Value4Farm

Case study collection:

Biogas

Anaerobic digestion is the breakdown of organic matter in an oxygen free environment. In a controlled environment (e.g. an anaerobic digestor - AD) this process can use a range of organic wates (such as crop residues and livestock waste) to produce biogas and nutrient rich digestate. The biogas can be used, within a combined heat and power unit (CHP), to produce heat and electricity or further refined to produce biomethane which can be used as an alternative to natural gas. The digestate (which can be solid or liquid) can be used as fertiliser or soil improver.

This collection of case studies explores biogas production on farms across Europe and is part of a Decision Support Tool (DST) aimed at farmers and their advisors to explore whether there is potential to integrate food and energy on their farm, particularly through agrivoltaics and biogas

The DST contains three main parts:

- An Open Access (free) Online Course “Integrating Food and Energy Production on Farmland” introducing the technologies and concepts behind renewable energy generation on farmland
- An Audit Tool - to evaluate the current environmental, social, economic, technical and governance situation of a farm and thus to support farmers and their advisors in deciding which path to follow if they are considering producing renewable energy via biogas or agrivoltaics.

- A Transition Tool – a collection of checklists, case studies and a partial budgeting tool for farmers and advisors who want to introduce agrivoltaics, biogas or both on their farm. It outlines the factors that need to be considered when introducing these technologies and provides links to supporting information and resources.

Find all these at *https://value4farm.eu/decision-support-platform/*

The case studies have been developed from published research and discussions with farmers and researchers. Links to further information are available for each case study.

Case studies:

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Biomethane from crop residues in the UK

Location:	Icknield Farm, Oxfordshire, UK Average regional monthly temperatures: 2°C to 21°C Average regional monthly rainfall: 34 mm - 57mm
Type of study:	Case study of practice (plant running since 2015) of a large scale anaerobic digester and biomethanation plant.
Type and set-up of plant:	The plant was built and is run in partnership with a renewable energy company and contains: • Two digester tanks (28m diameter) • Storage bags for the residue digestate • Combined Heat and Power (CHP) unit • Gas clean-up equipment • Three silage clamps for feedstock storage and preservation   Energy produced: • Biomethane, fed into the national gas network • Biogas, used in the CHP to generate heat and electricity for the anaerobic digester Feedstock used: • Silage - maize and rye • Some cereals – may be lower grade or distressed / diseased crops • Annually, 28,000 tonnes of locally sourced mixed feedstock (some from neighbouring farms) Feedstock is solely farm products. Food, domestic or industrial waste feedstocks have a more complicated preparation process (including pasteurisation and pre-sorting), different environmental licences, and a different route through local planning processes. Farmland utilised: Around 2600 / 2800 hectares
Crops grown on the farm:	Arable crops, mainly maize and rye. Varied rotations of food and feed crops, a typical rotation could be maize > wheat > possibly 2nd wheat crop > rye > maize. Other crops (grown in small amounts) include white straw crops, peas, beans, and poppies.

Impact on crops:	Using digestate as fertiliser has had a positive impact on crops. Changing rotations on the farm has also brought benefits with the maize and rye supporting weed control and providing a break crop.
Sustainability benefits:	Using digestate as fertiliser has reduced the amount of chemical fertiliser used on the farm from 1000 tonnes to around 220 tonnes per year. This reduces CO_2 emissions from fertiliser production and transport.  Digestate Changed crop rotations are improving the farm soils and greenhouse gas (GHG) emissions have reduced as methane is captured during the anaerobic digestion process. Financial sustainability for the farm is also improved. Producing, and selling, biomethane from crop residues has diversified farm income streams and increased farm revenue.
Energy generation:	The plant produces approximately 5.6 million m^3 biomethane per year. This is approximately the annual gas consumption of 5300 homes in the UK. The biomethane is injected into the national gas network close to the plant site. A small amount of the biogas produced is used to power a CHP unit which supplies heat and power to the plant.
Challenges:	The farm is located in the *Chilterns National Landscape* (a protected region in the UK) and impacts on the landscape have to be minimised. The site for the plant was selected, and the digesters buried 4m deep, to reduce the visual impact on the landscape.  Digesters Photo credits: University of Reading

Challenges (continued):	Planning issues with local government and the local community could have been a challenge, however, local government was keen to increase green energy production and reduce carbon emissions in the region and were positive about the proposed plant. Working with local and neighbouring communities through a series of local open meetings led to a positive reception to the plant. There were some initial issues with the functioning of the plant, for example maintenance problems and small part failures, these were rapidly dealt with by the company working in partnership to run and maintain the plant. The plant reached full running capacity approximately six months after installation and its' expected lifespan is around 20 years.
Clickable links:	This case study was adapted from an interview with farmer Guy Hildred and *information on the Icknield Farm website*. You can hear more from Guy in series of films in the free online course *Integrating food and energy production on farmland*.

Biogas from Food Waste in the UK

Location:	Bygrave Lodge Farm, Hertfordshire, UK Average regional monthly temperatures: 2°C to 21°C Average regional monthly rainfall: 30mm - 50mm
Type of study:	In production – case study of practice, plant opened in 2015. The farm leases land to an environmental waste company who operate and maintain the plant and supply the farm with digestate from the biogas production process which is used as fertiliser
Type and set-up of plant:	Plant is set up and run by *BioGen* (an organic waste management company) on land which is rented from the farm and has anaerobic digesters, storage (for feedstock and digestate) and two CHP units.  Feedstock: 45,000 tonnes food waste per year. The waste is a mixture of domestic, food industry, retailer and hospitality waste. Energy produced: The plant produces biogas, used in the CHP to generate electricity which is fed into the national grid.
Crops grown on the farm:	Arable
Impact on crops:	The digestate has had a positive impact on crops, the image below shows the contrast between crops where digestate has been applied (right) and has not been applied (left). 

Sustainability benefits:	Less fertiliser buy-in as the digestate supplies the farms fertiliser needs. Food waste is not sent to landfill, methane is captured and greenhouse gas (GHG) emissions are reduced, and as the digestate is used on-farm (on nearby fields), transport needs and CO_2 emissions are reduced.  Digestate application on farm Photo credits: Tom Macfarlane
Energy generation:	Electricity, which is fed into the national grid. The plant provides energy for approximately 4500 homes in the UK. Around 10% of the electricity generated is used to power the plant. Long term, the aim is to produce gas to be imported directly into the national gas network.
Challenges:	Due to the size of the plant and type of feedstock, a range of environmental risk assessments had to be undertaken, (for example *Environment permitting decision document*). As the digestate was produced from food waste and not crop residues, it required certification before it could be used on the farm (for example *BSI PAS 110: Producing Quality Anaerobic Digestate*) Connecting to the national gas network and supplying biomethane was not cost effective at the time so it was decided to use the biogas produced to generate electricity on site, which is exported into the national electricity grid. However, the long-term goal for the plant is to produce gas to be imported directly into the national gas network.
Clickable link:	*Biogen Food Waste Management*

Biogas at the Inagro research and demonstration site in Belgium

Location:	Flanders, Belgium Average regional monthly temperatures: 2°C to 22°C Average regional monthly rainfall: 31mm - 56mm
Type of study:	Case study of practice, plant started operation in 2007 Research / test facility
Type and set-up of AD:	Pocket digester – small scale digester (200 m^3 reactor volume) with 31kWel CHP (Combined Heat and Power unit)  Feedstock used –plant based feedstock, maize silage, combined with crop residues from the site, including, potatoes, tomato waste, chicory residues, parsnip The biogas plant was fully renovated in 2023 and is now a 'plug-and-play' biogas installation. Pre- and post-treatment technologies for biomass, biogas and digestate can be easily implemented and tested for research projects or in collaboration with industrial partners.
Crops grown on the farm:	The farm is a research and test facility and grows a range of crops in varied facilities including: • 35 ha arable, forage and vegetable crop field trails (16ha in organic production) including brassicas, leek, carrot, spinach, courgette, peas, beans • Greenhouses for e.g. leafy vegetables and strawberries • High tech facilities for mushrooms and chicory / endives
Impact on crops:	Digestate used on the fields as fertiliser supporting crop production and showcasing a circular farming system Crop residues that are otherwise not valorised are used for renewable energy production

Sustainability benefits:	Many of the benefits are in demonstrating the impact of anaerobic digestion and biogas production in small scale digesters to farmers. Research into optimal feedstocks and feedstock combinations and digester are also valuable to farmers. Using digestate reduces the need for chemical based fertilisers, and field trials have demonstrated its value on crop production. Economic benefits include testing different feedstocks and combinations of feedstock to show which are the most profitable, and the CHP unit provides the site with heat and electricity, reducing electricity buy-in.
Energy generation:	Around 180 MWh or electricity per year, some of the electricity is used by the biogas plant (e.g. for pumping and mixing), most of the electricity generated is used on site.  Photo credits: Inagro Some of the heat is used to maintain the temperature in the reactor (52 °C), most of the heat is used in the greenhouses and aquaculture department
Challenges:	As Inagro is a research site, making a profit from the anaerobic digester is not a priority. With this comes the opportunity to test a range of different feedstocks and make adjustments to the digester to give optimal outputs. This means the payback period is substantially longer than a commercial operation / business.
Clickable links:	• Adapted from a collection of case studies produced by Inagro, available at *pocketvergisting-praktijkvoorbeelden.pdf* (in Dutch) • *Inagro research and demo platform on anaerobic digestion* • *Contact Inagro*

Biogas in Italy

Location:	Ferrara Farm, Po Valley, Italy Average regional monthly temperatures: -1°C to30°C Average regional monthly rainfall: 36mm - 88mm
Type of study:	In production – case study of practice.
Type and set-up of plant:	Size of plant: 1MWe plant, produces 8.5 GWh electricity per year Feedstock used: crop residues from the farm (e.g. cover crops), livestock waste from the farm and neighbouring farms Size of farm: 320 hectares and dairy stable with herd of 150 cows  Photo credit: Biogasdoneright®
Crops grown on the farm:	Soybean, Alfalfa, Maize, Wheat, Sorghum, Triticale Mix of food and silage crops
Impact on crops:	Using digestate has improved soil fertility and crop yields have increased by 10 – 15%. Farm soils have benefited from the adoption of no-tillage for seeding, which supports soil moisture retention, and digestate is spread through an umbilical distribution system, reducing soil compaction from agricultural machinery. Cropping system changes and using crop residues and cover crops for biogas production mean that land use for food growing was reduced by only 10 hectares.

Sustainability benefits:	Use of digestate as a fertiliser has reduced the need for chemical fertilisers. Changing crop rotations has led to increased biodiversity. Rotations now use 7 crops (up from 4), with nitrogen fixing crops grown over more land. Soil coverage on the farm is now almost continuous over the year and leaching and run-off is reduced. Economic sustainability is also improved. Straw needed for livestock is now produced on-farm and not bought in and digestate covers most of the fertiliser needs of the farm, reducing the need for buying-in fertilisers. Other local farms also benefit financially as livestock waste from neighbouring farms is bought from them for biogas production. There has been a reduction in greenhouse gas emissions, as methane from livestock waste is captured, and soil carbon has increased.
Energy generation:	8.5 GWh electricity per year
Challenges:	Moving from a monoculture on the farm to new rotations and double cropping to increase production and crop residues available for biogas production. Demonstrating how this change supports biogas production while still maintaining food crop production. Finding sources of investment for the equipment needed to support on-farm changes, the farm had previously been unprofitable and finding sources of finance to start process of biogas production took time.
Clickable links:	This case study was originally published in *Biogasdoneright® Anaerobic Digestion and Soil Carbon Sequestration a Sustainable, Low Cost, Reliable and Win Win BECCS Solution* Additional case studies and information about the project is available from *Consorzio Italiano Biogas*.

Biogas in Sicily

Location:	Enna Farm, Enna province, Sicily Average regional monthly temperatures: 6°C to 32°C Average regional monthly rainfall: 3mm - 64mm
Type of study:	Planning and modelling, plant in development.
Type and set-up of plant:	Anaerobic digester producing biogas which is then further refined to biomethane. Feedstock is a mixture of crop residues and livestock waste, including: • Wheat residues • Sorghum • Opuntia • Sainfoin • Olive residues from oil production • Citrus pulp • Grape residues from wine production Size of farm – 550 hectares
Crops grown on the farm:	Durum wheat, in rotation with sainfoin (a nitrogen fixing, drought resistant species, native to the Mediterranean, often used for livestock silage) and sorghum. Opuntia may be grown in an arboriculture set-up for prickly pear fruit.  Image to the left shows sainfoin, to the right is opuntia Photo credit: Biogasdoneright®
Impact on crops:	Use of digestate as fertiliser to improve soil organic matter. Rotations of cereal crops with sainfoin means the land is in constant cultivation and soils are not left bare, reducing the risk of desertification. Sainfoin is a nitrogen fixer, planting it in rotation with durum wheat helps to maintain wheat grain protein levels and a second harvest of sorghum can be implemented

Sustainability benefits:	A reduced local livestock industry means the need for sainfoin silage has also reduced. This can lead to land being left in set-aside and accelerate the desertification process. Using the sainfoin as biogas feedstock means rotations are maintained, soil nitrogen is improved and there are no bare soils, reducing soil and moisture losses. Use of digestate as fertiliser has increased soil organic matter inputs, soil carbon content, and significantly reduced the need for chemical fertilisers on the farm. Residues from olive oil production, grapes and citrus pulp can cause pollution issues if not treated correctly. Using them as feedstock for biogas production reduces the risk of pollution. Economically, the farm has diversified income streams and reduced spending on fertilisers, making it more economically sustainable
Energy generation:	800-900 Nm^3/h of biogas, refined further to produce approximately 2.8 million kg of biomethane.
Challenges:	Financial status of the farm, previously it was unable to survive economically without CAP subsidies. Dry, poor soils and increasing desertification of soils due to land set-aside and loss of nitrogen fixing cover crops.
Clickable links:	This case study was originally published in *Biogasdoneright® Anaerobic Digestion and Soil Carbon Sequestration a Sustainable, Low Cost, Reliable and Win Win BECCS Solution* Additional case studies and information about the project is available from *Consorzio Italiano Biogas*