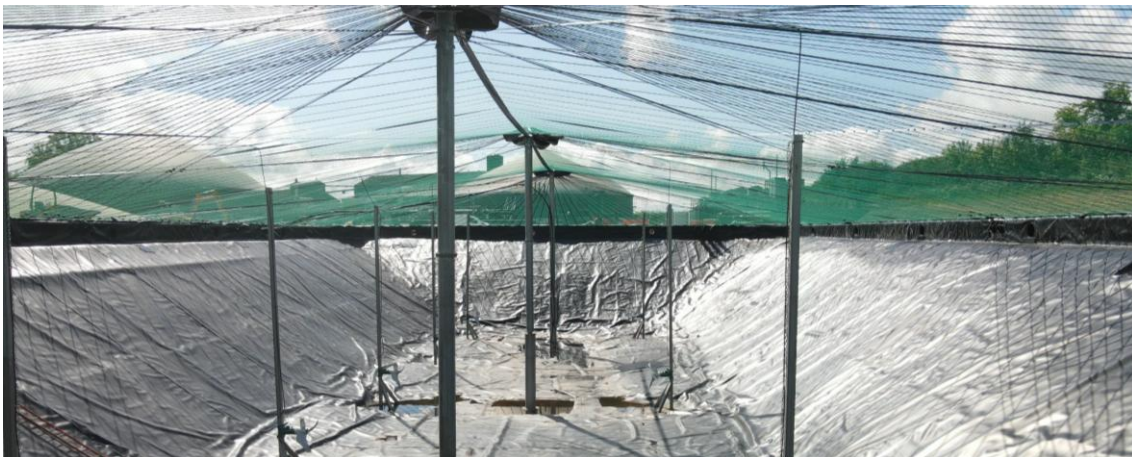


Figure 3. Inside the largest secondary anaerobic digestion lagoon

GAS UTILISATION

About 18% of the biogas is used on site in two Combined Heat and Power (CHP) plants to meet operating needs. Biomethane is then separated from CO₂ and other impurities using a three-stage membrane and vacuum system. The upgraded biomethane is injected to grid on site. The overall energy output of the plant is 6.6 MW_e equivalent, with 1.1 MW of electricity production and 5.5 MW electrical equivalent of biomethane injection.

The separated CO₂ is liquified, with any non-condensable fraction returned to the biogas stream. The CO₂ produced is certified as food grade, with the production process accredited as sustainable under ISO 14001:2015 and ISO 9001:2015. Daily production is around 32 tonnes, with a purity of 99.99%. The company operates its own fleet of tankers to deliver bulk orders, with onsite storage capacity of 150 tonnes. Since 2016 it has supplied over 60,000 tonnes of liquid CO₂ to the UK food and drink industry.

Apsley Farm conducts comprehensive carbon modelling every quarter to monitor and optimise its carbon footprint. Natural gas is still an essential part of the UK's energy economy and while biomethane is being substituted for this as a crucial part of the energy transition, its carbon footprint must be assessed and compared with that for the fossil fuel industry. The biomethane produced has a carbon intensity of around -1 g CO₂/MJ, representing a saving of 100% compared to European heat averages of 87 g CO₂/MJ. Methane slippage, measured by Scienco Ltd, is less than 0.2 percent due to the closed loop in the CO₂ off-gas stream.

Apsley Farms' gas production reduces the UK's CO₂ emissions by around 30,500 tonnes per year. Since the start of production, this has cut over 210,000 tonnes of CO₂ emissions.

Biofertiliser production

Apsley Farms markets a range of sustainable horticultural products based on by-products of the digestion process. Solid digestate is sold as Mulch, a peat-free soil improver, or after maturation as a top dressing or in a pre-prepared topsoil mix, and can be delivered free within a 50 km radius. Liquids are primarily sold for agricultural use as a natural fertiliser, displacing imported synthetic products. Both solid and liquid products have UK Soil Association approval for use in organic farming (Licence no. AL272287) and have been independently tested for benefits to plant growth.

Table 1 Laboratory results for digestate analyses (fresh weight basis)

Parameter	Units	Solid digestate	Liquid digestate
Oven Dry Matter	%	27.1	7.9
Total Nitrogen	g/kg	6.29	6.4
Ammonium Nitrogen	g/kg	2.42	2.89
Nitrate Nitrogen	g/kg	<0.01	<0.01
Total Phosphorus (P)	g/kg	2.67	2.01
Total Potassium (K)	g/kg	7.32	7.98
Total Magnesium (Mg)	g/kg	1.06	0.56
Total Sulphur (S)	g/kg	1.52	1.26
Total Copper (Cu)	g/kg	<0.01	<0.01
Total Zinc (Zn)	g/kg	<0.01	<0.01
Total Sodium (Na)	g/kg	0.13	0.11
Total Calcium (Ca)	g/kg	1.47	1.75

Other benefits

Apsley Farms employs around 60 local staff in its Farming, Engineering, Electrical & Programming, Maintenance, Haulage, Mulch, Accounts and Marketing teams. It contributes to the local economy by providing farmers with a guaranteed market for targeted break crops, allowing them to maintain beneficial crop rotations.

For the past eight years the company has sold green gas certificates to end-users and to traders across the UK and Europe, supporting the growth of a market for certified renewable biomethane. It currently produces green gas certificates for around 100 GWh per year and for the past three years has held accreditation from the Deutsche Energie-Agentur. Apsley Farms also offers a commercial CO₂ analysis and certification service using its onsite laboratory testing facilities.



Figure 4. CO₂ and Mulch products

FUTURE PLANS

The model adopted by Apsley Farms is based on the UK's Renewable Heat Incentive (RHI) which offers support for a range of renewable heat outputs including those based on biomass, biomethane and CHP. The current RHI subsidy is expected to end in 2035, and the company is actively exploring options for long-term financial and environmental sustainability, including:

- expansion of biomethane and CO₂ production, and capture of CO₂ from the CHP engines. A dry-ice facility is also being developed as another revenue stream.
- exploring hydrogen (H₂) production from biological sources or electrolysis, and/or biogas upgrading through electrolytic H₂ production and biological CO₂ conversion
- development of value-added bio-based products from digestate or the digestion process
- enhanced data analytics and machine learning to optimise process control

The company would also like to integrate other renewable energy technologies (e.g. solar, wind) to further reduce its carbon footprint and ensure a viable and sustainable future.

Contact of case story

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Further information on IEA Bioenergy and IEA Bioenergy Task 37

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