UNIVERSITY OF EXETER | ENVIRONMENT AND SUSTAINABILITY INSTITUTE

Think Tank and showcase: Research and innovation for net zero agriculture

exeter.ac.uk/**esi**

Working with natural systems for sustainable futures

Agenda

09.30	Coffee in the ESI	
10.00	Welcome	Professor Jane Wills, Director of the ESI
10.05	Introduction to Innovate UK's plans for research and innovation funding in net zero agriculture	Dr Chris Lyons (online)
10.15	Introduction to Bennamann Ltd incorporating a short introduction to the work of the International Fugitive Emissions Abatement Association (IFEAA)	Dr Chris Mann, Dr Penny Atkins
10.30	Integrating renewable energy in the Bennamann project	Professor Tapas Mallick, Dr Katie Shanks
10.40	Short response 1: Biomethane and digester microbiomes	Dr Richard Tennant
10.45	Short response 2: Biomethane and transportation	Professor Prathyush Menon (online)
10.50	Open debate, comfort break and coffee refills	
11.15	A paradigm shift in our understanding of soil carbon dynamics and potential implications for soil management	Professor Iain Hartley
11.25	Measuring and managing carbon on farm	Dr Hannah Jones
11.35	Thinking about animal feed	Professor Richard Titball
11.45	Open debate: emerging research and action agendas	
12.30	Lunch	
13.30	Bennamann site visit (for 20 pre-booked guests only)	Transport as pre-booked

UNIVERSITY OF EXETER | ENVIRONMENT AND SUSTAINABILITY INSTITUTE

Welcome

Prof Jane Wills, ESI Director

exeter.ac.uk/**esi**

Working with natural systems for sustainable futures

Think tank and showcase: Research and innovation for net zero agriculture

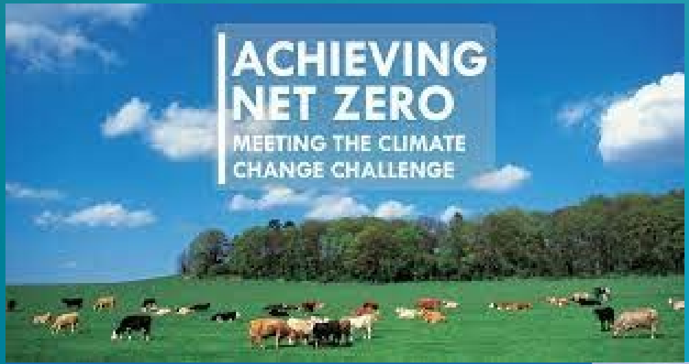
G7 – remember that – June 2021?!

Cornwall leading the way …

"As the eyes of the world look to Cornwall this week, not only will they see an area of outstanding beauty, they will witness a region that is innovative, exciting and looking firmly towards a bright future.

The exciting projects [investing in nature recovery] we have announced today are a fitting legacy for a region playing host to some of the most important diplomatic talks in a generation. As the world builds back better from coronavirus, Cornwall will lead the way."

Research and innovation for net zero agriculture in the context of change



Our ambitions for this event

Showcase innovation in farming beyond the usual focus, exploring:

- Bennamann's pioneering work in methane capture, storage, processing and deployment (critical for GHG/off grid livestock farming);
- The microbiology and ecology of slurry and soils and the potential to work with (long overlooked) natural organisms for positive change in yields and the environment;
- New sources of animal feed that can reduce GHG emissions, improve animal welfare and productivity.

Our ambitions for this event

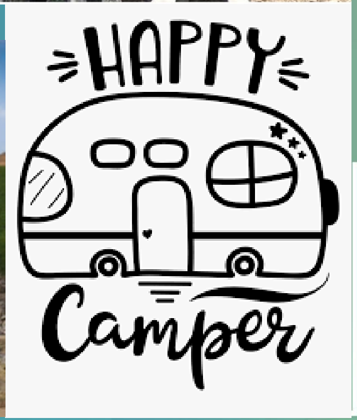
To think - more deeply about the arguments for a win/win/win.

To share - information, ideas and connections.

To find out – the power of research.

To contribute - to our region and community.

…. and to stick to time!



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Dr Chris Lyons

Agritech team, Innovate UK

Introduction to Innovate UK’s plans for research and innovation funding in net zero agriculture

Frontiers in Net Zero Farming

- Research and Innovation Funding in Net-Zero Agriculture

24.6.22

Chris Lyons
Innovation Lead for Agriculture, Innovate UK
chris.lyons@iuk.ukri.org

UK Research and Innovation

We work with the government to invest over £7 billion a year in research and innovation by partnering with academia and industry to make the impossible, possible. Through the UK's nine leading academic and industrial funding councils, we create **knowledge with impact**.

UK Research and Innovation

Topics

- Current Open / Soon to open Innovate UK programs
- International focus
- Farming Innovation Program
- How to keep updated

Innovate UK

Open Funding

Innovate UK Smart Grants: April 2022

UK registered organisations can apply for a share of up to £25 million for game-changing and commercially viable R&D innovation that can significantly impact the UK economy. This funding is from Innovate UK, part of UK Research and Innovation.

Eligibility

This competition is open to single applicants and collaborations.

To lead a project your organisation must:

- be a UK registered business of any size or a UK registered research and technology organisation (RTO)
- be or involve at least one micro, small or medium-sized enterprise (SME)
- carry out all your research and development (R&D) project activity in the UK
- intend to commercially exploit the project results from the UK

Opened:
25 April 2022
Closes:
27 July 2022

Innovate UK

Soon to Open Funding

Fast Start: Innovation

UK registered small and micro businesses can apply for a share of up to £30 million for affordable, adoptable and investable innovations in net zero and Healthcare.

Eligibility

This competition is open to single applicants only.

To lead a project your organisation must:

- be a UK registered micro or small business
- not have previously been awarded funding from Innovate UK
- carry out its project work in the UK
- intend to deliver the proposed outcomes from the UK for domestic or global benefit

Opens:11 July 2022
Closes:26 July 2022

SBRI: MRV tools and techniques for land based greenhouse gas removal, phase 1

Organisations can apply for a share of £375,000, inclusive of VAT, to develop tools, technologies and techniques to assist and enable the monitoring, reporting and verification (MRV) of land-based greenhouse gas removal (GGR) methods.

Eligibility

To lead a project, you can:

- be an organisation of any size
- work alone or with other organisations as subcontractors

Contracts will be awarded to a single legal entity only.

Opens: 27 June 2022
Closes: 7 September 2022

UKRI Innovate UK

Open Funding

Innovation Loans Future Economy Competition – Round 4

UK registered businesses can apply for loans for innovative projects with strong commercial potential to significantly improve the UK economy.

Eligibility

This competition is open to single SME applicants registered in the UK.

Opened:
9 June 2022
Closes:
13 July 2022

Horizon Europe Guarantee - EIT KICs 2022

This funding route is to deliver the UK Government's Horizon Europe guarantee. Specifically, it covers funding for UK partners involved in EIT-KIC activities in the 2022 calendar year.

Eligibility

UK-based organisations involved in EIT-KIC activities in 2022 who would have received EIT grant funding had the UK been associated to Horizon Europe.

Opened:
23 May 2022
Closes:
No submission deadline

Innovate UK

Global Incubator Programme - Gateway to Asia

Calling agrifood innovators to scale to Asia via Singapore

Ready to scale your business into Asia?

Innovate UK's Global Incubator Programme, delivered in partnership with Innovate UK EDGE, is an acceleration programme for innovative businesses to work with world-leading incubators abroad.

We are currently accepting applications for up to 8 innovative SMEs in the agrifood and innovative food and beverage sectors to join our programme with GROW in Singapore.

The programme will be delivered virtually with opportunities for a physical presence in Singapore in accordance with public health guidelines and upon request.

Why Asia?

The ASEAN region is emerging as a major hub for agrifood and aquaculture innovation and there are significant opportunities for innovative UK businesses to be successful in the areas of advanced agrifood and innovative food solutions.

Asia is expected to be home to 5 billion people by 2050, accounting for 60% of global food consumption. To meet this demand, governments across Southeast Asia are aggressively pursuing strategies to ensure greater food security.

This includes active support for agrifood innovators who can help grow the local ecosystem.

Why work with GROW?

GROW is Southeast Asia's first dedicated agrifood accelerator with an impact focus.

Through their fund and accelerator programs GROW works with businesses to supercharge their growth on the global stage. GROW's portfolio of companies represent industry-leading solutions across the agrifood value chain.

GROW is supported by Enterprise Singapore and backed by leading agrifood VC AgFunder. For more information about GROW visit gogrow.co

Key Dates

- APPLICATIONS CLOSE 1 JULY 2022
- SHORTLIST INTERVIEWS 12 & 13 JULY 2022
- INCUBATION PROGRAMME 1 SEP 2022 – END JAN 2023
- MARKET VISIT W/C 24 OCT 2022
- CONTINUED SUPPORT FROM INNOVATE UK EDGE

UKRI Innovate UK

In partnership with GROW

WHAT TO EXPECT:

- **Connections and network**: 1:1 support and opportunities to engage with GROW's global network of agrifood companies, experts, mentors, and industry partners
- **Group learning insight sessions**
- **Pitching opportunities** - Access to our investor, corporate, and strategic partner networks in Asia
- **Resources** - Variety of trusted professional service providers at discounted rates to help you fast-track your expansion into the region
- **Build a local team** - GROW can support the company with the EntrePass visa application (into Singapore) and help the company establish local presence
- **Community** - Plug into the ASEAN agrifood ecosystem and engage with fellow entrepreneurs and events

WHAT IS THE COST?

Innovate UK and Innovate UK EDGE will cover all initiative and virtual incubation costs and will make a contribution to T&S costs if travel to Singapore is possible. Participating companies will be asked to provide a £1,000 refundable deposit on acceptance to the programme. This will be returned on successful completion of the programme

HOW TO APPLY?

The Global Incubator Programme has a competitive application process where only the best applications will be successful following an evaluation process. Those shortlisted will be interviewed by a panel and finalists will undergo financial eligibility checks. All applications must be made online through the Innovate UK EDGE website and received no later than 23:45 on 1 July 2022. To support potential applicants, a Global Incubator Programme briefing will take place on 7 June 2022. Innovate UK is committed to improving the diversity of who we support. As such we welcome applications from those under-represented in the agrifood sector.

ADDITIONAL INFORMATION & ASSISTANCE:

To fill in the online application form or to register for the briefing event, please visit the Innovate UK EDGE website. We are committed to a policy of equal treatment and opportunity in every aspect of this programme. For more information, assistance with your application, or to discuss accessibility needs, please contact Ian Holmes Ian.Holmes@innovateukedge.ukri.org

TO APPLY FOR THIS PROGRAMME, YOU MUST

- Be a UK based company
- Be a business with fewer than 500 employees
- Be an agrifood or innovative food & beverage business

We welcome applications from agrifood tech and innovative food & beverage businesses involved in (but not limited to) the following areas:

- Controlled environment agriculture
- Sustainable food production systems
- Sustainable packaging & bioplastics
- Plant-based foods
- Alternative proteins
- Functional ingredients
- Food traceability and provenance
- Food waste and circular economy
- Climate smart agritech solutions
- Regenerative agriculture
- Human & animal nutrition
- Aquaculture
- Agriculture inputs & bio fertilisers

Farming Innovation Programme

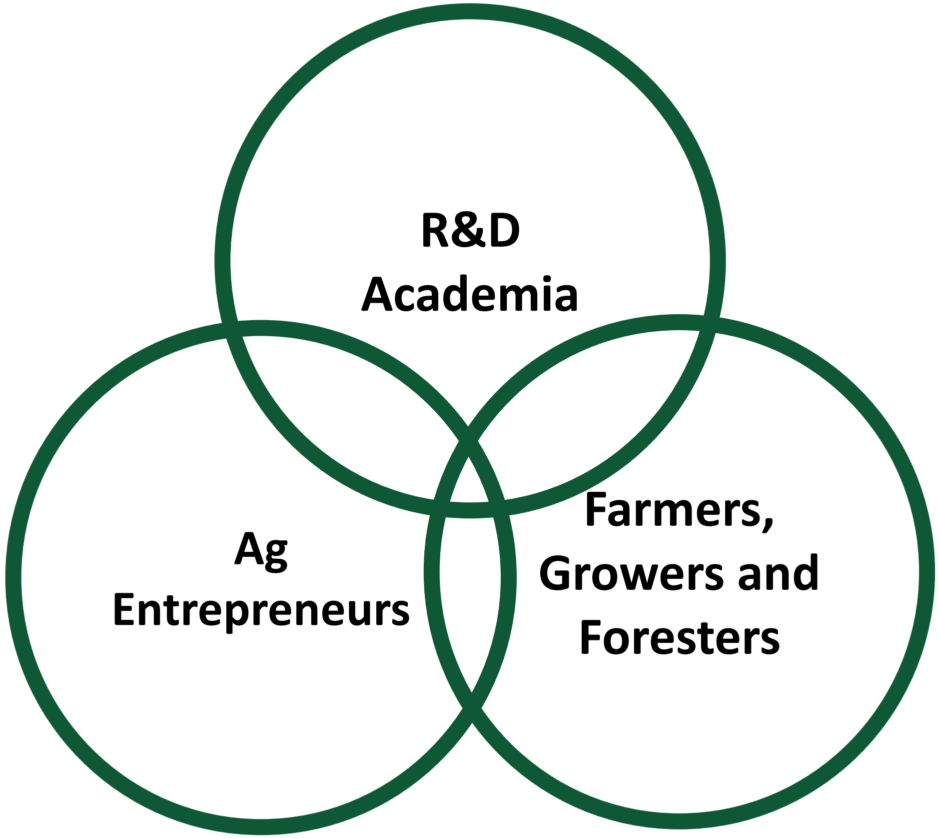
Industry-led R&D Partnership Fund Overview

Farming Innovation Programme

UKRI and **Defra** will deliver in partnership and building on the success of £90m **Transforming Food Production challenge**

Expanding on the partnership for the Farming Innovation Pathways competition launched earlier this year.

Innovation is vital to helping farmers and growers to become more productive, environmentally sustainable and resilient.



Department
for Environment
Food & Rural Affairs

UK Research
and Innovation

Farming Innovation Programme – three funds

INDUSTRY-LED R&D PARTNERSHIP FUND
Connecting groups of farmers, growers, foresters and businesses with researchers for R&D that is responsive to immediate, practical industry needs

FARMING FUTURES R&D FUND
Driving more fundamental R&D into strategic and sector-wide challenges that will improve productivity and enhance environmental outcomes in the long term.

ACCELERATING ADOPTION FUND
Smaller-scale, agile projects to trial the on-farm viability of new technology ideas, processes and practices and boost their adoption by farmers and growers.

Farming Innovation Programme

INDUSTRY-LED R&D PARTNERSHIP FUND

Connecting groups of farmers, growers, foresters and businesses with researchers for R&D that is responsive to immediate, practical industry needs

Fund aims:

- Increasing **productivity** and **environmental sustainability** in the agricultural and horticultural sectors in **England**.

- **Collaboration** between farmers, growers and foresters, and the innovation community **for better R&D agricultural solutions** to benefit the sector as a whole

Department for Environment Food & Rural Affairs

UK Research and Innovation

Industry-led R&D Partnership – three competitions

	What you want to do →	Take a look at
	Explore an idea that could benefit your farm and others	Research Starter
	Check whether an idea works in practice	Feasibility
	Develop a new farming product or service	Small R&D Partnership

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UK Research and Innovation

Explore an idea that could benefit your farm and others → Research Starter Rd 2

Summary

Total budget	Total project costs	Duration
1 Million	£28-56 thousand	Up to 12 months

Lead must be a farming, growing or forestry business of any size **based in England**

Not have been awarded Innovate UK funding as a project lead within the last 5 years

Stage 1 deadline
6th July 2022
11:00 am

Projects to start by 31st March 2023

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Check whether an idea works in practice

→ Feasibility Rd 2

Summary

Total budget	Total project costs	Duration
5.5 Million	£200-500 thousand	Up to 24 months

at least 50% of the farmers, growers or foresters involved, **based in England**

For **UK registered businesses** wishing to **collaborate** with other UK organisations

Dates To Be Confirmed

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Develop a new farming product or service

→ Small R&D Partnership Rd 2

Summary

Total budget	Total project costs	Duration
11 Million	**£1-3** Million	Up to **36 months**

at least 50% of the farmers, growers or foresters involved, **based in England**

For **UK registered businesses** wishing to **collaborate** with other UK organisations

Businesses within a supply chain, are encouraged to come together as a partnership to solve major challenges or opportunities

Dates to be confirmed

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Specific Themes

Address a significant **industry challenge or opportunity** in at least one of the below:

- ✓ livestock
- ✓ plants
- ✓ novel food production systems
- ✓ bioeconomy and agroforestry

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Scope

In Scope

Address major on-farm or immediate post farmgate challenges or opportunities. Solutions **must** significantly **improve:**

- ✓ productivity
- ✓ sustainability and environmental impact
- ✓ progression towards net zero emissions
- ✓ resilience

Out of Scope

- × equine-specific
- × wild caught fisheries
- × cellular or acellular production systems, fermentation systems for bacteria, yeast or fungi
- × projects that **do not include or benefit** farmers, growers or foresters in **England**

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Farming Innovation Programme

You want to	Competition name	Project size	Length (up to)	Who can lead
Explore an idea and develop a team	Research Starter	£28-56K	1 year	UK Businesses
Check if an idea works in practice	Feasibility Studies	£200-500K	2 years	UK Businesses
Develop a new product or service	Small R&D partnerships	£1-3 million	3 years	UK Businesses
	Large R&D partnerships	£3-5 million	4 years	UK Businesses
Work on longer-term innovations	Farming Futures R&D	£3-6 million	4 years	Research organisations or UK businesses

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https:farminginnovation.ukri.org

Farming Innovation Programme

Competition name	Opens	Closes	Status
Large R&D partnerships (round 1)	30 March 2022	29 June 2022	Details available
Research Starter (round 2)	23 May 2022	6 July 2022	Details available
Farming Futures (theme 2: sustainable proteins)	Summer 2022	TBC	Upcoming
Feasibility Studies (round 2)	Autumn 2022	TBC	Upcoming
Small R&D partnerships (round 2)	Autumn 2022	TBC	Upcoming

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https:farminginnovation.ukri.org

Farming Innovation Pathways (FIP) Industrial research and feasibility studies - Winners

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Sector	Project title	Lead	Sub sector	Grant cost(£)
Broadacre	Testing a novel, net-zero, waste-derived treatment for Cabbage Stem Flea Beetle on Oil Seed Rape	Agrigrub Ltd	Combinable Crops	109,439.
Broadacre	Development of an Innovative Agricultural Water Management Platform (Holistic Automated Irrigation Management - HAIM)	Fmec Group Uk Ltd	Combinable Crops	172,411.
Broadacre	Identify innovative solutions for monitoring and forecasting wireworm (Agriotes spp.) in potato crops to improve sustainability for English farmers (DETECT-PEST)	Branston Limited	Tubers & roots	159,454.

Sector	Project title	Lead	Sub sector	Grant cost(£)
Horticulture	Tenderstem Harvest Feasibility Study	Muddy Machines Ltd	Salad crops	159,049.
Horticulture	Recycling coir in a circular economy for horticultural cropping substrates: PEAT-FREE	Microbiotech Ltd	Salad crops	111,643.
Horticulture	Fenland Agro-voltaic Veg Production	F.C Palmer & Sons	Fieldscale vegtables	149,964.
Horticulture	Improving sEed QUality In the Post-plant protection Product Era (EQUIPPE)	A.L.TOZER Limited	Fieldscale vegetables	181,862.

Farming Innovation Pathways (FIP)
Industrial research and feasibility studies – Winners cont.

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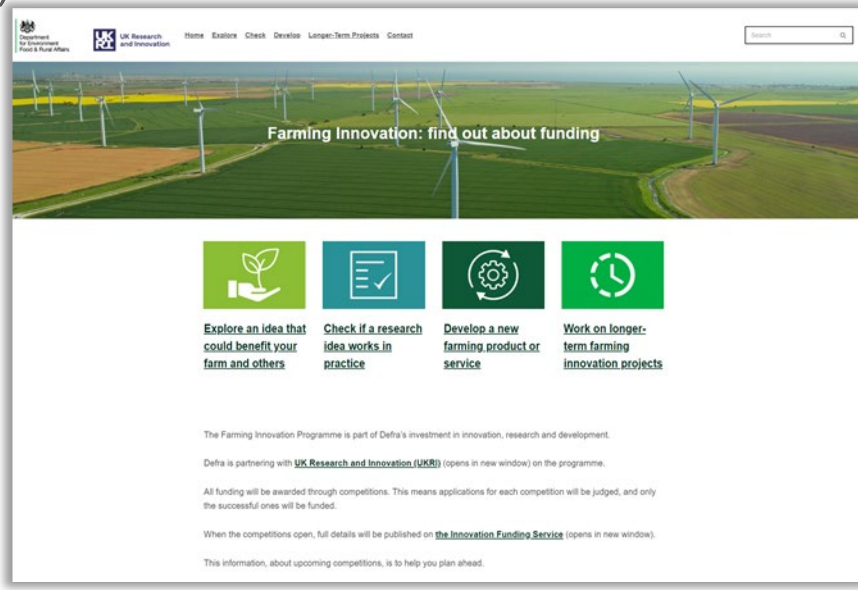
Sector	Project title	Lead	Sub sector	Grant cost(£)
Livestock	SlurryBugs - a novel bacterial approach to mitigating slurry ammonia emissions and enhancing fertiliser value	Envirosystems (UK) Ltd	Ruminant	196,570.
Livestock	Intelligent screening of Mycobacterium avium paratuberculosis (MAP) in dairy cattle	Roboscientific Limited	Ruminant	173,382.
Livestock	Magnetic induction heating method for stun and dispatch of slaughter weight broilers	Inductive Power Projection Ltd	Monogastric	143,178.
Livestock	Direct mRNA detection for early pregnancy diagnosis in cattle	Vetsina Animal Diagnostics Limited	Ruminant	196,956.
Livestock	FlockLight: An automated lighting system for poultry behaviour management	Aviasenze Limited	Monogastric	164,903.
Livestock	Oxi-Tech in situ ozone disinfection for robot milking	Oxi-tech Solutions Limited	Ruminant	170,669.

Contact us

Customer Support Services:

0300 321 4357 (Monday - Friday 9:00am - 11:30am & 2:00pm - 4:30pm)

support@innovateuk.ukri.org



Farming Innovation: Website

www.farminginnovation.ukri.org/

Farming Innovation Programme – research starter pilot - EoI Round 2:

https://apply-for-innovation-funding.service.gov.uk/competition/1158/overview

Large R&D projects:

https://apply-for-innovation-funding.service.gov.uk/competition/1123/overview

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Prof Andrew Atkins, Dr Chris Mann

Bennamann Ltd

Introduction to Bennamann Ltd incorporating a short introduction to the work of the International Fugitive Emissions Abatement Association (IFEAA)

A CALL TO ARMS

International Fugitive Emissions Abatement Association:

‘Creating Practicable Sustainable Solutions to Reduce Human Impact’
By
building a community,
creating knowledge,
demonstrating solutions
and monitoring the impact

Methane - Livestock

Methane - Water Treatment

Methane - Oil and Gas

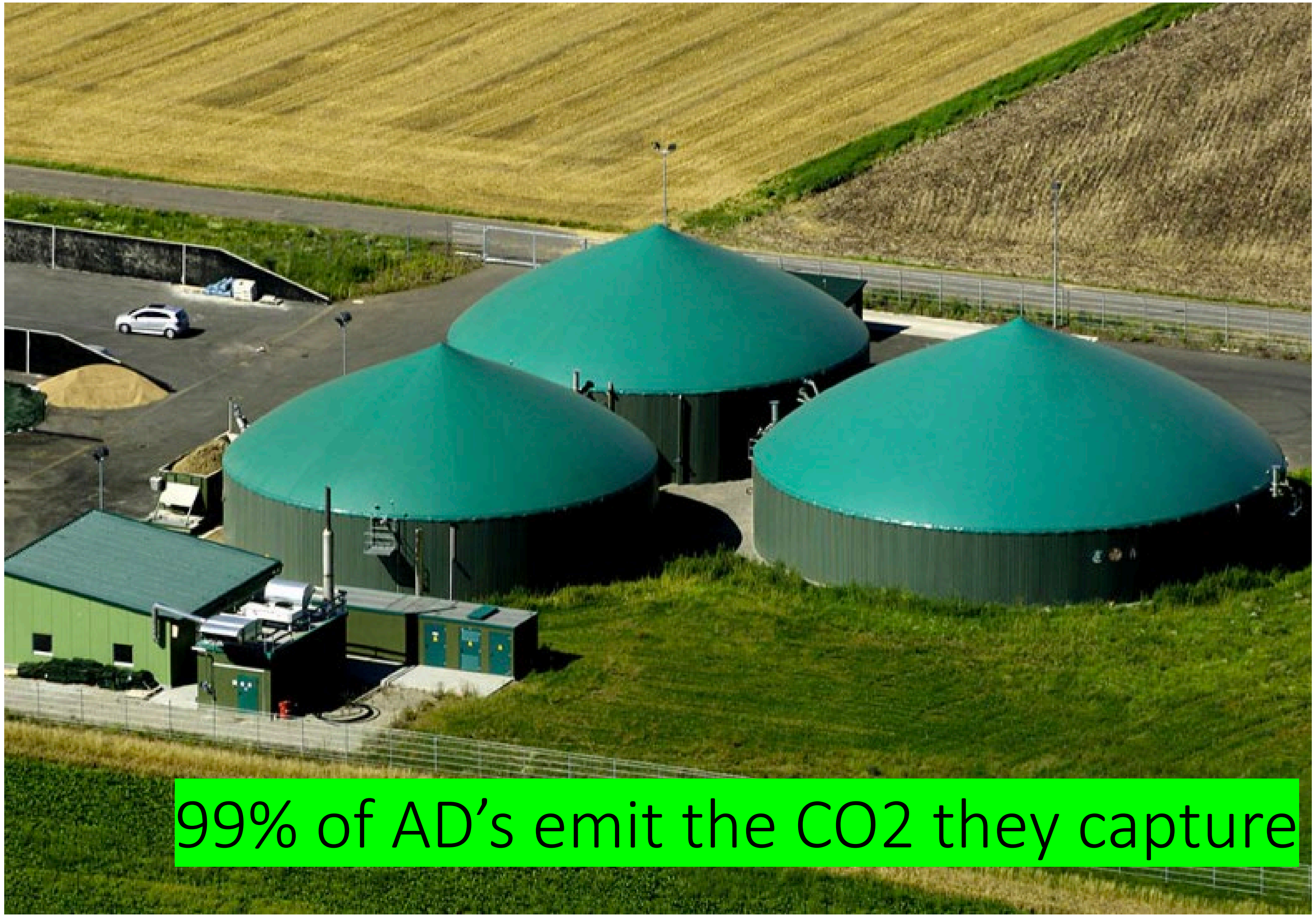
Methane is responsible for nearly 50% of near-term climate change
But its not just methane....

Kyoto gases	Geophysical properties		GWP-weighted share of global GHG emissions in 2010			
	Atmospheric lifetime (year)	Instantaneous forcing ($W/m^2/ppb$)	SAR (Kyoto)	WGI (20 and 100 year from AR5 & 500 year from AR4)		
			100 years	20 years	100 years	500 years
CO_2	various	1.37×10^{-5}	76 %	52 %	73 %	88 %
CH_4	12.4	3.63×10^{-4}	16 %	42 %	20 %	7 %
N_2O	121	3.00×10^{-3}	6.2 %	3.6 %	5.0 %	3.5 %
F-gases:			2.0 %	2.3 %	2.2 %	1.8 %
HFC-134a	13.4	0.16	0.5 %	0.9 %	0.4 %	0.2 %
HFC-23	222	0.18	0.4 %	0.3 %	0.4 %	0.5 %
CF_4	50,000	0.09	0.1 %	0.1 %	0.1 %	0.2 %
SF_6	3,200	0.57	0.3 %	0.2 %	0.3 %	0.5 %
NF_3 *	500	0.20	not applicable	0.0 %	0.0 %	0.0 %
Other F-gases **	various	various	0.7 %	0.9 %	0.8 %	0.4 %

* NF_3 was added for the second commitment period of the Kyoto period, NF_3 is included here but contributes much less than 0.1 %.

** Other HFCs, PFCs and SF_6 included in the Kyoto Protocol's first commitment period. For more details see the Glossary (Annex I).

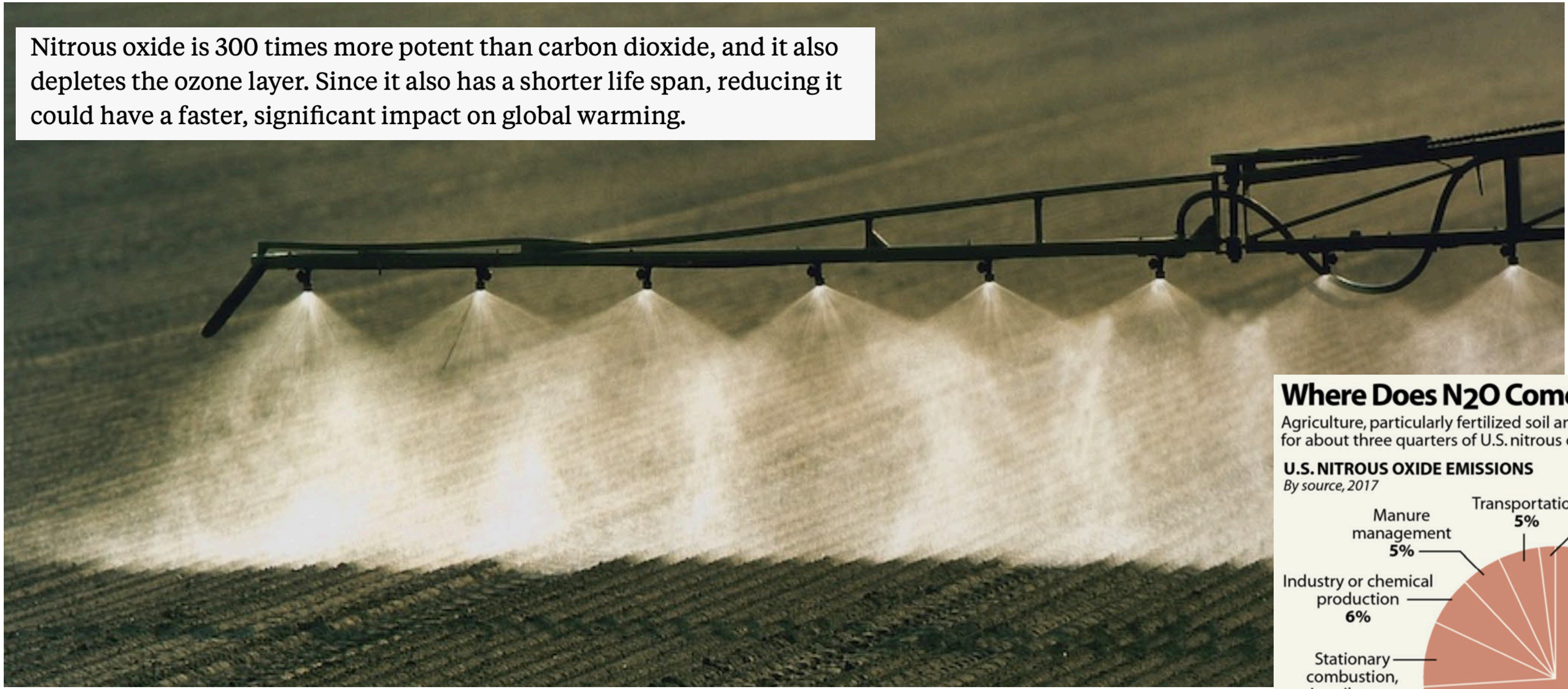
Not just Methane :Carbon Dioxide:

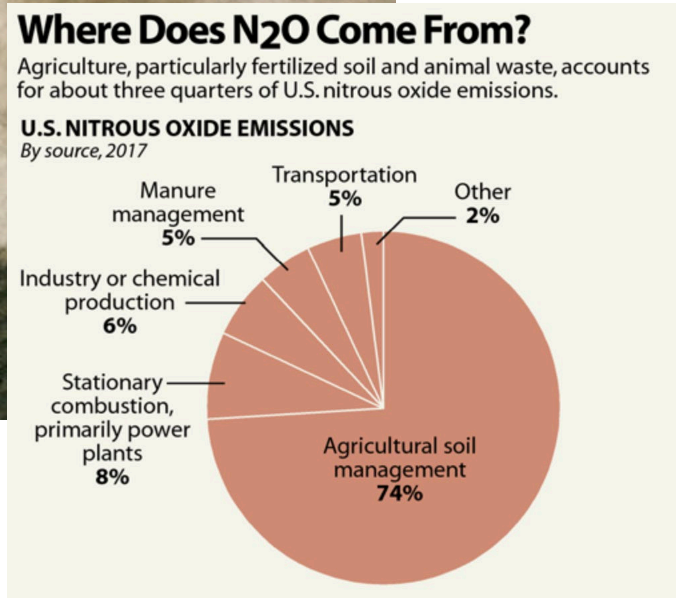


99% of AD's emit the CO_2 they capture

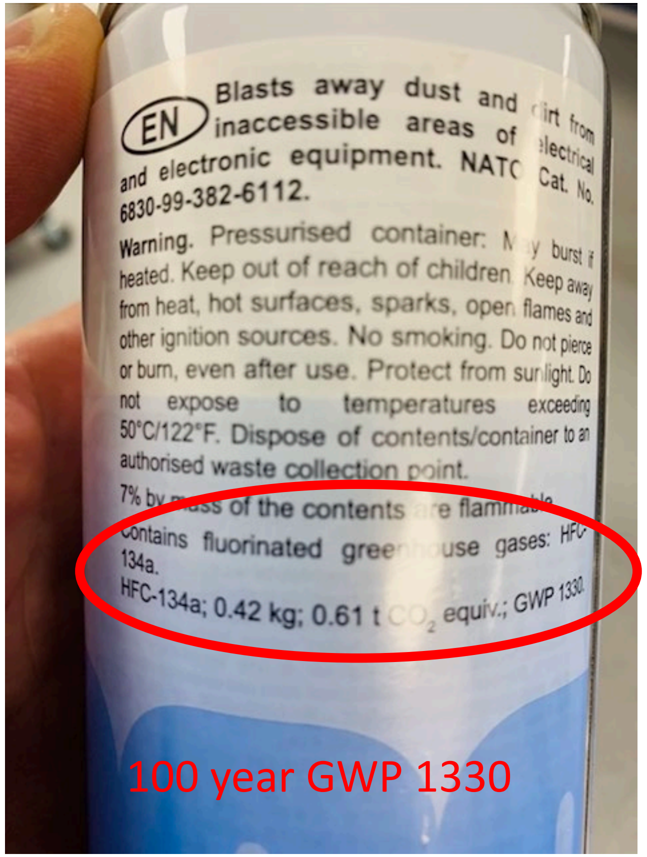
Other gases → eg: Nitrous Oxide

Nitrous oxide is 300 times more potent than carbon dioxide, and it also depletes the ozone layer. Since it also has a shorter life span, reducing it could have a faster, significant impact on global warming.





Other gases: HFC Just Plain Lazy!



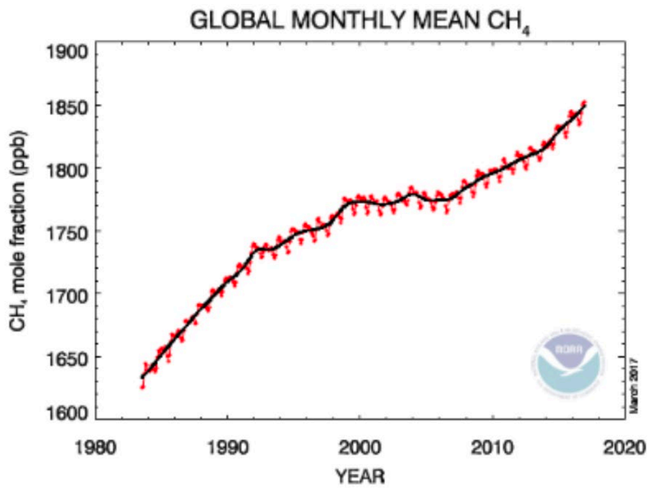
HFC 134a
Hydro Flouro Carbon -134a
Global Warming Potential ≈ 4000
compared to CO_2 over a 20 period
One 400 gramme can ≈ 1.8 tonnes of CO2

And H_2 has a GWP 32 over 20 Years

International Fugitive Emissions Abatement Association (IFEAA) supports action to reduce fugitive emissions

- IFEAA aims to promote action to reduce fugitive emissions by:
  - Seeking out the best examples of scientifically robust research and progressive policy across agricultural, waste and oil and gas sectors
  - Using targeted commissioned research to fill evidence gaps
  - Raising awareness across a broad range of stakeholders including international and local and national policy makers, industry, influence groups and forums and the wider public

- Membership is growing and includes IMechE, Bennamann, CNH, South West Water, Seekops, Mirico and Brighton University.




COP26'S MESSAGE IS HERE,
NOW THE WORK BEGINS!
THIS IS THE ROLE OF IFEAA.

Bennamann

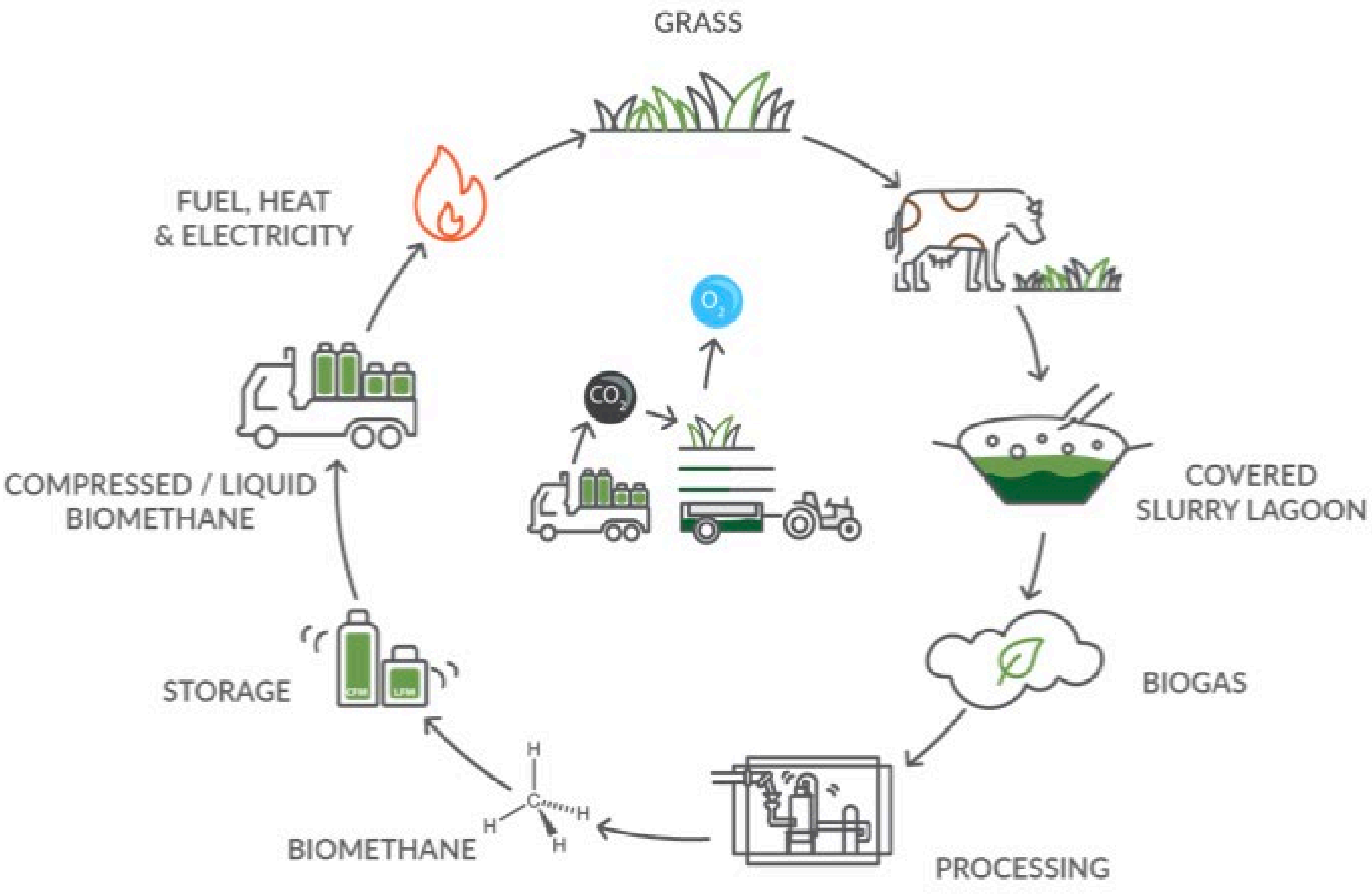
The Energy Independent Farm 24th June 2022

Dr Chris Mann, Co-founder, Chairman & CTO

Delivering a Local Clean Energy Revolution

European Union
European Regional
Development Fund

THE BENNAMANN CYCLE – CAPTURING & REPURPOSING FUGITIVE METHANE



THE LOW HANGING FRUIT – FUGITIVE METHANE FROM SLURRY LAGOONS

- Slurry lagoons on diary farms act as a collector and concentrator of waste biomass
- A typical dairy farm produces six times more fugitive methane than it can use – Bennamann collects excess, sells and shares the profit
- A New Holland gas tractor running on fugitive methane takes the equivalent of 680 cars off the road annually
- Typical 150 head dairy farm produces 40,000kg of fugitive methane and is worth £10,000 – £15,000 in cash and operational savings to the farm
- The equivalent carbon saving is 3440 tonnes

FUGITIVE METHANE – THE CHALLENGE AND THE OPPORTUNITY

Kyoto gases	Geophysical properties		GWP-weighted share of global GHG emissions in 2010			
	Atmospheric lifetime (year)	Instantaneous forcing ($W/m^2/ppb$)	SAR (Kyoto)	WGI (20 and 100 year from AR5 & 500 year from AR4)		
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METHANE IS RESPONSIBLE FOR 42% OF NEAR-TERM GLOBAL WARMING (IPCC 5th Assessment Report)

MINIMISING MANMADE FUGITIVE METHANE EMISSIONS WILL HELP SLOW THE ONSET OF NEAR-TERM CLIMATE CHANGE

METHANE IS A FUEL THAT CAN DIRECTLY REPLACE ALL FOSSIL FUELS, FURTHER REDUCING IT'S GLOBAL WARMING IMPACT

- **Over 20 years a methane molecule absorbs and traps heat 86 times more efficiently than CO2**
- **Capturing 1 kg of fugitive methane effectively removes the equivalent of 86 kg of CO2 from atmosphere**
- ***Methane is unique in that it's the only GHG that can power it's own capture and removal – and then some!***
- **Captured fugitive methane offers an 86 fold GWP benefit over 'carbon neutral' feedstock derived biofuels**
- **Capturing fugitive methane *now* offers the potential to slow down the early onset of global warming**

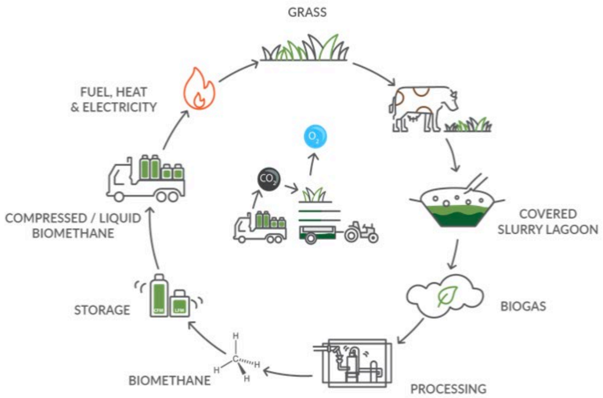
What is radically new about Bennamann's approach?

Conventional Natural Gas and LNG sector

Economies of scale and ***geographical remoteness*** demand a ***continuous supply, centralised processing,*** and distribution through a ***piped grid network*** or ***'just in time' bulk LNG transportation***

This renders it:

- Vulnerable to geopolitics
- Sensitive to fluctuations in supply and demand
- Limited access to the ***global*** customer base



Local storage of cleaned biogas at source

Rapid mobile biogas upgrading shared between sites

Purification and liquefaction cooled by liquid nitrogen from existing supply chain

Local aggregation and distribution

Bennamann's **local aggregation & distribution model** model exploits

Local biogas storage and process preparation

Rapid mobile biogas refining and liquefaction

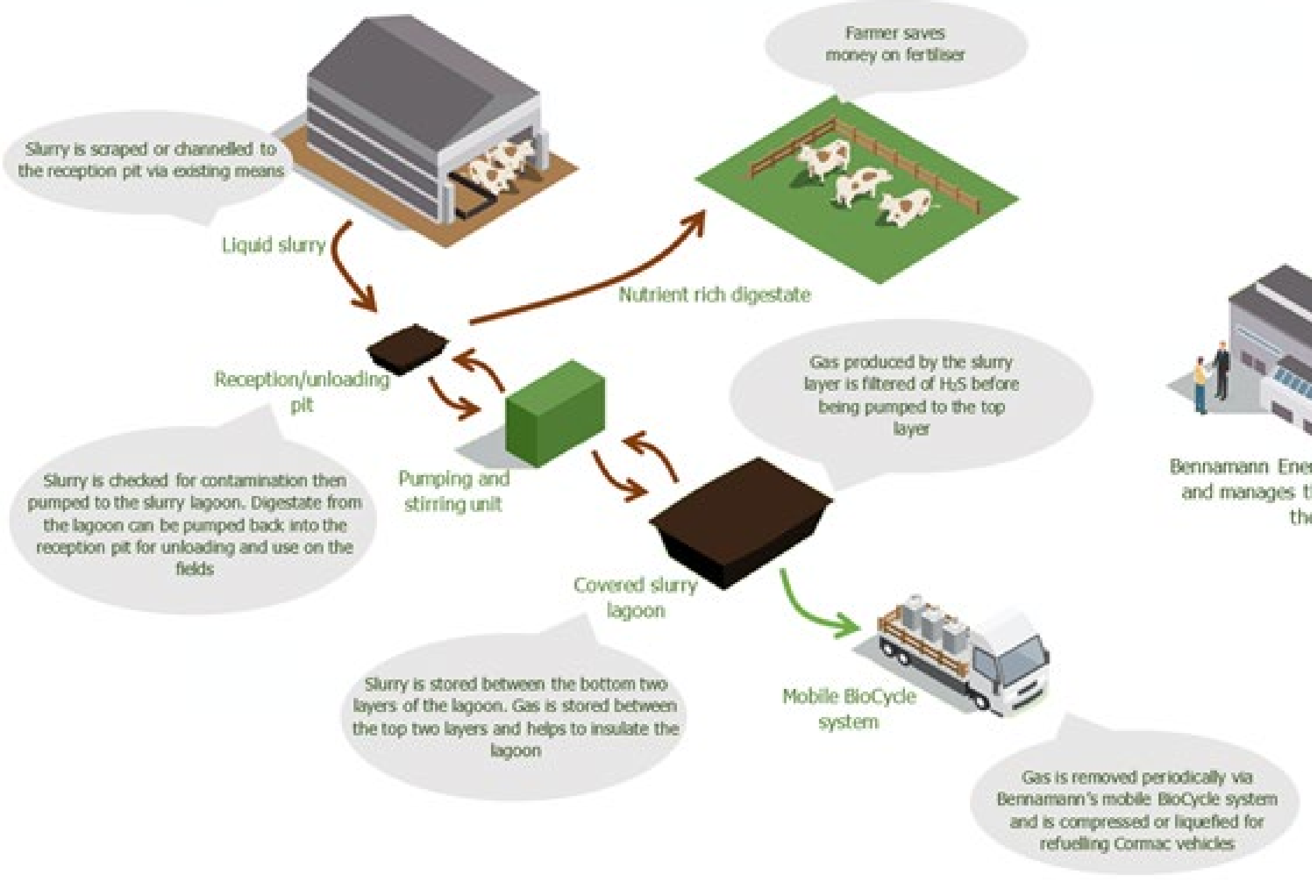
IoT monitoring control and networked logistics

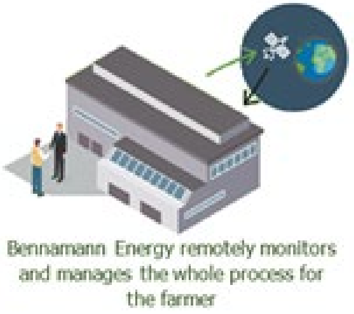
This provides ***de-integrated, de-centralised & de-synchronised*** biogas processing, liquefaction and storage

Road transportation logistics for distribution/ sales.

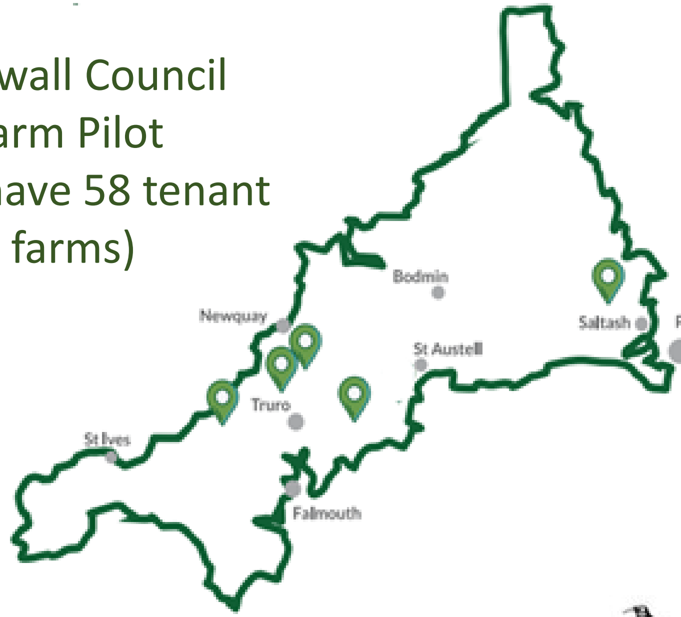
That dramatically reduces capital cost, increases flexibility and provides resilience to fluctuations price and demand

Bennamann offers a secure and resilient global energy market for untapped sources of fugitive and biomethane with unrestricted access to the global customer base





Cornwall Council
Six Farm Pilot
(CC have 58 tenant diary farms)



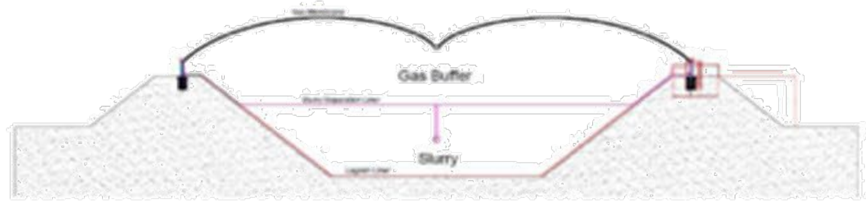

CORMAC: Methane Truck and Hotbox

GAME CHANGING ZERO CARBON ZERO INFRASTRUCTURE POWER GENERATION

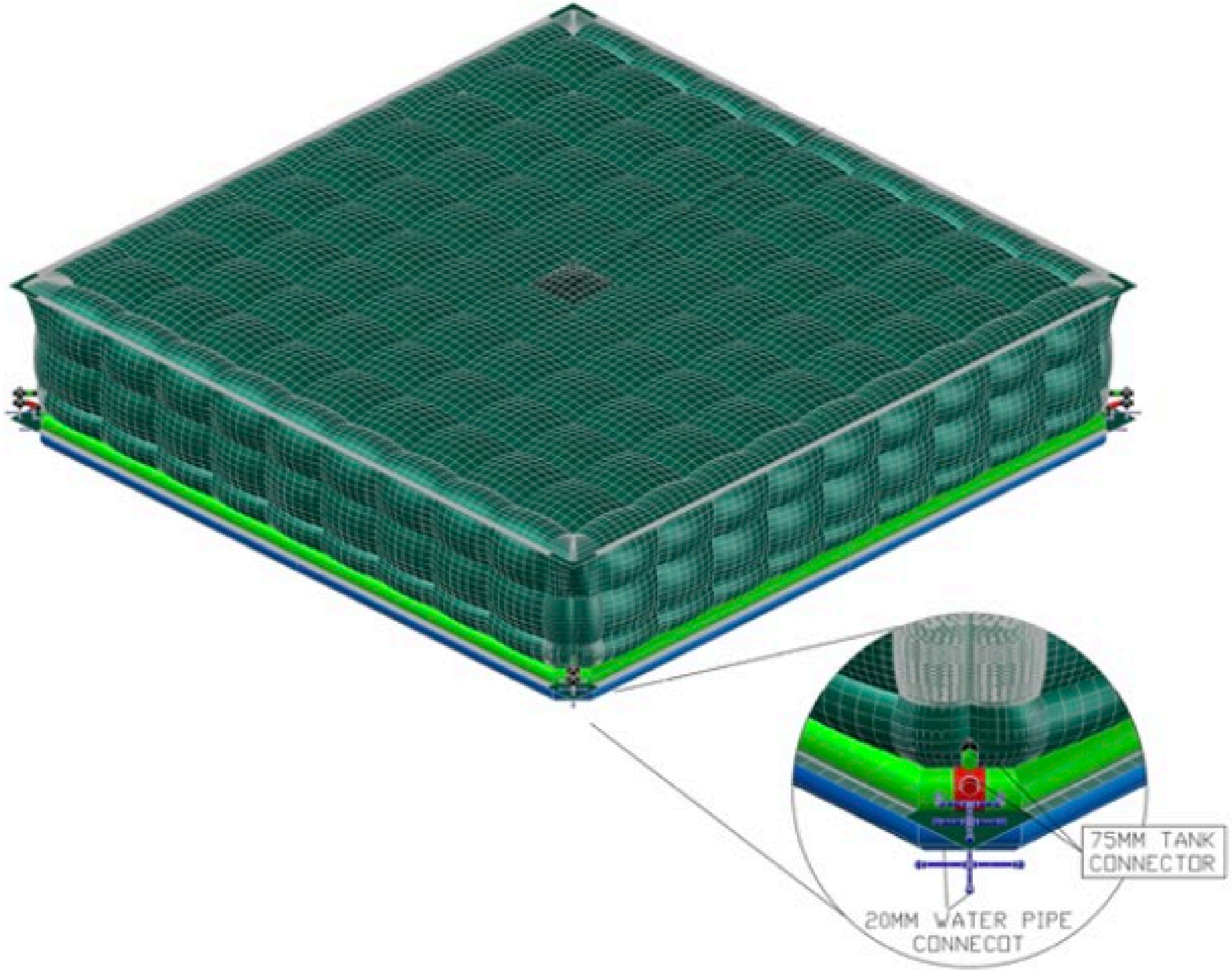
KEY PIECES OF THE JIGSAW

PRODUCT PORTFOLIO: GAS CAPTURE – COVERED LAGOONS

OPTION 1: NEW LAGOON

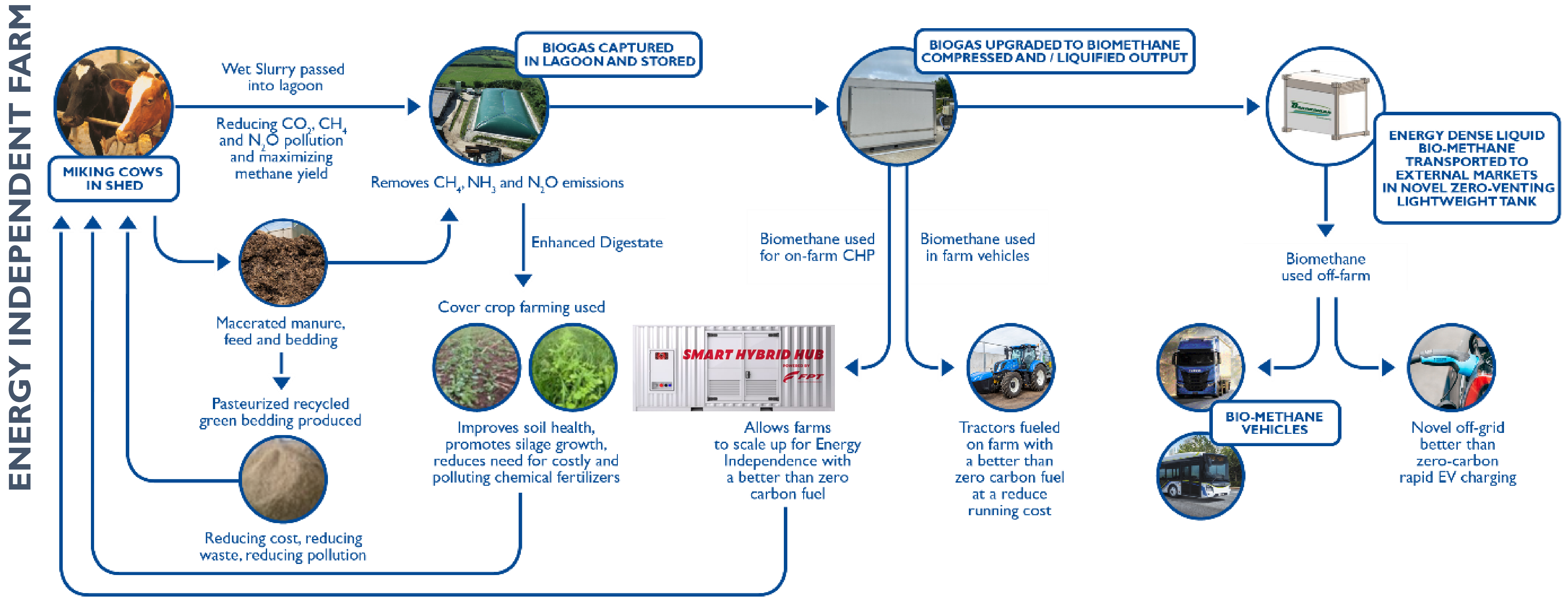


OPTION 2: RETROFIT



Energy Independent Farm℠ Dairy Farm

How the Bennamann system works

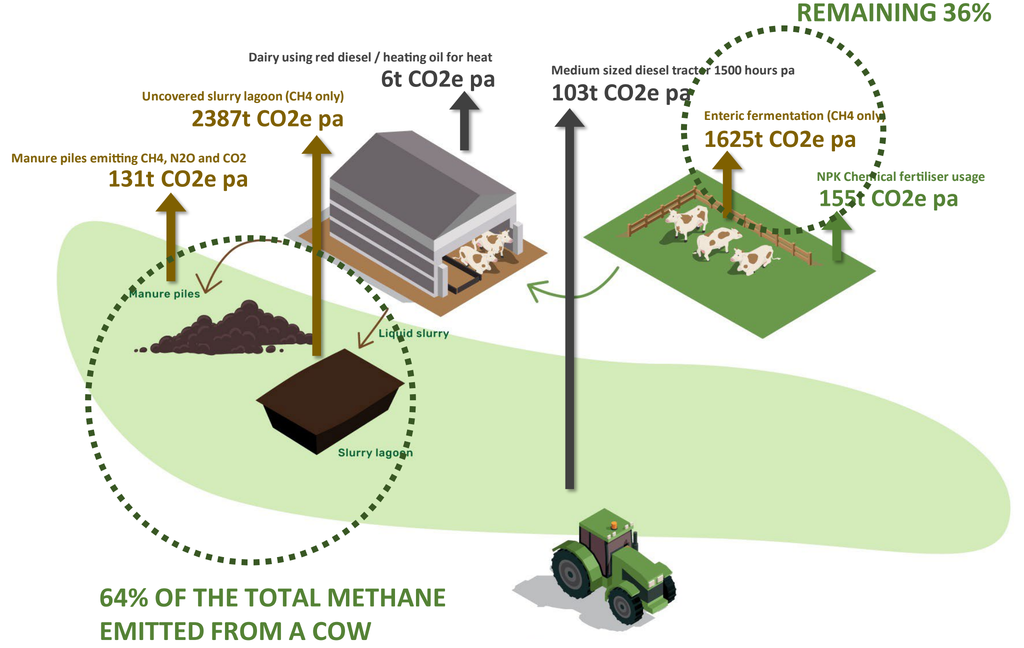


Dairy Farm CO_2e_{20} Emissions Today & Tomorrow

Before and After Energy Independent Farm℠ Implementation

BENNAMANN SOLUTION

CO_2e_{20} Output 150 Cow UK Dairy Farm - BEFORE



CO_2e_{20} Output 150 Cow UK Dairy Farm - AFTER

FARM CO_2e OUTPUT (kg CH4 GWP20 86kg CO_2e)	~4400 tCO_2e pa

→

TOTAL METHANE CO_2e REDUCTION (86kg CO_2e)	~2500 tCO_2e pa

\+

CO_2e REDUCTION FROM METHANE USED AS FUEL	~290 tCO_2e pa

=

FARM CO_2e OUTPUT (kg CH4 GWP20 86kg CO_2e)	~1600 tCO_2e pa

~64% Reduction in methane CO_2e_{20} emissions on farm

TOTAL CO_2e REDUCTION (86kg CO_2e)	~2800 tCO_2e pa

=

140 UK household carbon footprints

~65% Reduction in CO_2e_{20} emissions from farm

Members of IFEAA

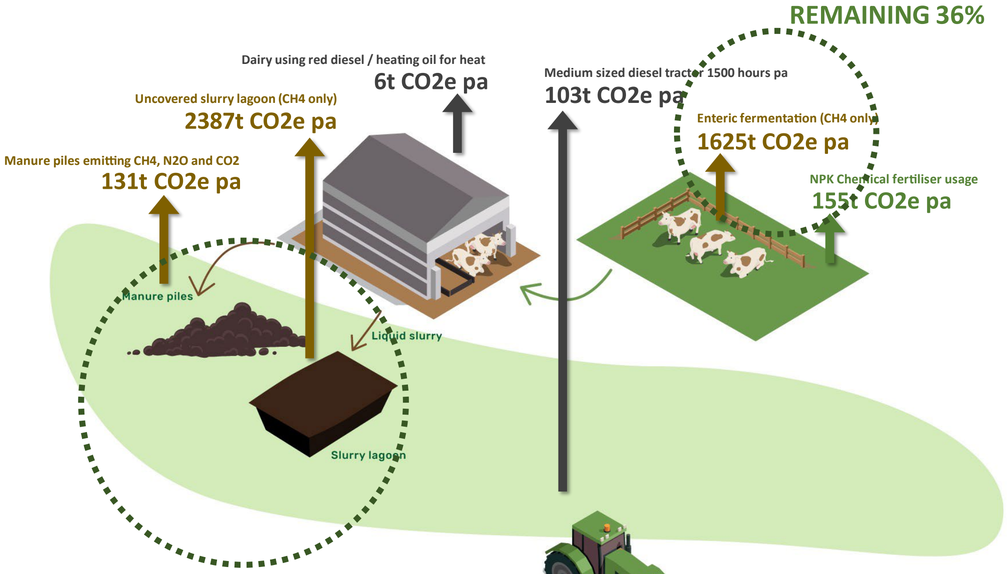
Dairy Farm CO_2e_{20} Emissions Today & Tomorrow

Bennamann | CNH INDUSTRIAL VENTURES

Before and After Energy Independent Farm℠ Implementation

BENNAMANN SOLUTION

CO_2e_{20} Output 150 Cow UK Dairy Farm - BEFORE



64% OF THE TOTAL METHANE EMITTED FROM A COW

CO_2e_{20} Output 150 Cow UK Dairy Farm - AFTER

FARM CO_2e OUTPUT (kg CH4 GWP20 86kg CO_2e)	~4400 tCO_2e pa

→

TOTAL METHANE CO_2e REDUCTION (86kg CO_2e)	~2500 tCO_2e pa

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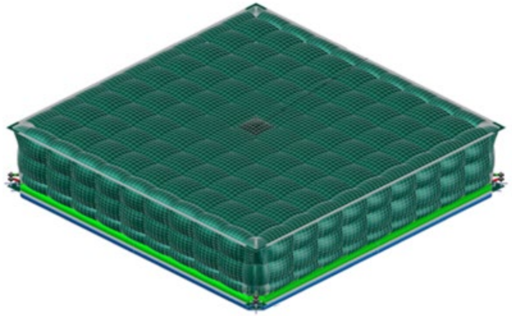
= **140 UK household carbon footprints**

~65% Reduction in CO_2e_{20} emissions from farm

ifeaa Members of IFEAA

BENNAMANN – A GLOBALLY SCALABLE SOLUTION – CAPTURING FUGITIVE METHANE FROM DIARY WASTE

New build lagoon



Retrofit cover

Capture and clean farm biogas emitted from lagoons

Mobile upgrading to Automotive grade biomethane

Store and use biomethane on farm (fuel & energy)

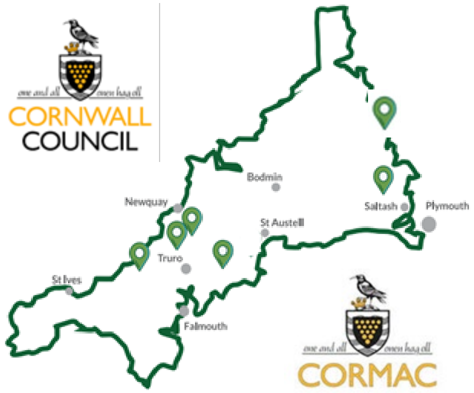
Gas vehicles

Off grid EV charging

Export to external customers via virtual pipeline

BENNAMANN FARM PROJECTS THIS YEAR

Bennamann | CNH INDUSTRIAL | VENTURES



SIX CORNWALL COUNCIL FARMS

Farm 1 – fully live

Farm 2 – planned live Q3 2022

Farm 3 – planned live Q4 2022

3 farms producing biomethane to provide fuel for on-site tractors and Cormac vehicles as well as on-site energy independence

Waitrose Leckford lagoon planned live Q3 2022

Producing biomethane in Q4 2022 providing fuel for on-site tractors and Waitrose's logistics trucks

FARMER BENEFITS

INCREASED PROFITABILITY

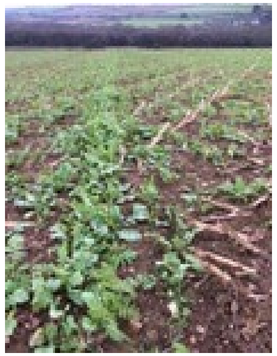
- Reduced operating costs – Fuel, Energy, Less spreading, reduced fertiliser usage, green bedding
- External methane sales profit share

ENERGY INDEPENDENCE

- Low cost green energy produced on site
- Protected from market price & supply volatility
- Overcome grid limitations and upgrade cost barriers
- Benefit from AD with no need for expensive technology or export to grid

ENVIRONMENTAL BENEFITS

- Methane and CO_2e_{20} emissions reduced by ≈ 65%
- Reduced NH_3 & NO_x emissions
- Replace Fossil fuels
- Reduced use of carbon intense chemical fertilisers
- Improved soil health
- Save water usage via rainwater harvesting
- Reduction of smells and pests

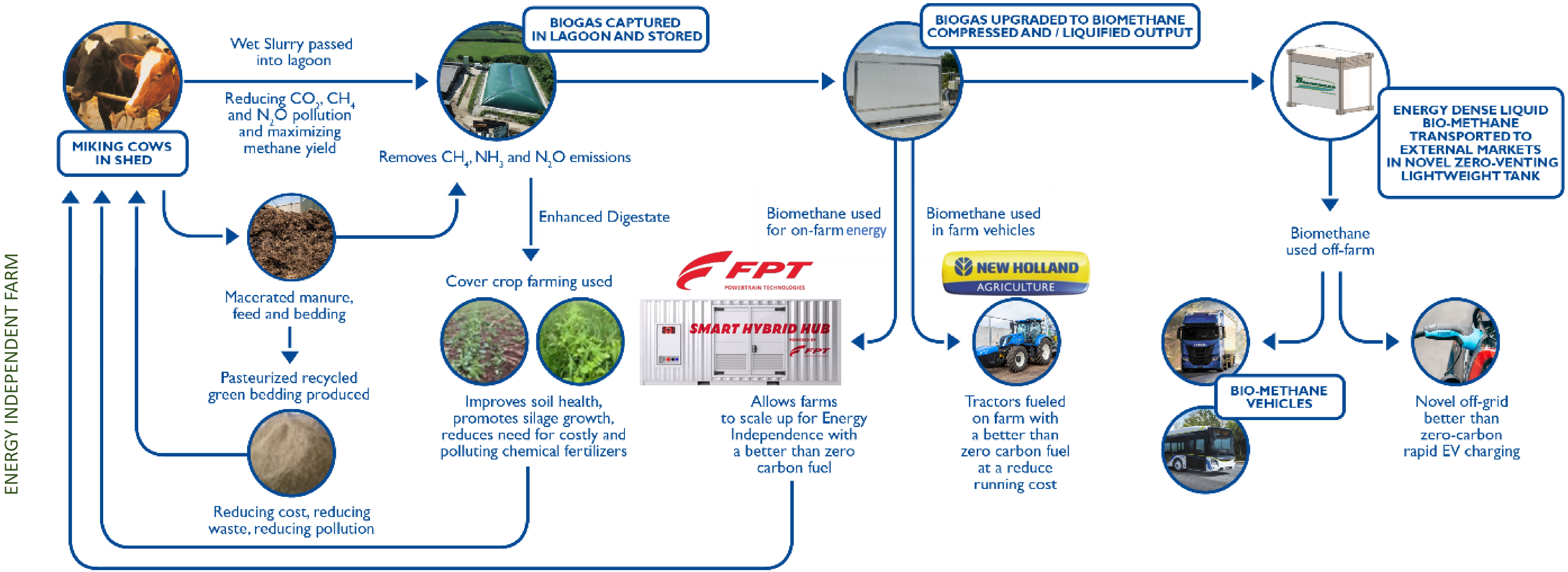


REGULATORY COMPLIANCE

- Clean Air Strategy
- SAAFO

Energy Independent Farm℠ Dairy Farm

How the Bennamann system works



How does the approach transfer across to the waste water sector

- Instead of CHP upgrade to vehicle grade fuel to take advantage of the Renewable Transport Fuel Certificate
- Access higher revenues in much larger market and advances in dedicated methane power in heavy applications in Transport, Agriculture, Contruciton Equipment and Energy sectors
- Use a smaller scale modular approach to aggregate across all sites not centralised
- Exploit the modular fugitive methane

THANK YOU

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Prof Tapas Mallick, Dr Katie Shanks

Environment & Sustainability Institute, University of Exeter

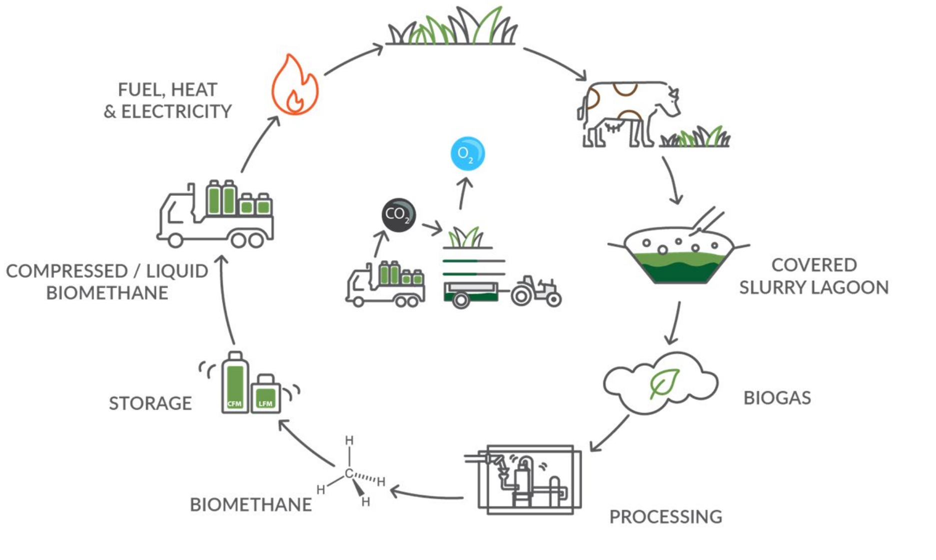
Integrating renewable energy in the Bennamann project

UNIVERSITY OF EXETER | ENVIRONMENT AND SUSTAINABILITY INSTITUTE

Net-Zero in Agritech & Renewable Energy

Tapas Mallick

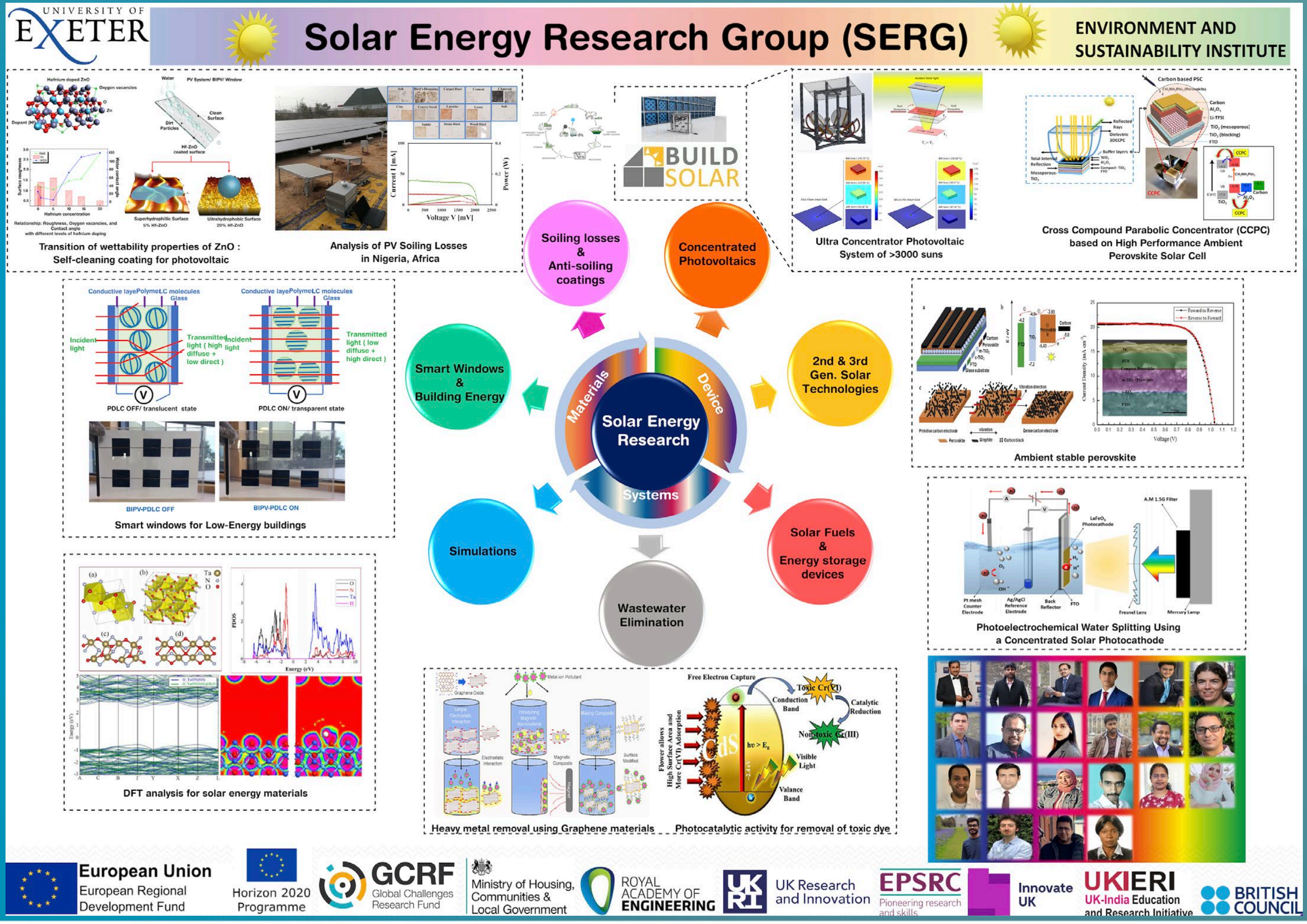
Katie Shanks



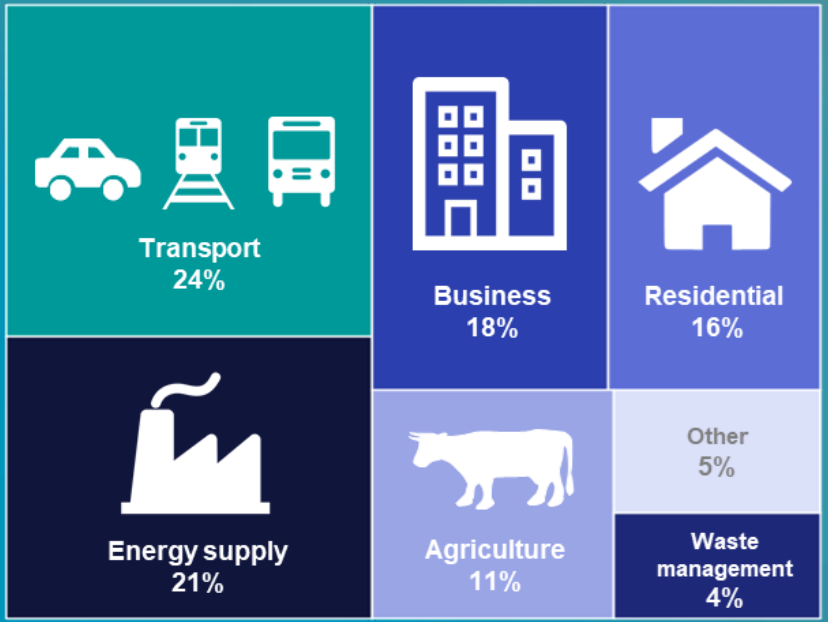
European Union
European Regional Development Fund

Working with natural systems for sustainable futures

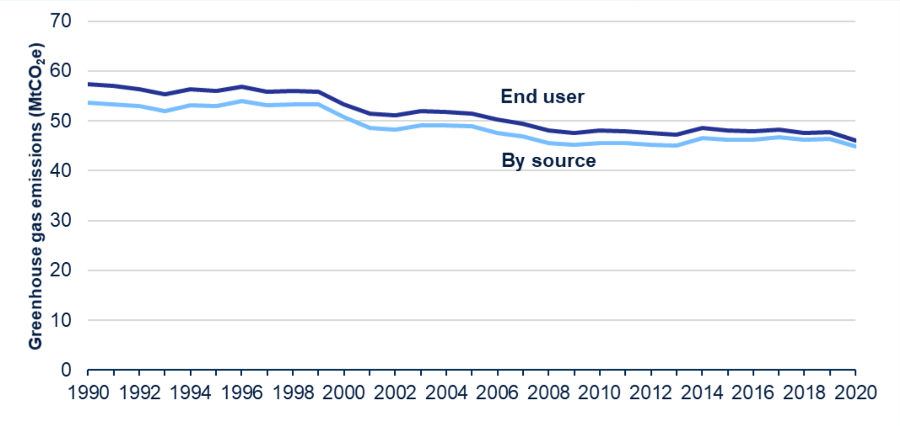
The Solar Energy Research Group



Why net-zero in Agritech?



- Technology, economic, policy and social changes
- Bioenergy conversion
- Improved Energy efficiencies
- Low carbon machineries
- Effective use of Solar Energy
- Load and demand shifting
- User adaptation



BEIS, 2022

Pathways to Net-Zero - Agrivoltaics

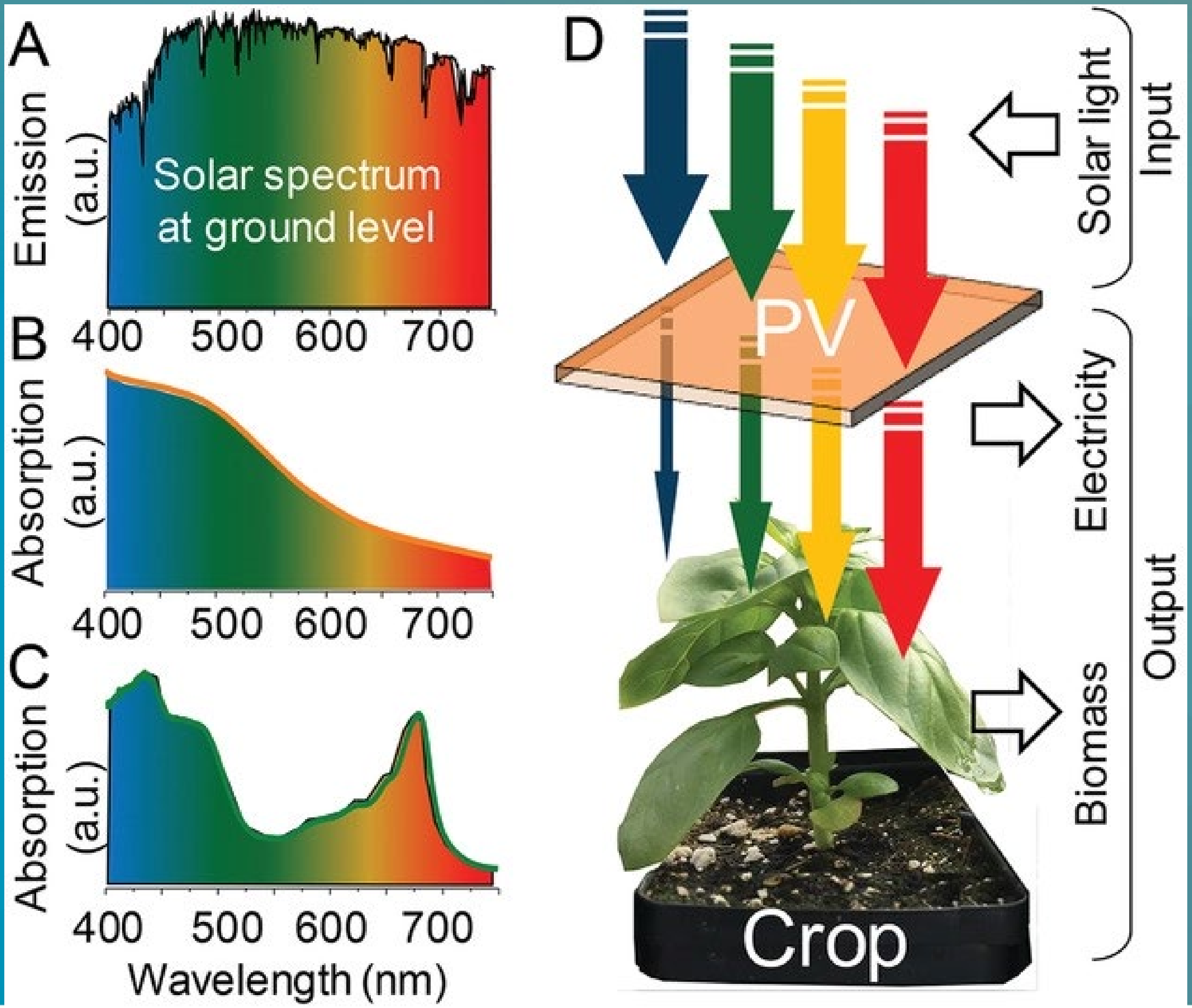
Source: https://www.agrovoltaics.com

Pathways to Net-Zero - Agrivoltaics

Source: PV-Magazine

Pathways to Net-Zero - Agrivoltaics

Source: Polysolar Technology limited



Source: Thompson et al., 2020

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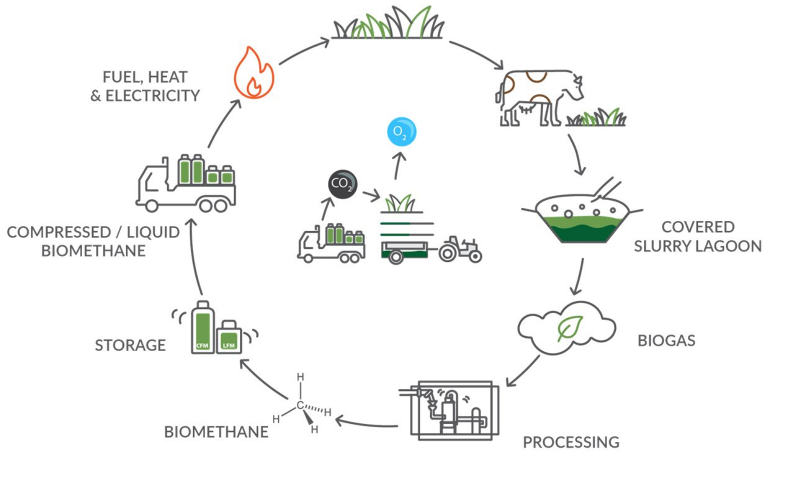
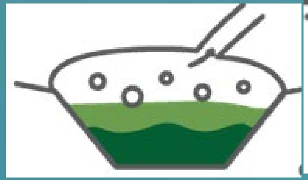
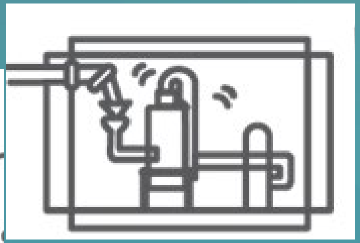
Renewable Technology for the Energy independent farm

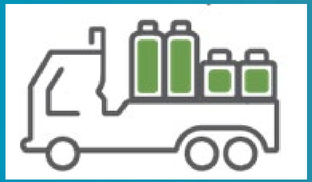


Energy modelling and cost effectiveness

- **Energy Demands:** Farm & Bennamann Systems

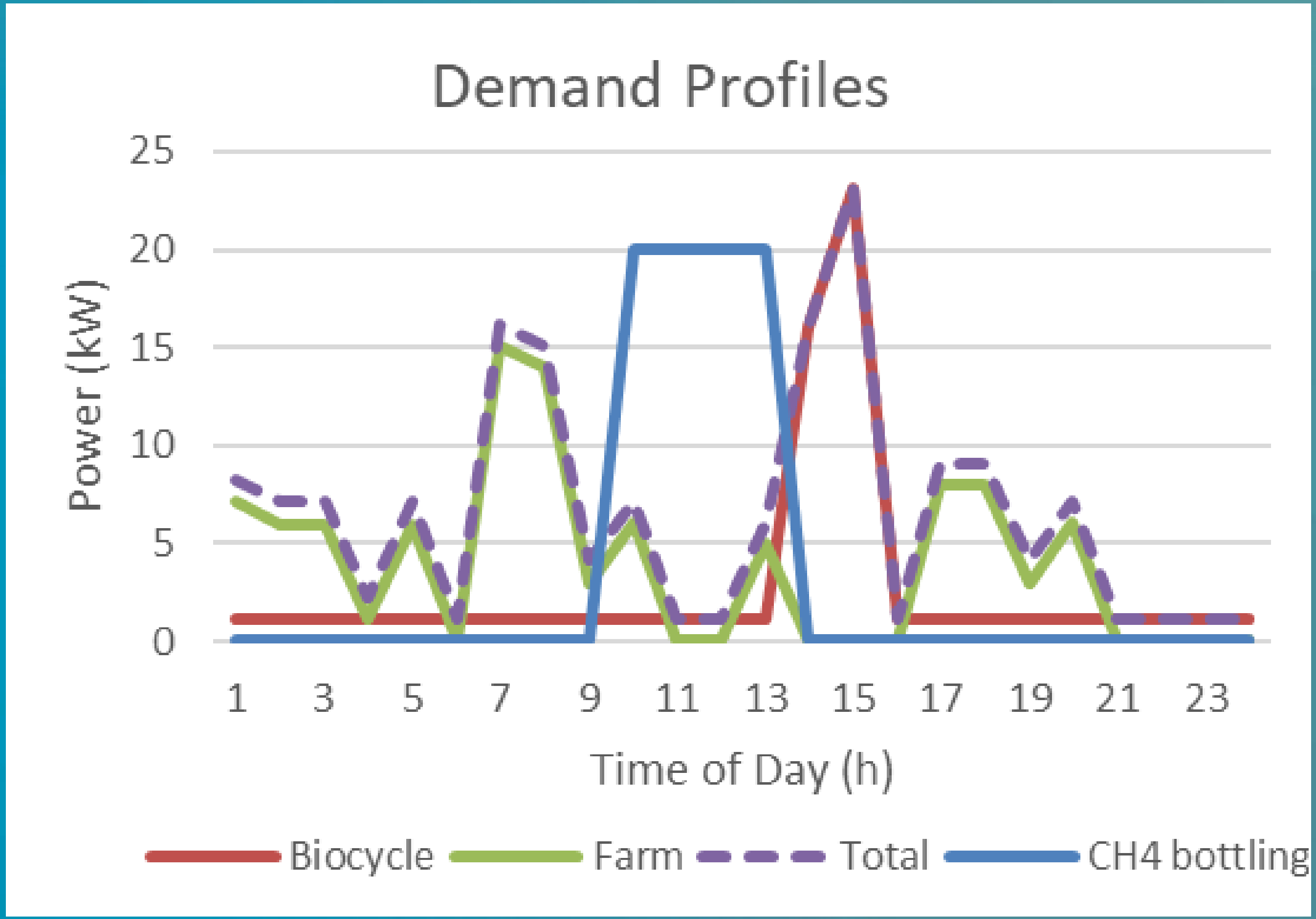
- **Energy supplies:** Biogas, Solar & Wind.

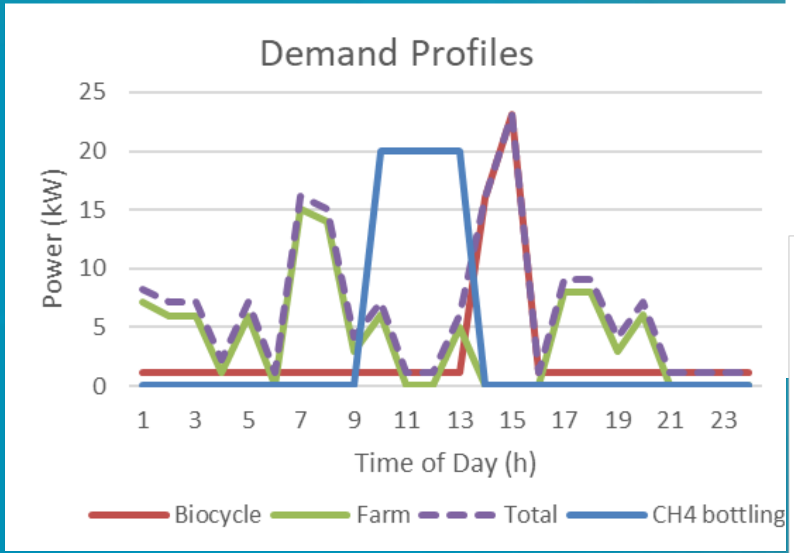


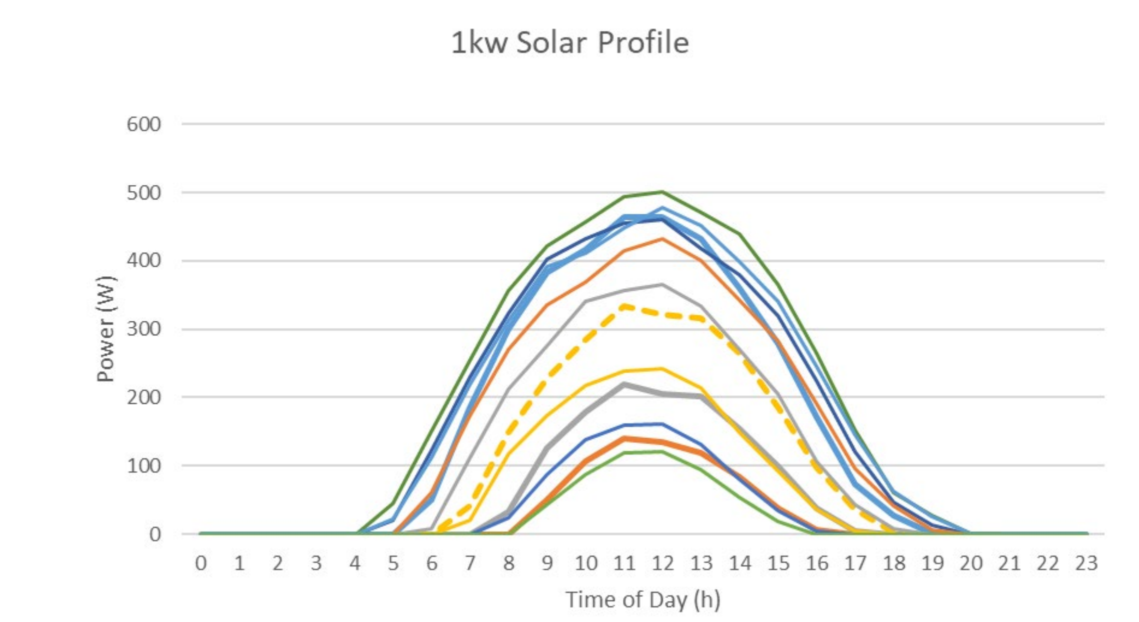
Example Farm

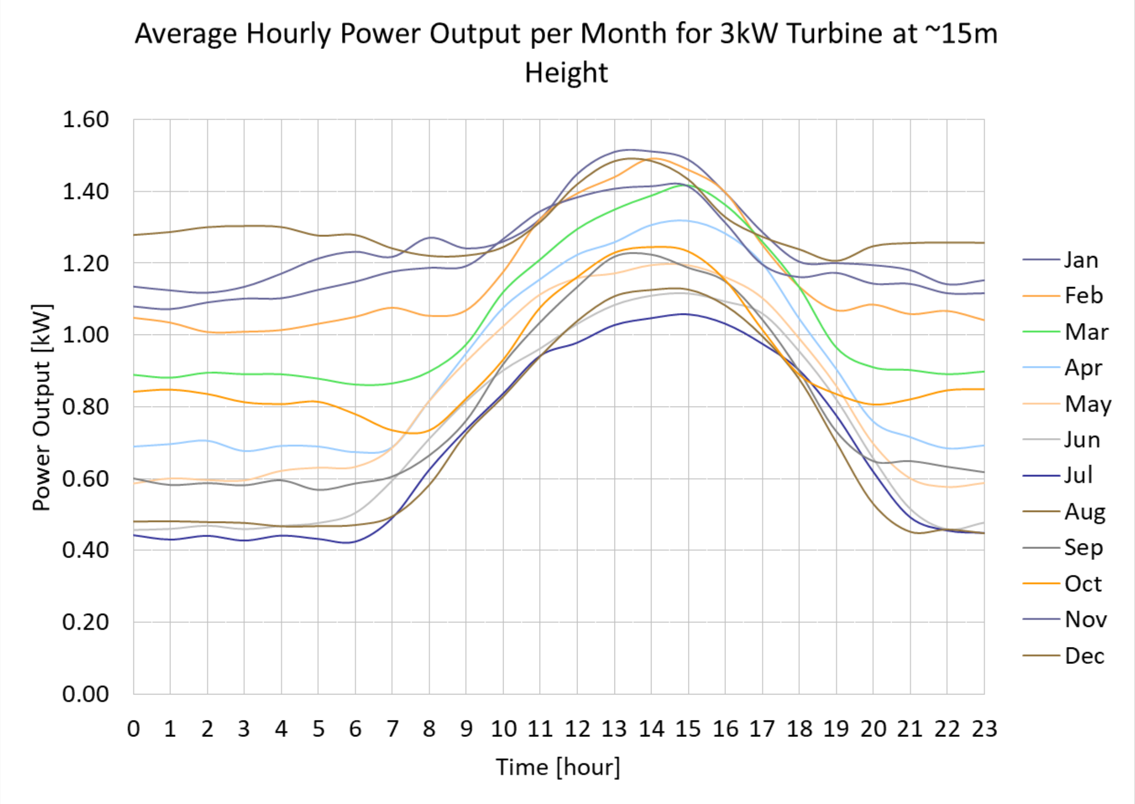
Total no. Cows:	120
	Scaled values (from pilot Farm 260 cows, 16m3 biogas/hr)
Estimated Annual Slurry (tonnes):	2215
Estimated Annual Biogas potential (RBP) (m3):	64689
Estimated Annual Methane potential (m3):	38814
Hourly Biogas Production rate (m3):	7.4
Hours of 50m3 processing time required:	3.5hr/day, 24hr/week, 48hr/biweekly
Farm Energy Demand (average daily total, kwh):	94.5
Biogas Energy Demand (average daily total, kwh):	63.4
Biogas 50m3 processing power demand (20kw/hr):	70kwh/day, 480kwh/week, 960kwh/biweekly
Available roof area for solar panels (for most south facing roof):	370m2
Roof orientation (degrees from north facing):	100°
Roof tilt (angle from horizontal in degrees):	15°

Demand Profile



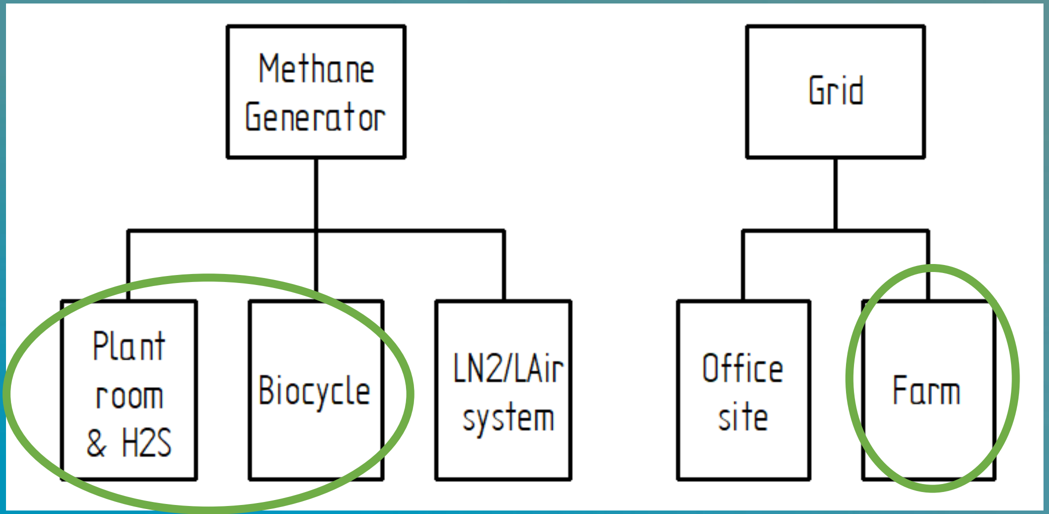

Demand Profiles
25
20
15
10
5
0
Power (kW)
1 3 5 7 9 11 13 15 17 19 21 23
Time of Day (h)
Biocycle
Farm
Total
CH4 bottling

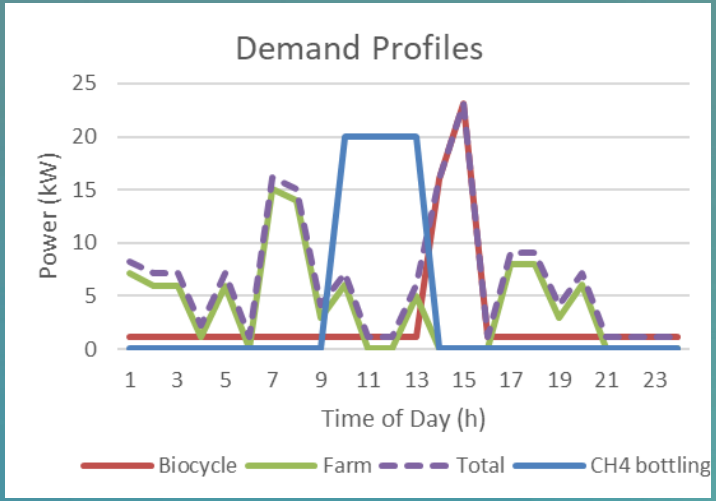

1kw Solar Profile
600
500
400
300
200
100
0
Power (W)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time of Day (h)

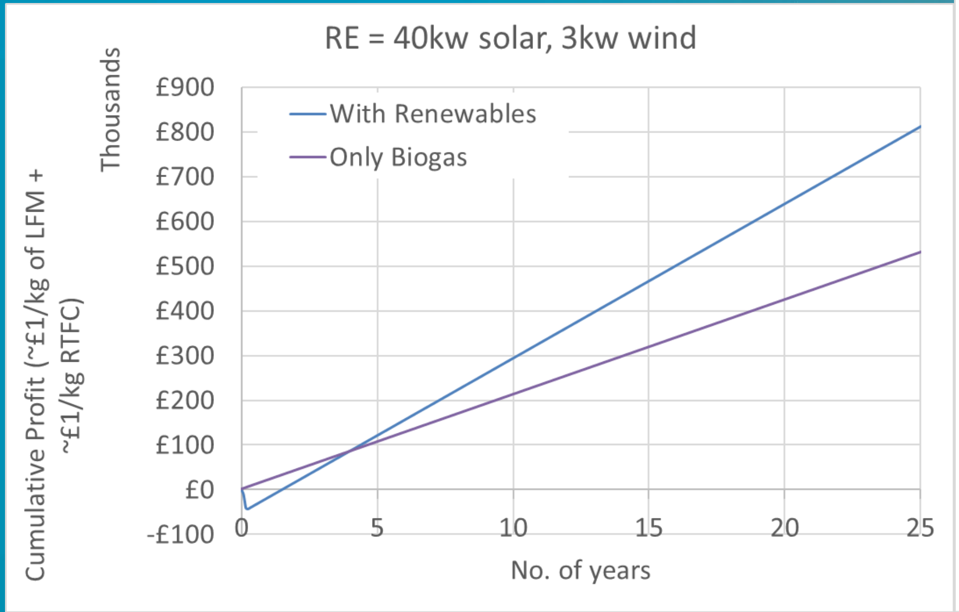

Average Hourly Power Output per Month for 3kW Turbine at ~15m Height
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Power Output [kW]
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time [hour]
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

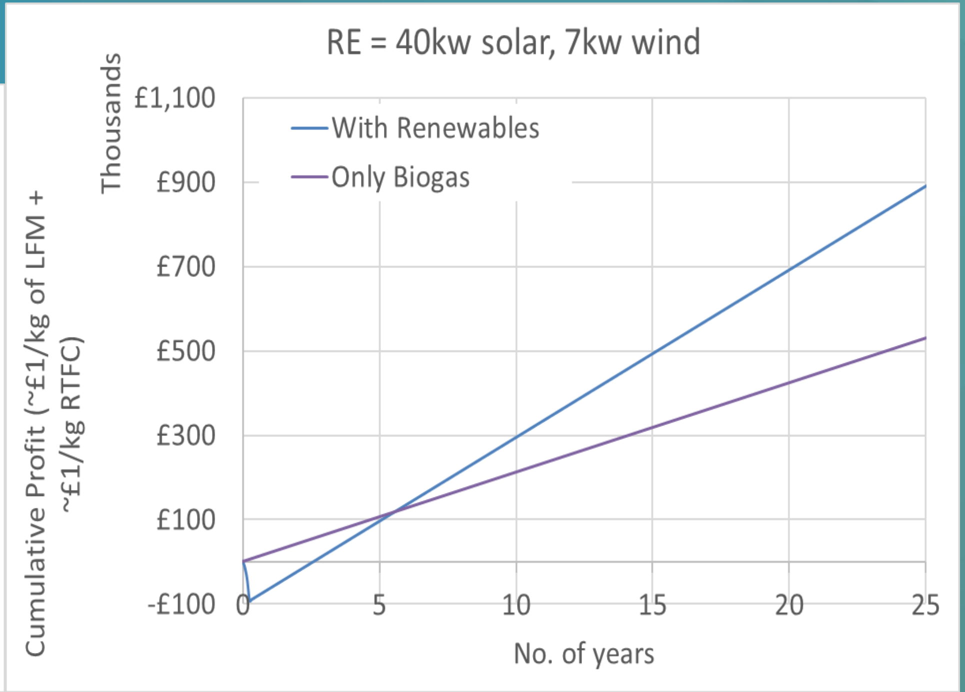
Limitations (research opportunities)

- Grid connection and capacity
  - Limited in rural locations
  - Energy storage on site
  - Energy sinks on site
- Planning requirement for wind turbines:
  - 12 month bat and bird survey.
  - Then planning approval is required.
- Faster install for initial low demands:
  - turbine below 11.1m
  - <3kw


Methane Generator
Grid
Plant room & H2S
Biocycle
LN2/LAir system
Office site
Farm

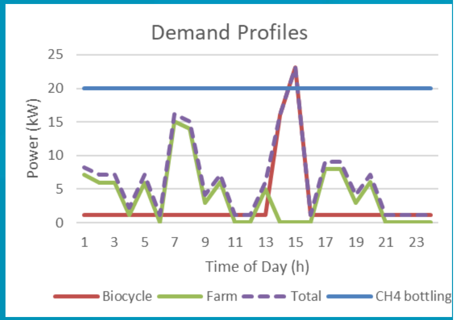

Demand Profiles
Power (kW)
Time of Day (h)
Biocycle
Farm
Total
CH4 bottling

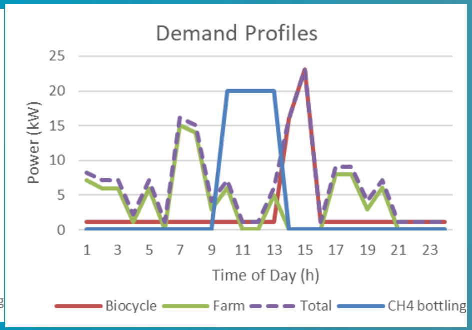

RE = 40kw solar, 3kw wind
Thousands
Cumulative Profit (~£1/kg of LFM + ~£1/kg RTFC)
With Renewables
Only Biogas
No. of years

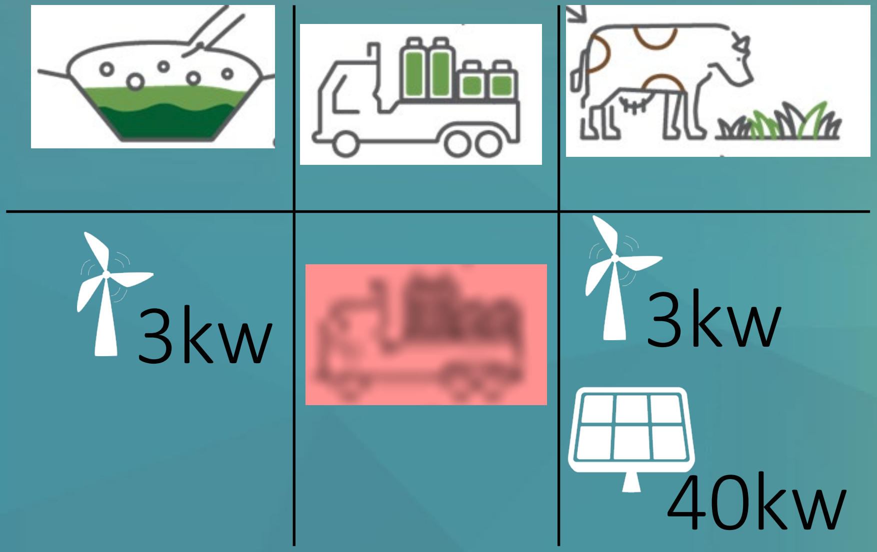

RE = 40kw solar, 7kw wind
Thousands
Cumulative Profit (~£1/kg of LFM + ~£1/kg RTFC)
With Renewables
Only Biogas
No. of years

Summary of model results

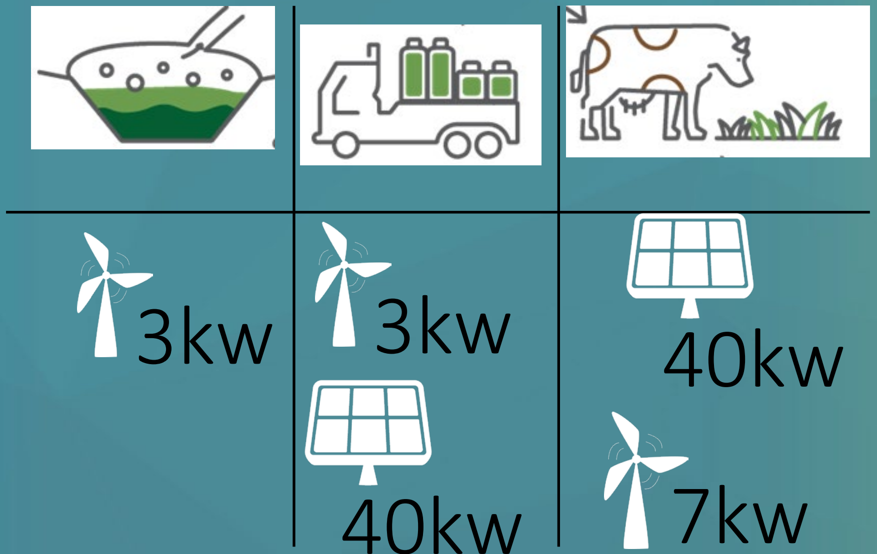
- Small farms (<150 cows)
- 25yrs £300k saving
- 50% Demand met



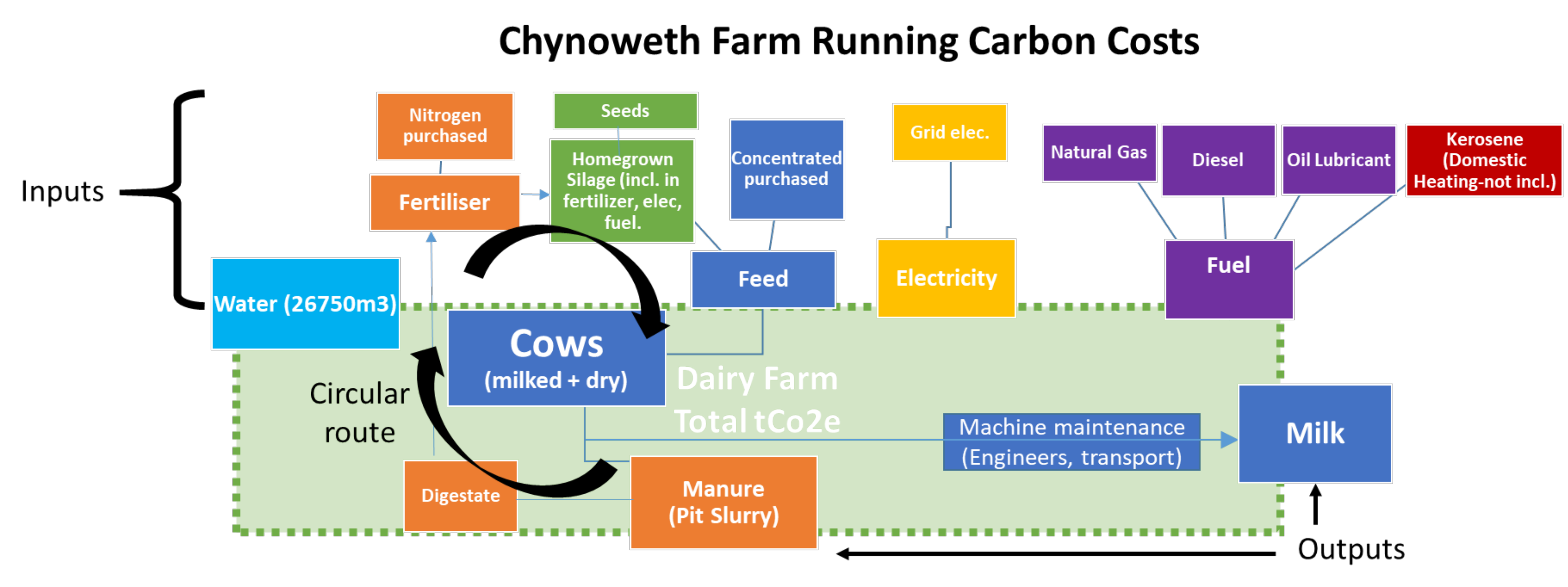




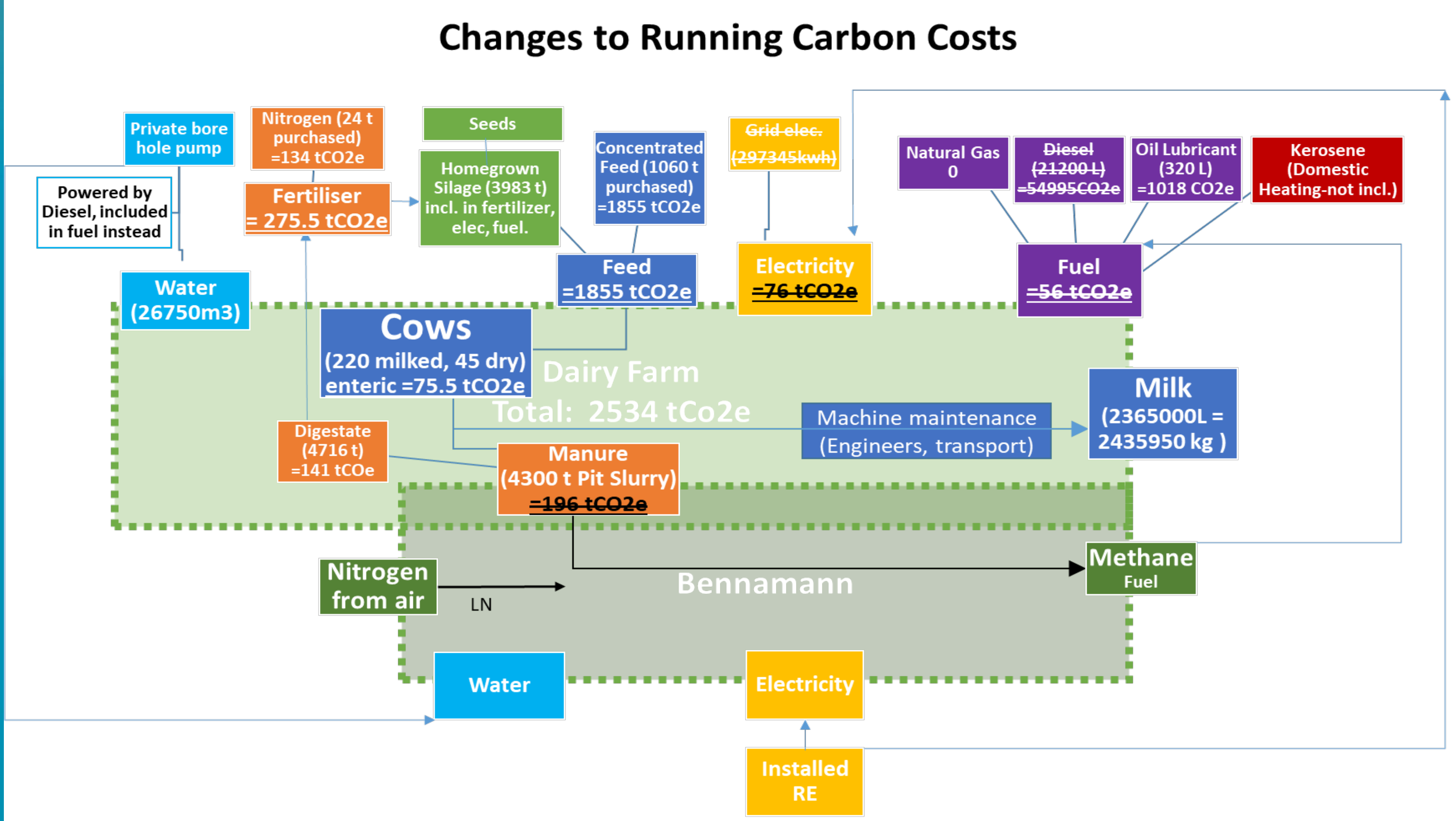
- Large Farms with permanent system
- 25yrs >£450k saving
- 70% Demand met



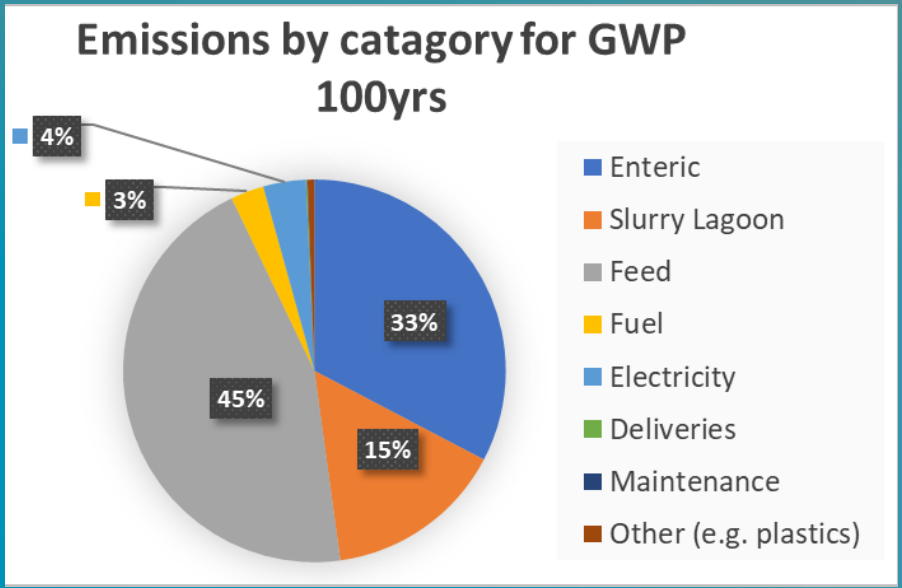
Carbon Footprint



Carbon Footprint

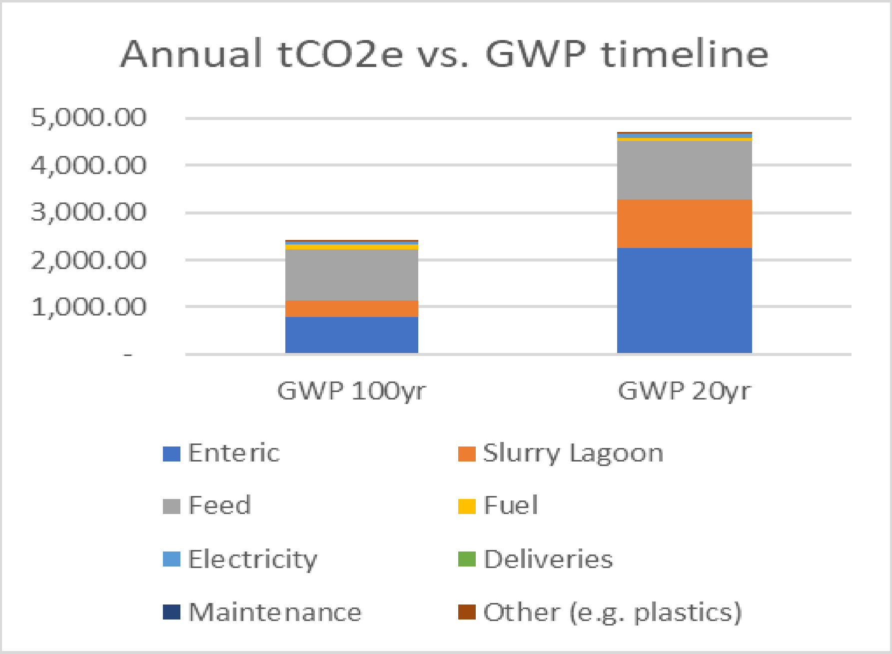


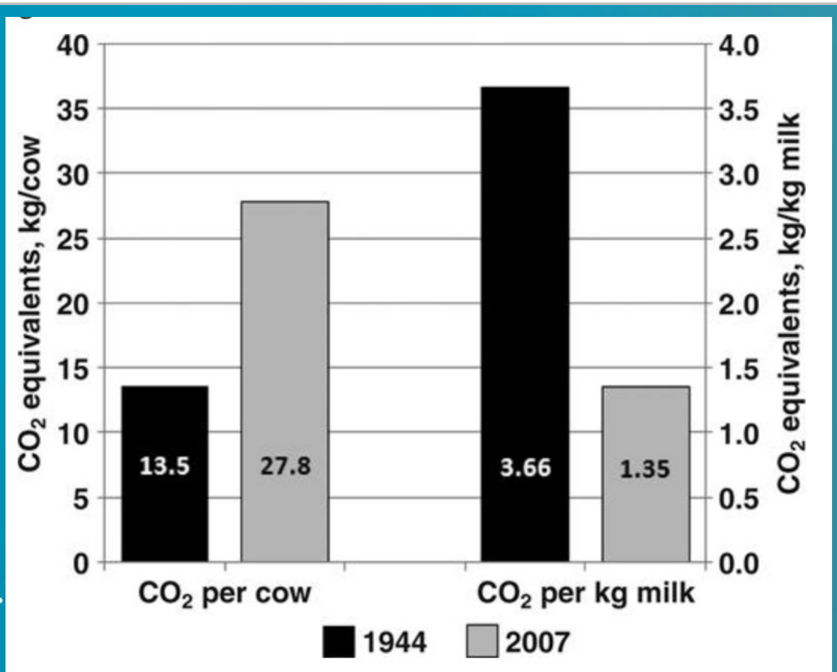
Carbon footprint



20yrs vs 100 yrs

GHG	GWP20	GWP100
CO2	1	1
CH4	72	25
N2O	289	298





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Dr Richard Tennant

Microbial Biofuels Group, University of Exeter

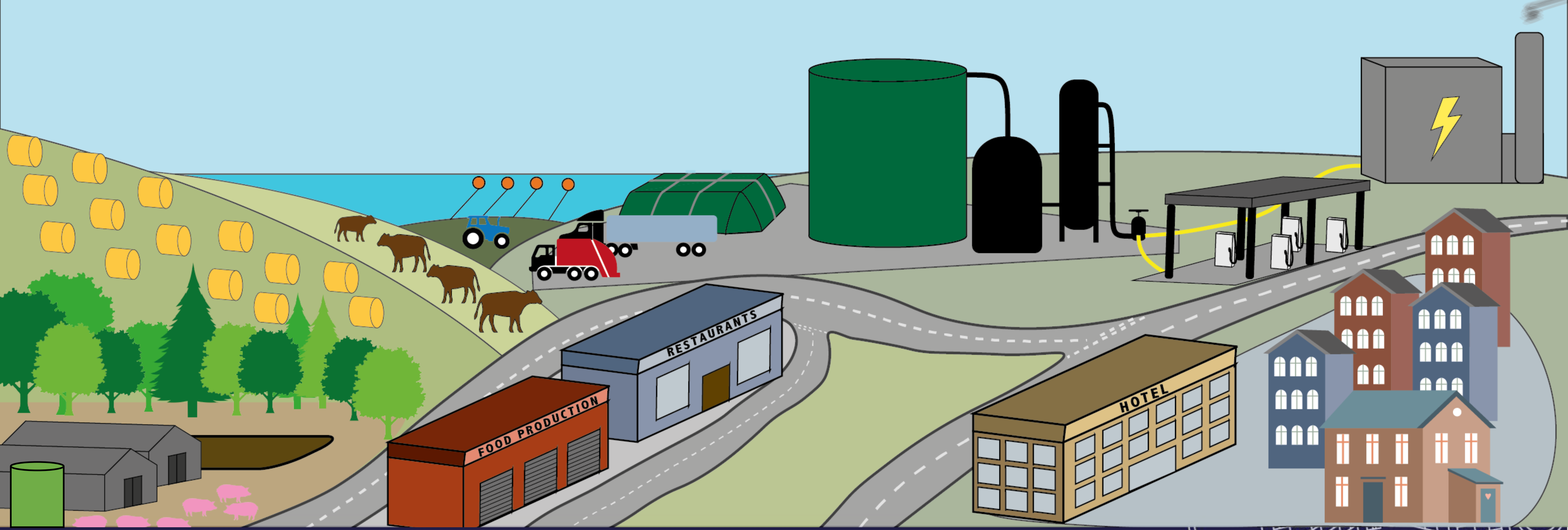
Short response 1: Biomethane and digester microbiomes

Biomethane and Digester Microbiomes

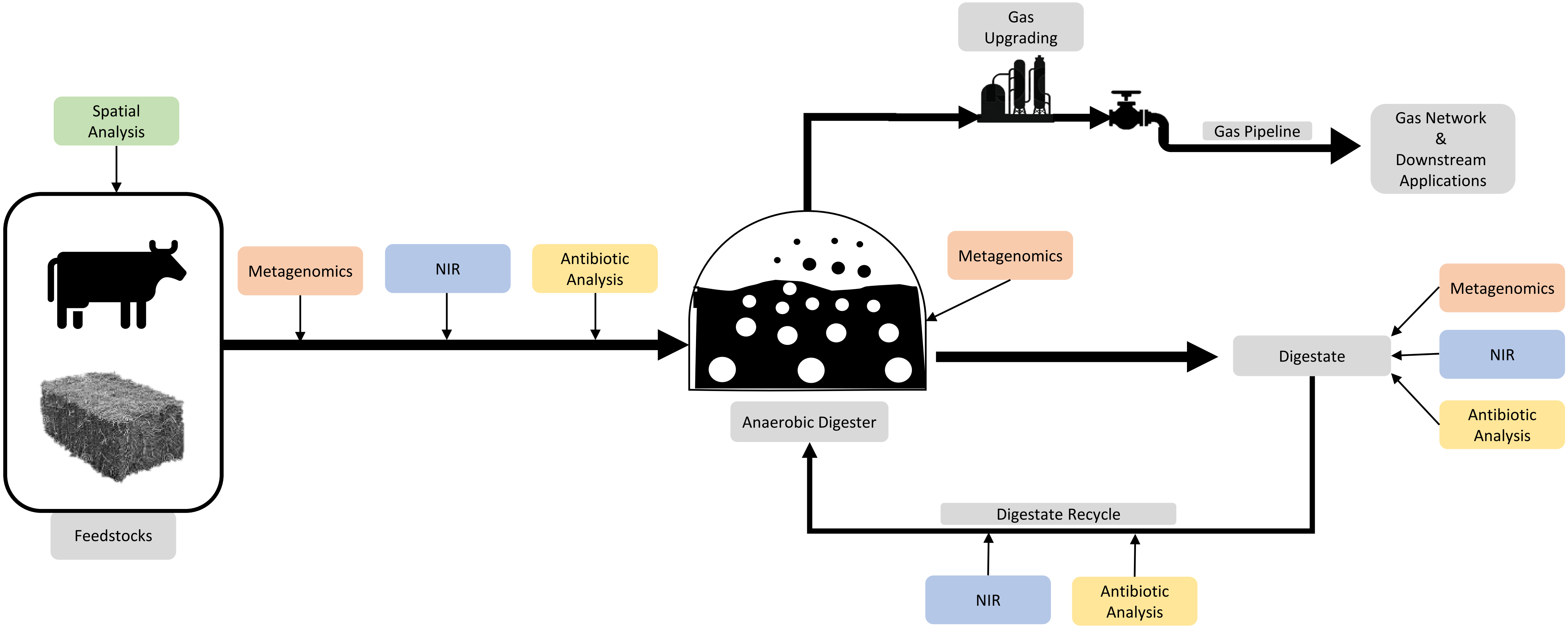
New Frontiers in Net Zero Farming – June 24th 2022 - ESI

Dr. Richard K. Tennant – Senior Research Fellow
R.K.Tennant@exeter.ac.uk

- A range of different feedstocks can be utilised by anaerobic digestion.
- These feedstocks can be transported to a central AD facility to produce biogas
- Upgrading biogas to biomethane; **identical** to fossil methane and can be injected into the fossil natural gas grid
- Utilised in a range of applications *e.g.* power plants, compressed to CNG and residential
- Feedstocks can also be processed onsite at smaller AD facilities for local combined heat and power (CHP)

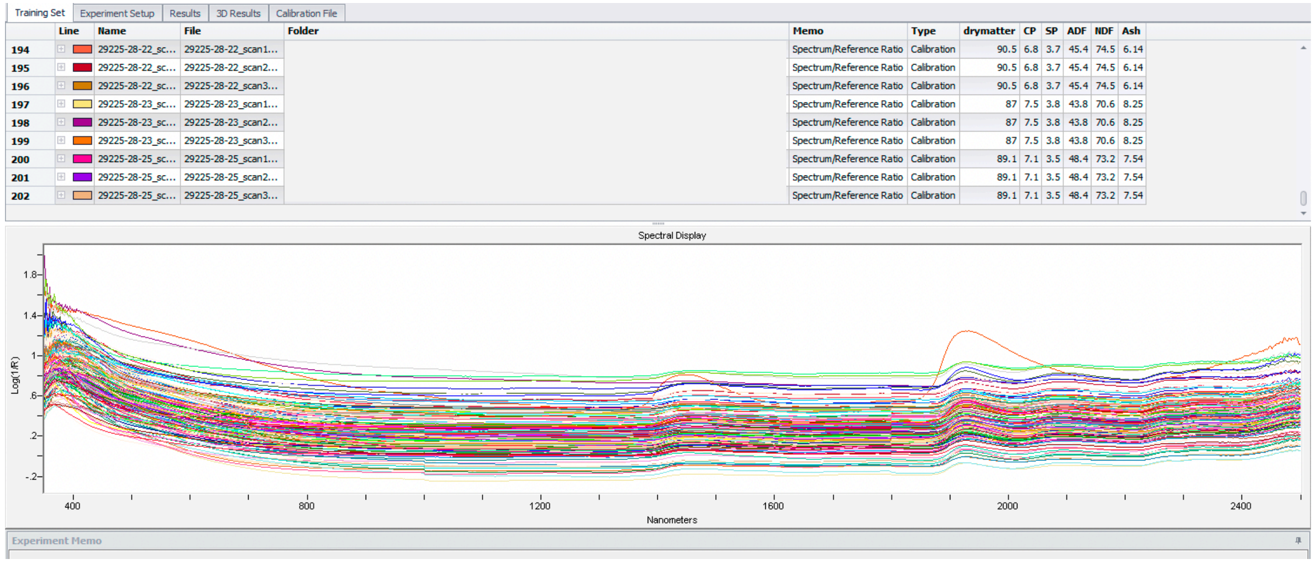


Renewable Natural Gas



Near Infrared (NIR)

- NIR utilises the absorption of electromagnetic radiation between 780 nm and 2,500 nm.
- Chemometric models can be generated for a range of applications.
- Minimal sample preparation; Non-destructive method; Real-time measurements.
- Custom NIR models allow for feedstock/digestate specific analysis.



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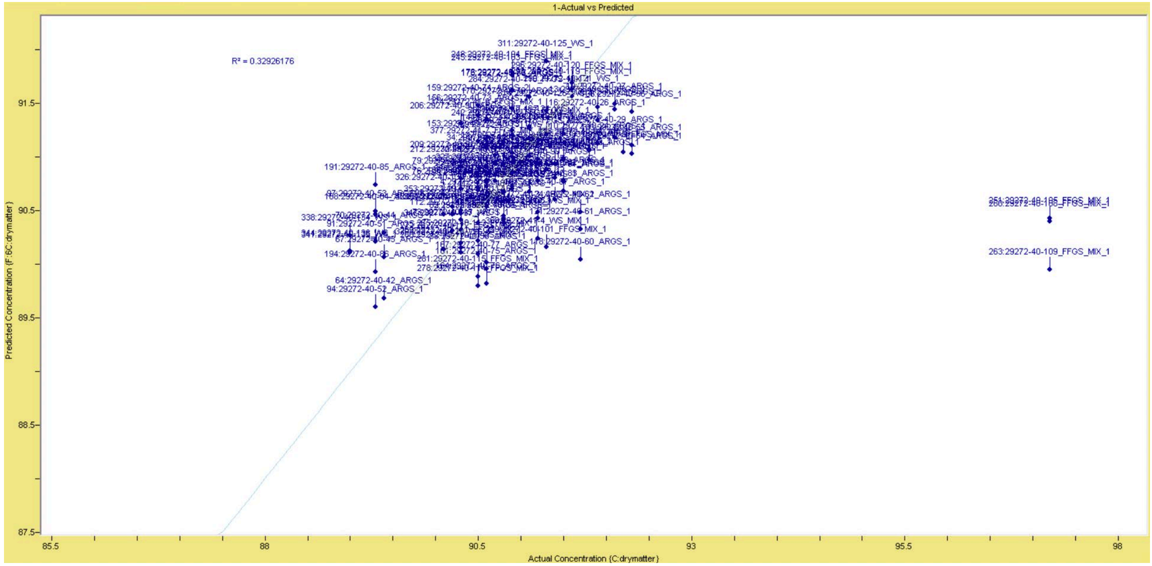
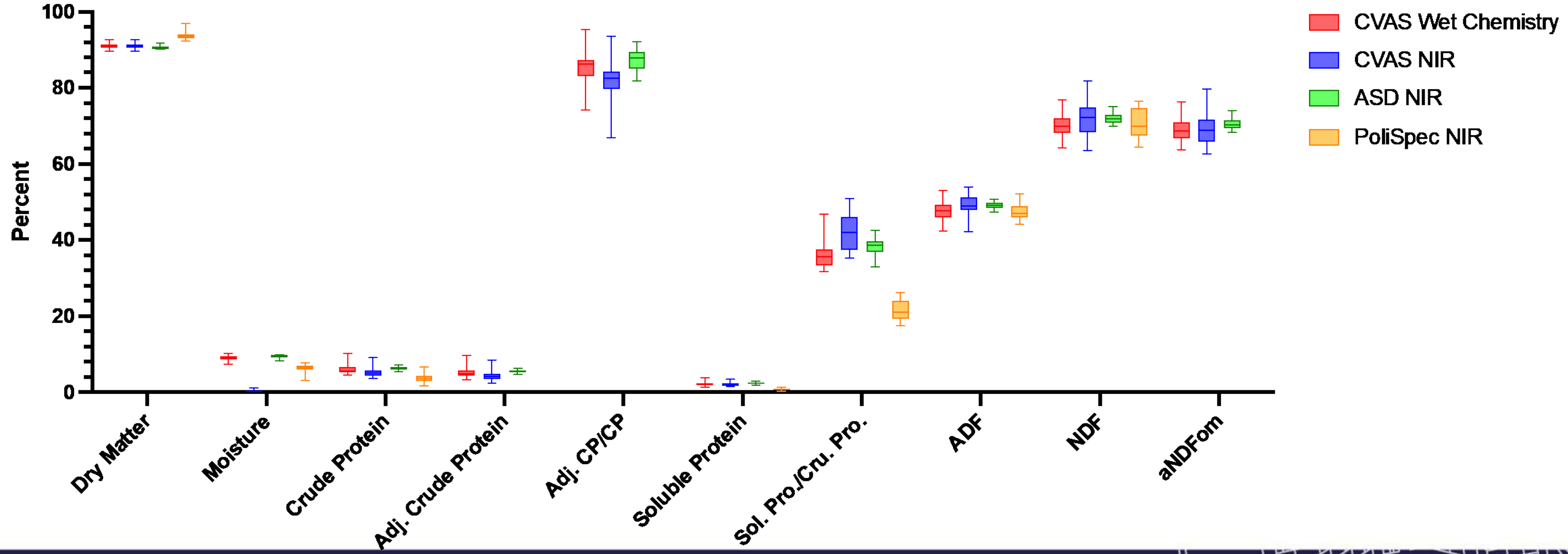
195		29225-28-22_sc...	29225-28-22_scan2...		Spectrum/Reference Ratio	Calibration	90.5	6.8	3.7	45.4	74.5	6.14
196		29225-28-22_sc...	29225-28-22_scan3...		Spectrum/Reference Ratio	Calibration	90.5	6.8	3.7	45.4	74.5	6.14
197		29225-28-23_sc...	29225-28-23_scan1...		Spectrum/Reference Ratio	Calibration	87	7.5	3.8	43.8	70.6	8.25
198		29225-28-23_sc...	29225-28-23_scan2...		Spectrum/Reference Ratio	Calibration	87	7.5	3.8	43.8	70.6	8.25
199		29225-28-23_sc...	29225-28-23_scan3...		Spectrum/Reference Ratio	Calibration	87	7.5	3.8	43.8	70.6	8.25
200		29225-28-25_sc...	29225-28-25_scan1...		Spectrum/Reference Ratio	Calibration	89.1	7.1	3.5	48.4	73.2	7.54
201		29225-28-25_sc...	29225-28-25_scan2...		Spectrum/Reference Ratio	Calibration	89.1	7.1	3.5	48.4	73.2	7.54
202		29225-28-25_sc...	29225-28-25_scan3...		Spectrum/Reference Ratio	Calibration	89.1	7.1	3.5	48.4	73.2	7.54



NIR in-house model evaluation

- Model tested on the samples that were held back from the model generation and compared with wet chemistry and alternative commercial NIR options.

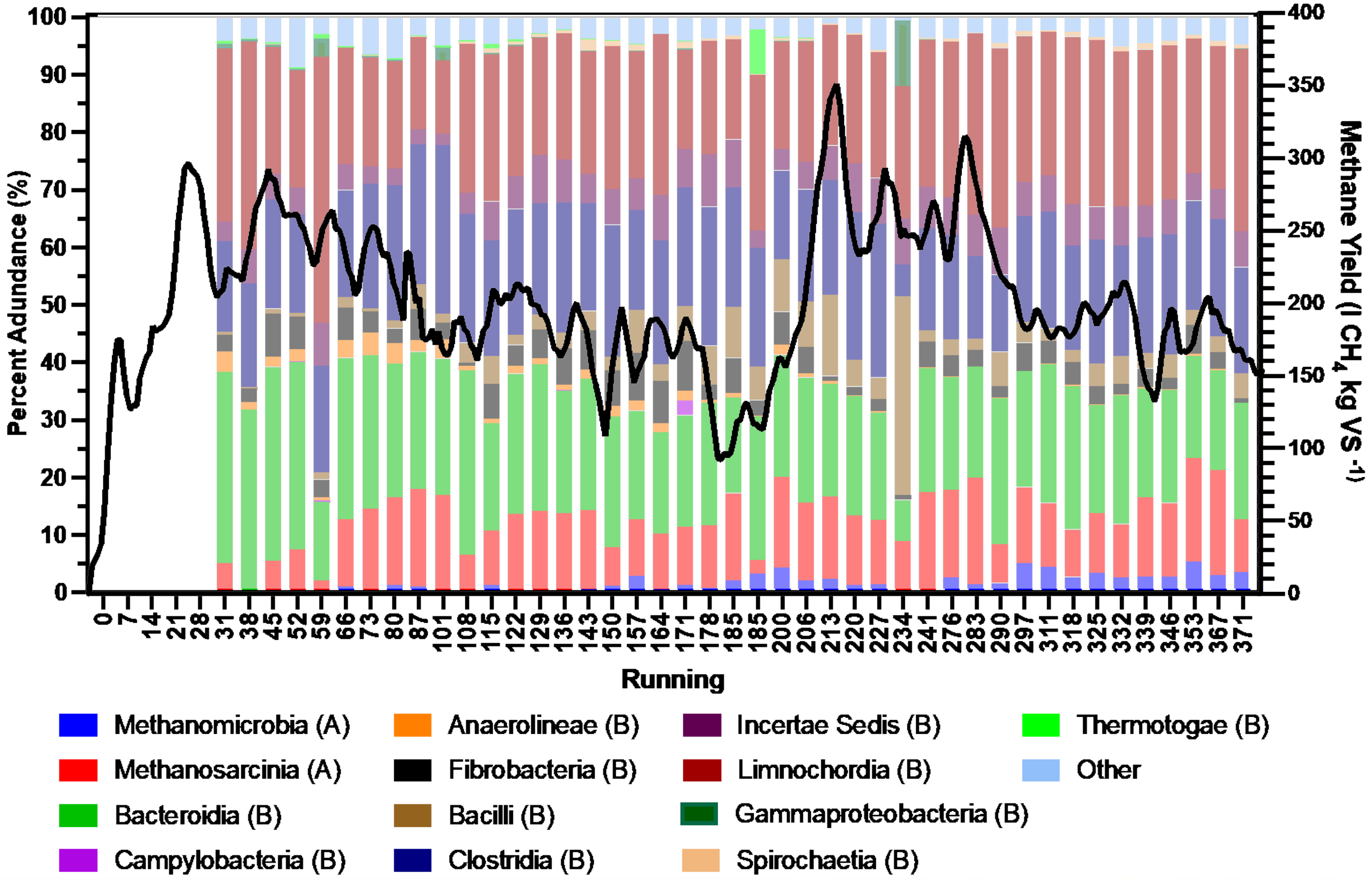


Metagenomics

- The microbiome is fundamental to anaerobic digestion
- Changes in the microbial community can have a direct effect on the methane yield from a digestor.
- The microbiome is established from the feedstock
    - Community can be altered by changes in feedstock, chemical additions, operating conditions or substrate availability
- There maybe more than one microbe that is responsible for a particular function; differing demography with a robust functionality.
- By understanding the microbiome, can we maximise methane production and monitor digester health?

Metagenomics

- Weekly samples were collected from a year long co-digestion AD.
- Amplicon sequencing was performed on all samples and WGS performed on selected samples throughout the operation.
- Taxa with an abundance greater than 1% displayed. Remaining combined as ‘Other’



Identifying key microbes

- Greater correlation between classified taxa and methane yield during a period of operational consistency.

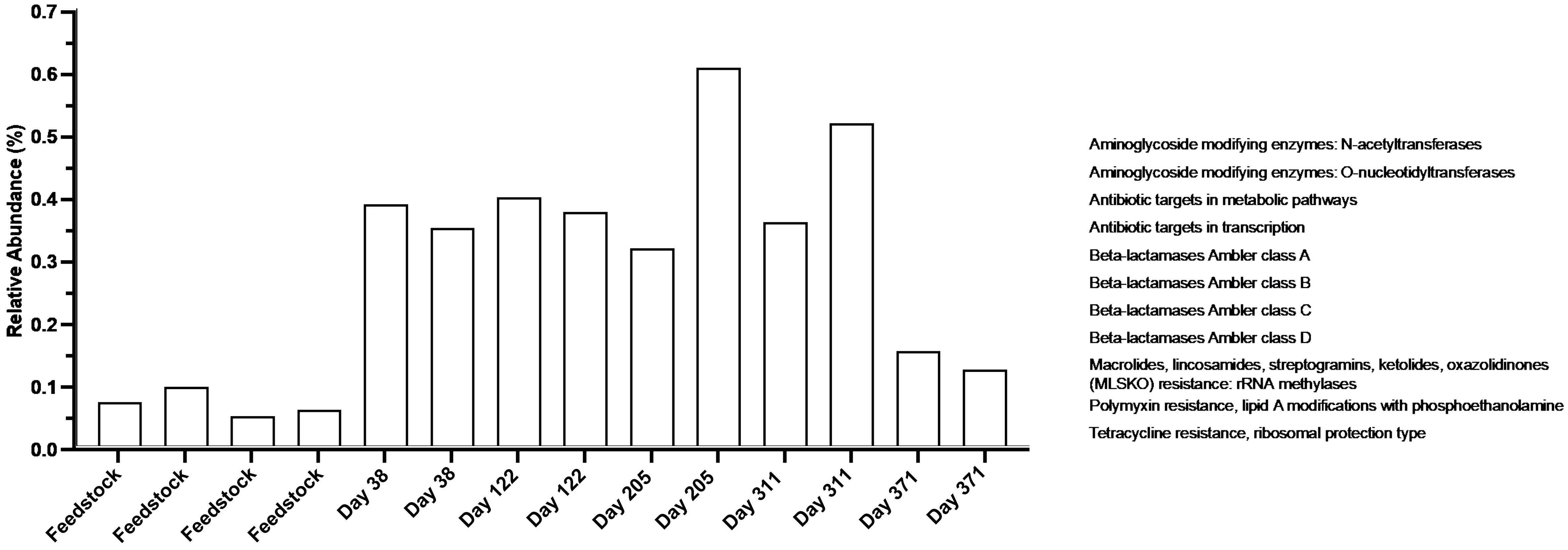
Entire operation

Taxa	Correlation with methane yield (5 day average)		
	0 day offset	7 day offset	14 day offset
Methanomicrobia (A)	0.206	0.031	-0.249
Methanosarcinia (A)	0.256	0.192	-0.001
Bacteroidia (B)	-0.105	0.049	0.185
Campylobacteria (B)	0.024	-0.096	-0.040
Anaerolineae (B)	-0.033	0.194	0.218
Fibrobacteria (B)	0.112	0.137	0.097
Bacilli (B)	-0.195	-0.359	-0.052
Clostridia (B)	0.168	0.043	-0.293
Incertae Sedis (B)	-0.115	-0.226	-0.276
Limnochordia (B)	-0.025	0.086	0.006
Gammaproteobacteria (B)	-0.187	-0.190	0.214
Spirochaetia (B)	0.012	-0.078	-0.121
Thermotogae (B)	0.002	-0.075	-0.012

Day 123 - 287

Taxa (during days 123 - 287)	Correlation with methane yield (5 day average)		
	0 day offset	7 day offset	14 day offset
Methanomicrobia (A)	0.462	0.302	-0.131
Methanosarcinia (A)	0.009	0.332	0.020
Bacteroidia (B)	0.366	0.343	-0.102
Campylobacteria (B)	0.015	-0.145	-0.012
Anaerolineae (B)	-0.028	-0.052	-0.255
Fibrobacteria (B)	0.254	0.285	0.034
Bacilli (B)	-0.431	-0.464	0.102
Clostridia (B)	-0.117	-0.240	-0.697
Incertae Sedis (B)	-0.133	-0.096	0.058
Limnochordia (B)	0.497	0.475	0.500
Gammaproteobacteria (B)	-0.359	-0.383	0.346
Spirochaetia (B)	0.229	0.215	0.013
Thermotogae (B)	-0.018	-0.155	0.002

Metagenomics – AMR



Summary

- NIR provides rapid, non-destructive analysis of both feedstock and digestate samples.
- Custom feedstock and digestate models can be generated and despite their limited sample size and diversity, the models are in good agreement with the wet chemistry data.
- Anaerobic digestion comprises of a dynamic microbial community that is in constant flux with a variety of biotic and abiotic parameters.
- 13 taxa (Class) account for 95% of the microbiome
- When breaking the pilot down into sections, positive correlations between methane yield and the Bacterioidia (Acidogens) and Limnochordia (Acetogens) are also observed
  - Correlations observed in methane yield 7 days later – *early indicators*?
- Changes in abundance of AMR genes are observed but more samples and replicates needed to perform robust analyses.

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Prof Prathyush Menon

Centre for Future Clean Mobility, University of Exeter

Short response 2: Biomethane and transportation

UNIVERSITY OF EXETER | Centre for Future Clean Mobility

Net-Zero Farming

24th June 2022

Towards Zero Emission Sustainable Transport

Prof Prathyush P Menon, University of Exeter

UNIVERSITY OF EXETER | Centre for Future Clean Mobility

What we do, and who we work with

- Innovation, design, assembly & test of zero emissions powertrains for land, sea and air.
- Smart AI capabilities in powertrains, navigation, and control
- More than 30 companies currently work with CFCM, for accelerated innovation in clean powertrains.
- Heart of the Southwest LEP investment in CFCM to establish facility.

babcock

BMT

QUATTRO Group

LYNCH Electric Motors

TEIGNBRIDGE

Select

SIEMENS

emPARTS

durapower

ECOMAR PROPULSION

Sc Group

O.S.Energy MARINE POWER SOLUTIONS

MSubs Ltd underwater vehicles & equipment

Harland & Wolff

DANA

SOLIS MARINE CONSULTANTS

Logan Energy hydrogen technologies

BOSCH Invented for life

NetworkRail

CITY SCIENCE endless possibilities

UTE Ltd

ktn KTP BEST OF THE BEST AWARDS 2020

serco

heart of the south west local enterprise partnership

PUNCH | Flybrid

University of Strathclyde Glasgow

UKRI Innovate UK

Office for Zero Emission Vehicles

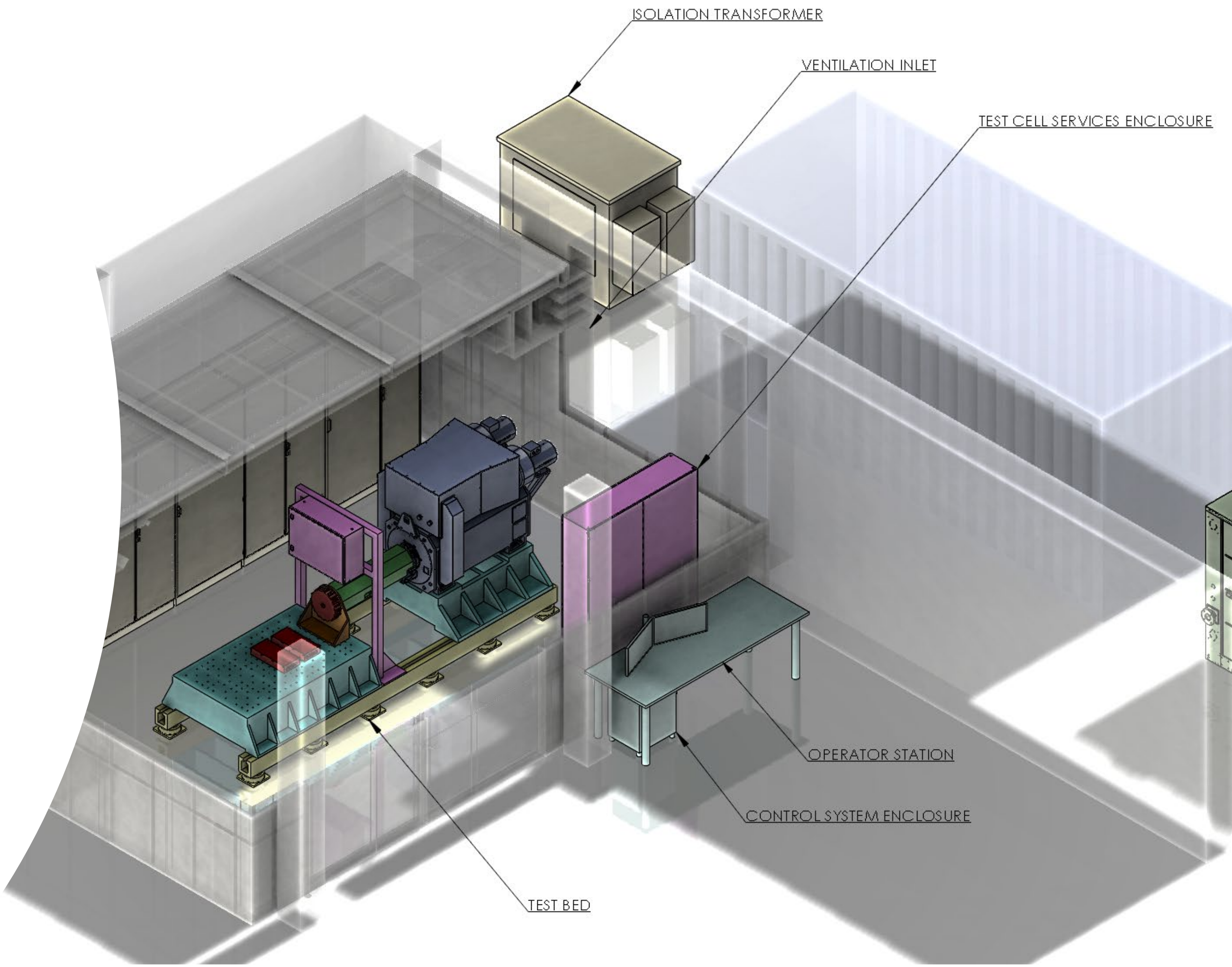
INDUSTRIAL STRATEGY

UNIVERSITY OF PLYMOUTH

UNIVERSITY OF EXETER | Centre for Future Clean Mobility

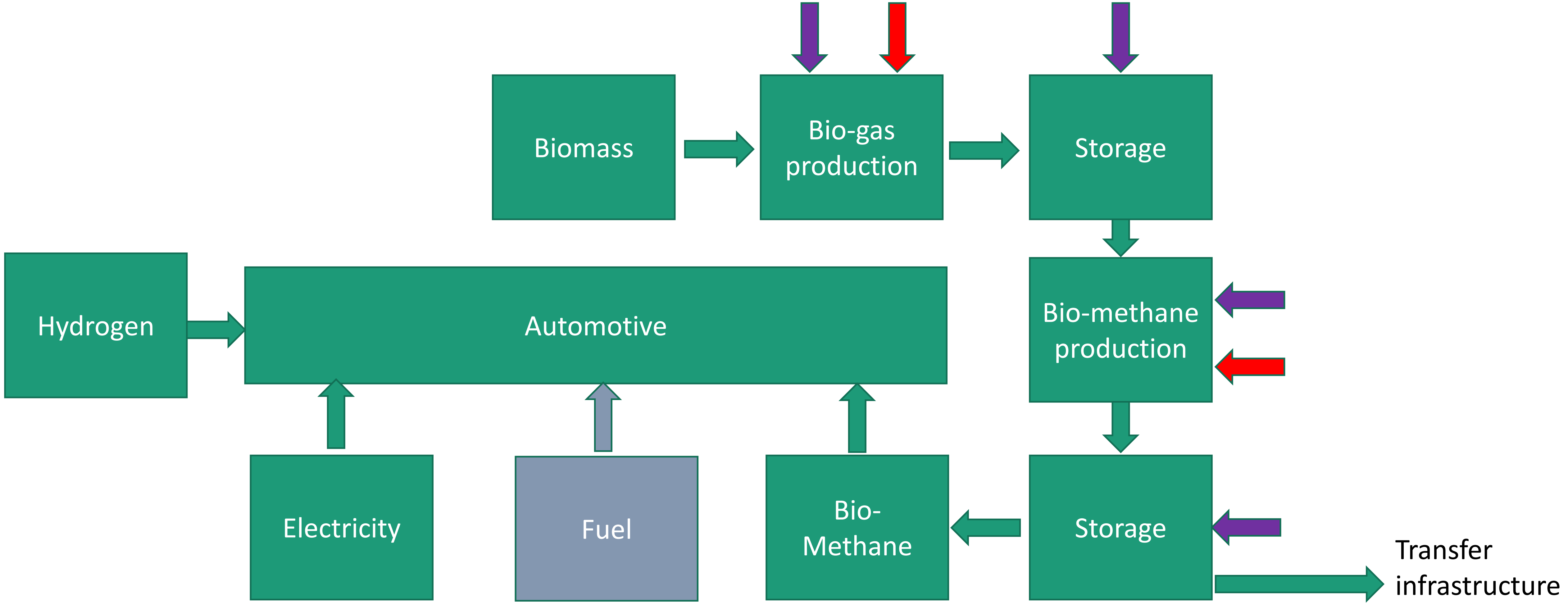
Our interests

- **Fundamental research on zero emissions powertrains for large, complex, long endurance assets.** The second generation of electrification.
- **Clean Powertrain design and test** for optimal efficiency, performance, range and through life costs
- **Autonomous systems,** including live data assisted propulsion systems
- **Powertrain assembly & test facility** up to 750 kW (900 kW peak) powertrain dynamometer; Dynamic duty cycle play (can be gathered from respective type Farm vehicle) back to powertrain.
- Test and verification of powertrain designs & optimised control strategies for efficiency and low cost

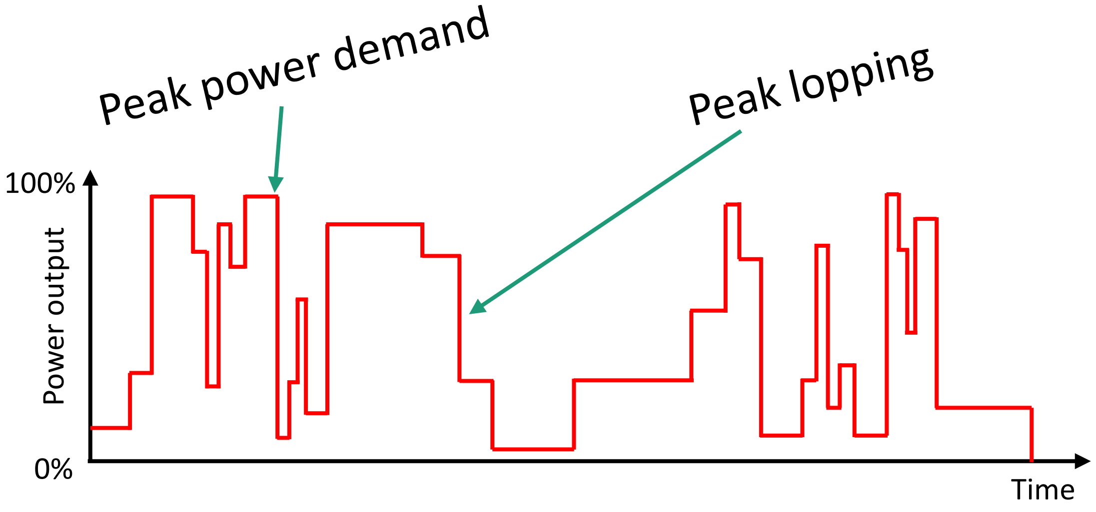


Centre for Future Clean Mobility

Towards lowering emissions



Design Process:



Control strategy of how to deliver required power is key to reducing energy use (cost)
- Peak lopping and other strategies

Stage 1: understand use requirements

Stage 2: assemble all possible clean powertrains

Stage 3 run the duty cycle through each powertrain (+diesel, possibility with biofuel)

Stage 4: choose best configurations

Stage 5: price (BoM), weights, dimensions, constraints

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Team

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TBC
Postdoctoral researcher

MATT HARVEY
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TBC
Administrator

Thank you

Contact

p.m.prathyush@exeter.ac.uk

Q&A / Comfort break / Coffee

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Prof Iain Hartley

University of Exeter

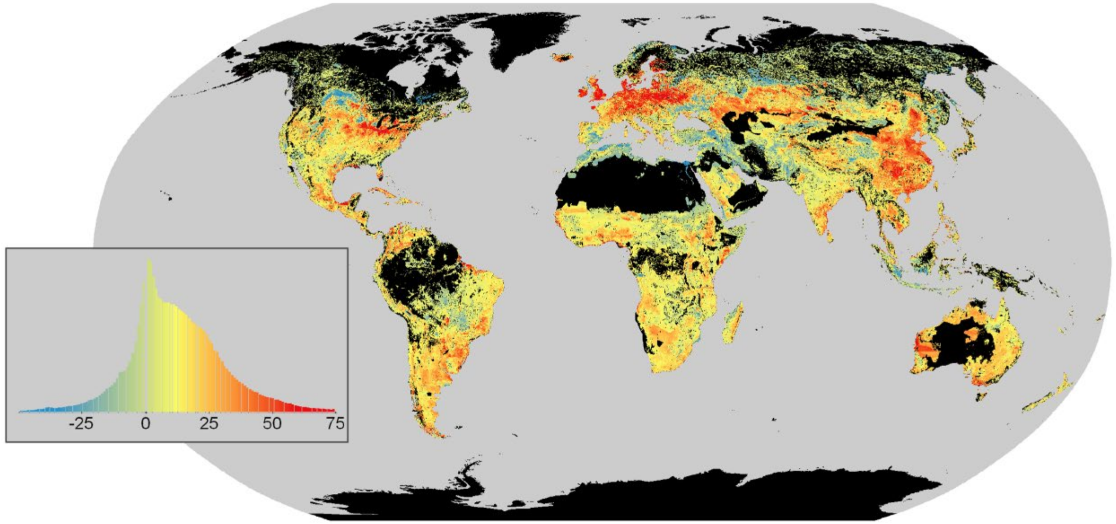
A paradigm shift in our understanding of soil carbon dynamics and potential implications for soil management

A paradigm shift in our understanding of soil carbon dynamics and potential implications for soil management

Iain Hartley, Geography, University of Exeter

Why increase soil carbon?

- Soils have lost >130 billion tonnes of carbon due to farming (pasture and arable)
- Restoring some of this lost carbon could be a strategy for climate change mitigation
- Organic matter in soils delivers many other key ecosystem services
  - Nutrient cycling
  - Water retention
  - Erosion reduction



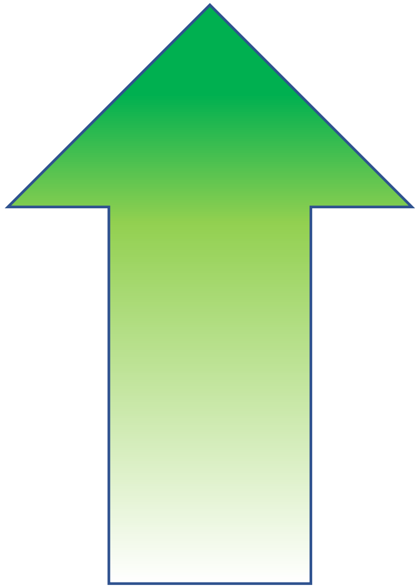
SOC change in the top 2m (Mg C·ha^{-1}); positive values indicate SOC losses

Sanderman et al. 2017 PNAS

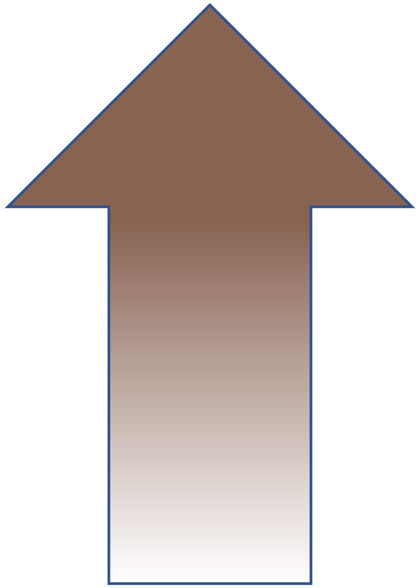
Conventional model of soil carbon storage

- Carbon storage = balance between inputs and outputs
- Inputs are determined by plant productivity or management
- Outputs are determined by the quality/decomposability of the inputs and environmental factors (e.g. temperature and moisture)

How do you increase soil C storage?



Increase rate of carbon input



Add low quality organic matter

New Paradigm

- Carbon storage = balance between inputs and outputs
- Inputs are determined by plant productivity or management
- Outputs are determined by the accessibility of organic matter to microbes (and environmental factors)
- Stabilisation and protection of carbon is controlled by soil properties

How do you increase soil C storage?

Increase rate of C input

Add high quality organic matter?

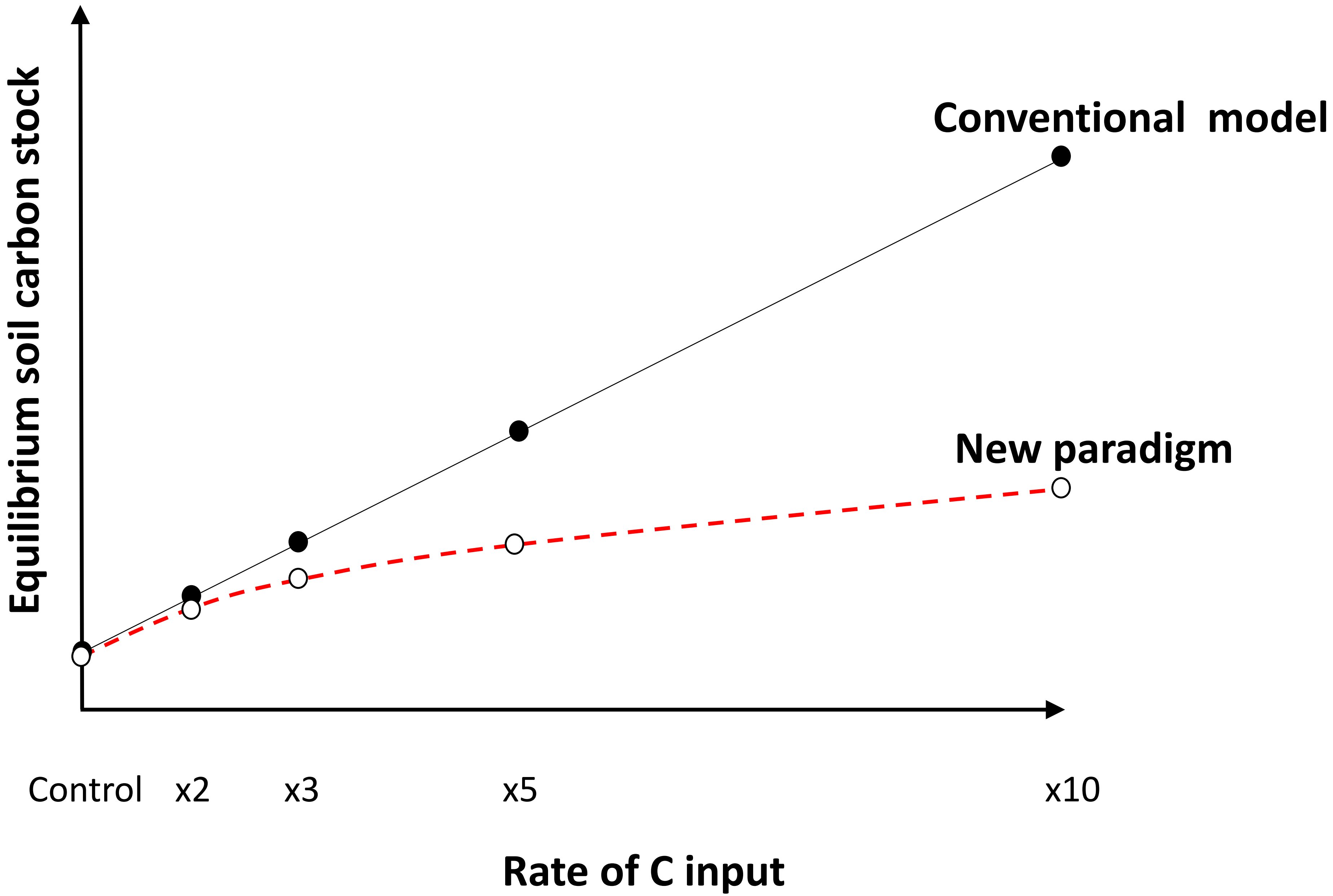
Increase soil stabilisation capacities

How do you increase soil C storage?

Increase rate of
C input

Add low quality
organic matter

In carbon-saturated soil, we return to the classical view but with reduced efficiency of carbon sequestration



Equilibrium soil carbon stock
Conventional model
New paradigm
Control
x2
x3
x5
x10
Rate of C input

Implications for managing soil carbon

- Greater carbon sequestration potential from lower rates of carbon input to larger areas:
  - Increase area receiving organic amendments, but impractical?
- Can soil stabilisation capacities be increased?
  - Avoid/minimise physical disturbance
  - Increasing rooting depth – subsoils are undersaturated in C
- Is tillage always a bad thing?
  - Is there a role for infrequent but deep tillage?

Conclusions

1. Almost all organic compounds can decompose rapidly in the right conditions
2. The majority of organic matter in soils is microbially derived

- Efficient processing and subsequent stabilisation of carbon inputs are key to promoting high rates of soil carbon sequestration

- Can this new understanding be used to identify ways of increasing soil carbon storage?

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Dr Hannah Jones

Farm Carbon Toolkit

Measuring and managing carbon on farm

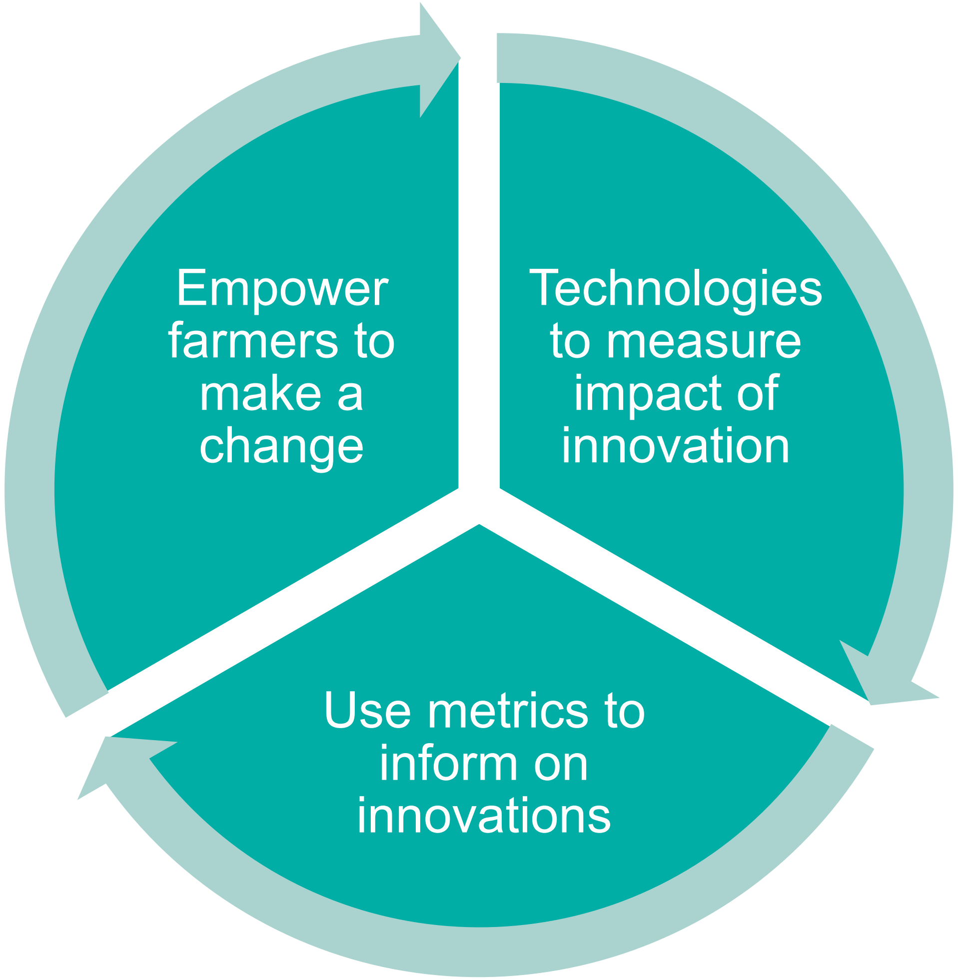
exeter.ac.uk/**esi**

Working with natural systems for sustainable futures

Farm Carbon Toolkit

Measuring and managing carbon on farm

Hannah Jones


Empower farmers to make a change
Technologies to measure impact of innovation
Use metrics to inform on innovations

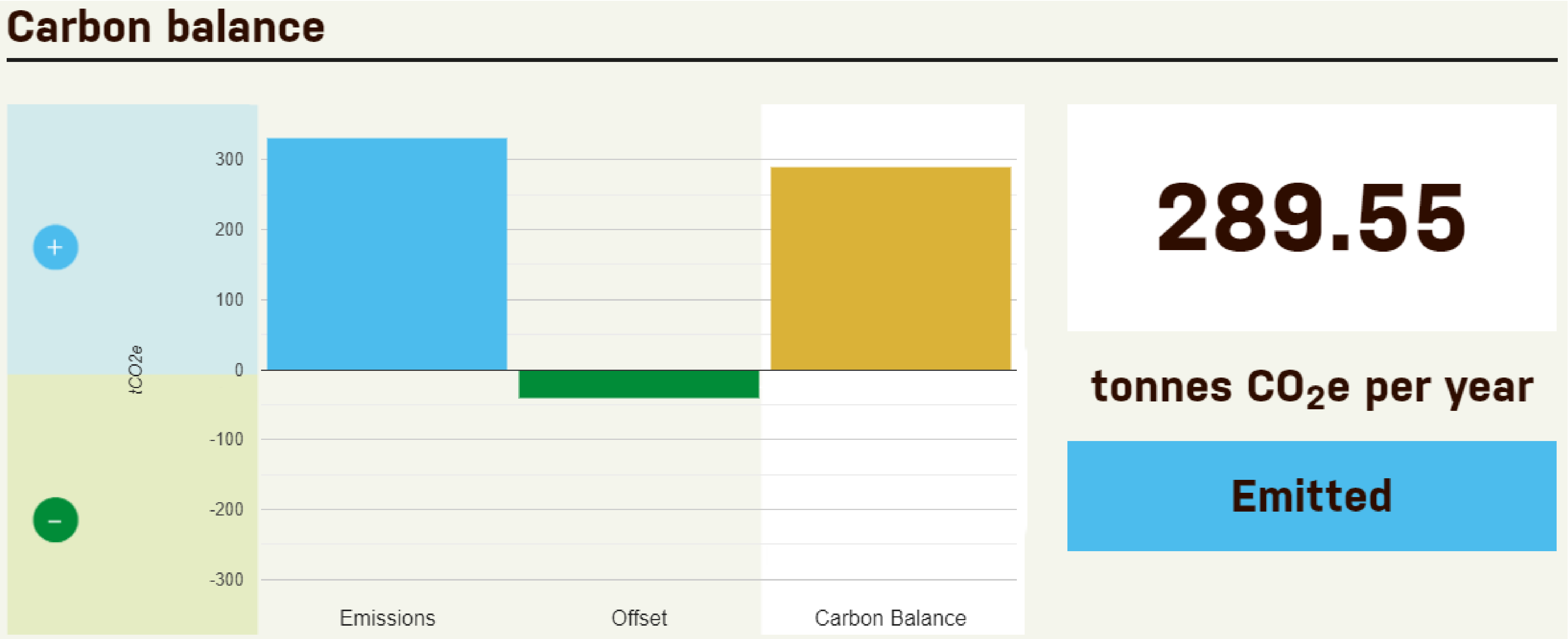
Opportunities for change

Measuring change

Farm Carbon Toolkit

Image from breedr.co.uk

The carbon budget – basic concept



The Farm carbon calculator:

https://calculator.farmcarbontoolkit.org.uk/

Individual farms

Emissions	tonnes CO_2e	%
Fuels	64.54	10.96%
Materials	6.26	1.06%
Inventory	18.41	3.13%
Crops	51.60	8.76%
Inputs	193.30	32.82%
Livestock	254.39	43.19%
Waste	0.46	0.08%
Total	**588.96**	**100%**

Offset	tonnes CO_2e	%
Field Margins (Uncultivated)	-0.59	0.43%
Habitats	-15.26	11.07%
Hedgerows	-17.51	12.71%
Woodland	-104.45	75.79%
Total	**-137.83**	**100%**

Emissions	Emissions by Scope				By GHGs			Total tCO₂e
	Scope 1 tCO_2e	Scope 2 tCO_2e	Scope 3 tCO_2e	Outside of Scope tCO_2e	CO_2 tCO_2e	CH_4 tCO_2e	N_2O tCO_2e	
Fuels	44.14	11.07	36.63	0.00	91.83	0.00	0.00	**91.83**
Materials	0.00	0.00	5.35	0.00	5.35	0.00	0.00	**5.35**
Inventory	0.00	0.00	18.92	0.00	18.92	0.00	0.00	**18.92**
Crops	7.92	0.00	0.00	0.00	-21.98	0.00	29.90	**7.92**
Livestock	1,015.52	0.00	521.92	0.00	852.47	0.19	684.78	**1,537.44**
Total	**1,067.58**	**11.07**	**582.81**	**0.00**	**946.59**	**0.19**	**714.68**	**1,661.46**

Total Emissions/hectare/year

Current report figure

10.86 kg CO_2e

Benchmarked average

6.89 kg CO_2e

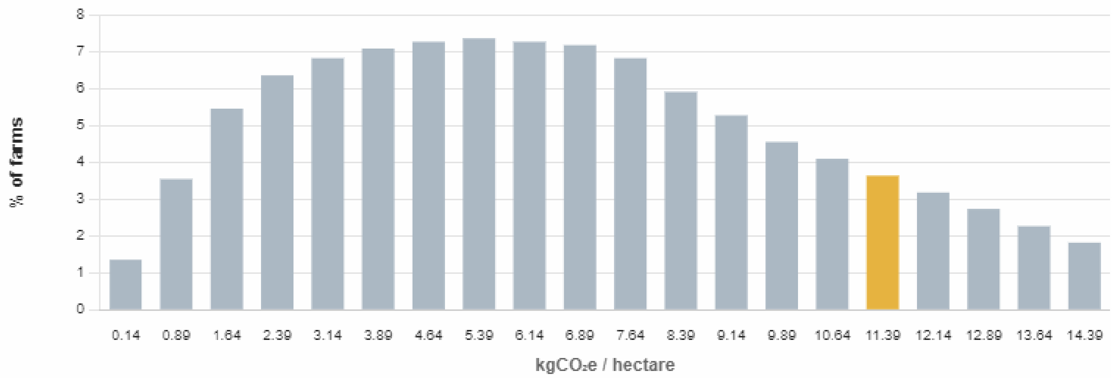
Total Emissions/kgFCPM/year

Current report figure

1.16 kg CO_2e

Benchmarked average

1.36 kg CO_2e



Dairy - Total Emissions per kgFCPM

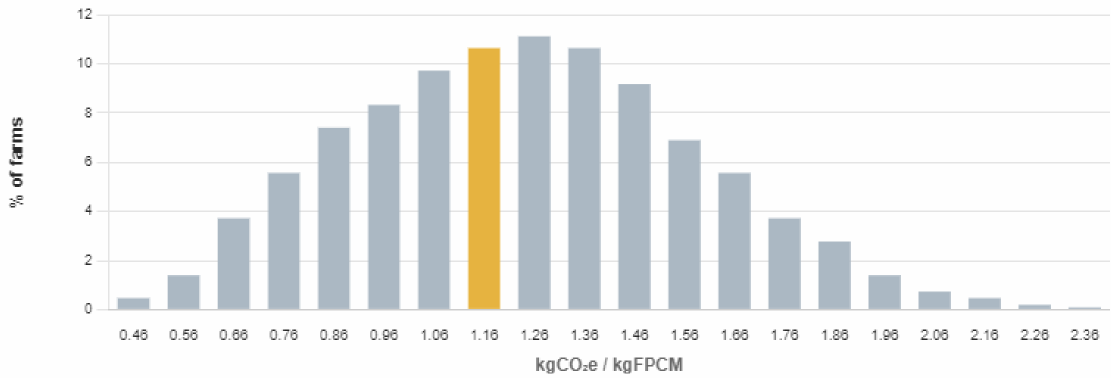


Table 1. Performance indicators for current and future dairy systems

	Current old model	Current new model	Target
Stocking rate (LU/ha)	2.1	2.1	2.7
Fat plus protein (kg/ha)	866	866	1,222
Replacement rate (%)	26	26	18
Calving rate (% calved in six weeks)	65	65	90
Fertiliser N (kg N/ha)	186	186	150
Grass utilized (t DM/ha)	7.3	7.3	12.1
Concentrate intake (kg DM/cow)	1,025	1,025	450
LESS spreading (% slurry applied)	10	10	100
Protected urea (% N applied)	-	-	100
GHG intensity (kg CO_2-eq/kg FPCM)	1.12 (0.95)[1]	0.99 (0.82)	0.74 (0.62)
GHG intensity (kg CO_2-eq per ha)	10,714 (9,111)	9,465 (7,862)	10,498 (8,832)

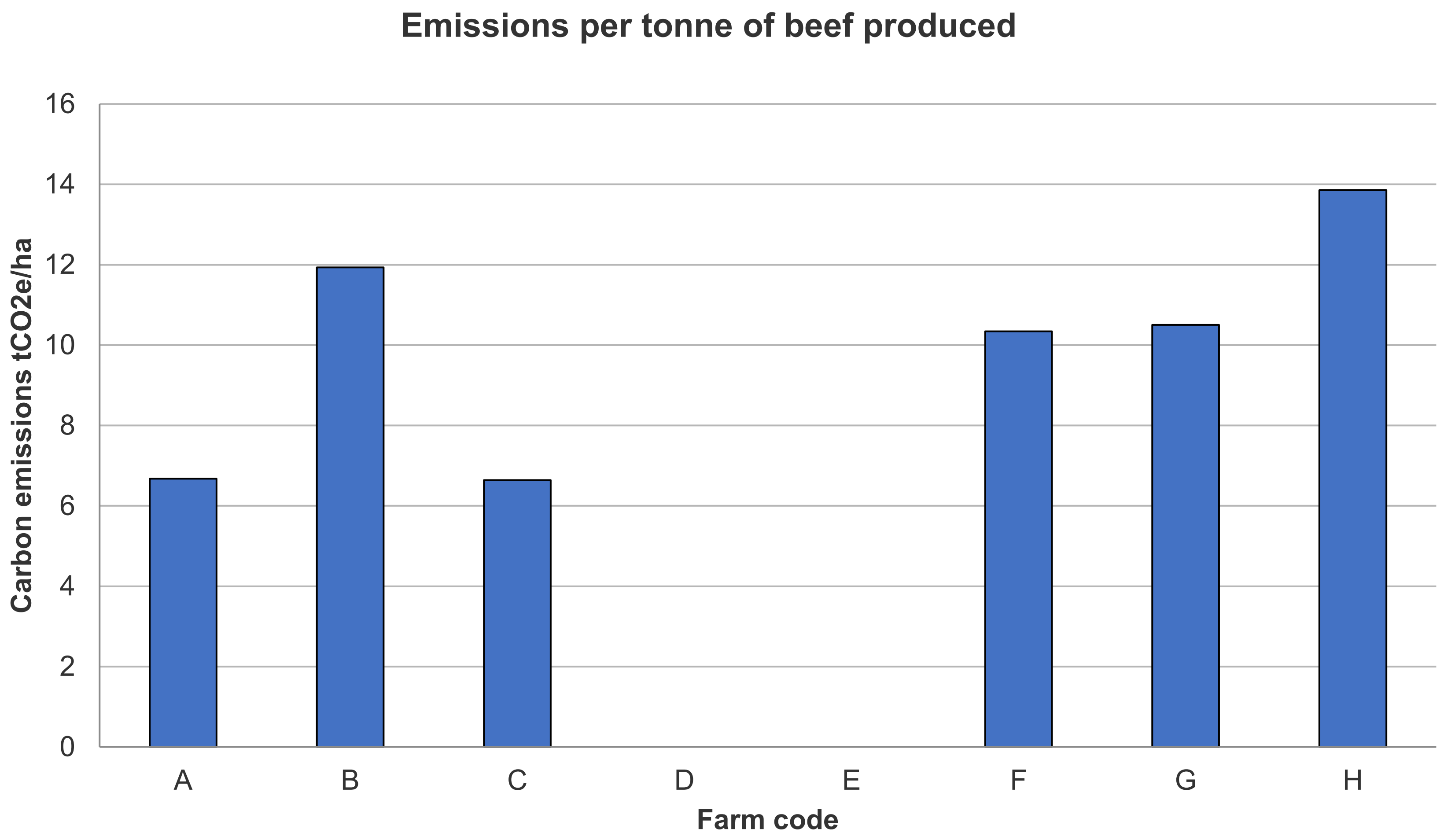
[1]*500 kg carbon sequestered per ha*

Taken form Heron & al 2021, Greenhouse gas emissions from dairy production in Ireland, Moorepark conference proceedings

Learning and communication

- Workshops
- Field walks
- Cooperative learning
- Benchmarking
- Factsheets
- Bespoke session
- Videos

Farm benchmarking



Adapting to the future

Future challenges for measuring change:

- Technical expertise on farm
- Remote sensing
- Hardware
- Ecological impacts
- Animal health expertise

and integrating a change in

We work with a range of partners to address the challenges of measuring and reducing emissions on farm.

Peer-reviewed data is added to the carbon calculator

The impacts is large and immediate!

Farm Carbon Toolkit

Thank you for listening!

www.farmcarbontoolkit.org.uk

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Prof Richard Titball

University of Exeter, Entec Nutrition Ltd.

Thinking about animal feed

exeter.ac.uk/**esi**

Working with natural systems for sustainable futures

Thinking about animal feed

Richard W Titball

Emeritus Professor of Molecular Microbiology, University of Exeter

Chief Scientific Officer, Entec Nutrition Ltd

entec nutrition

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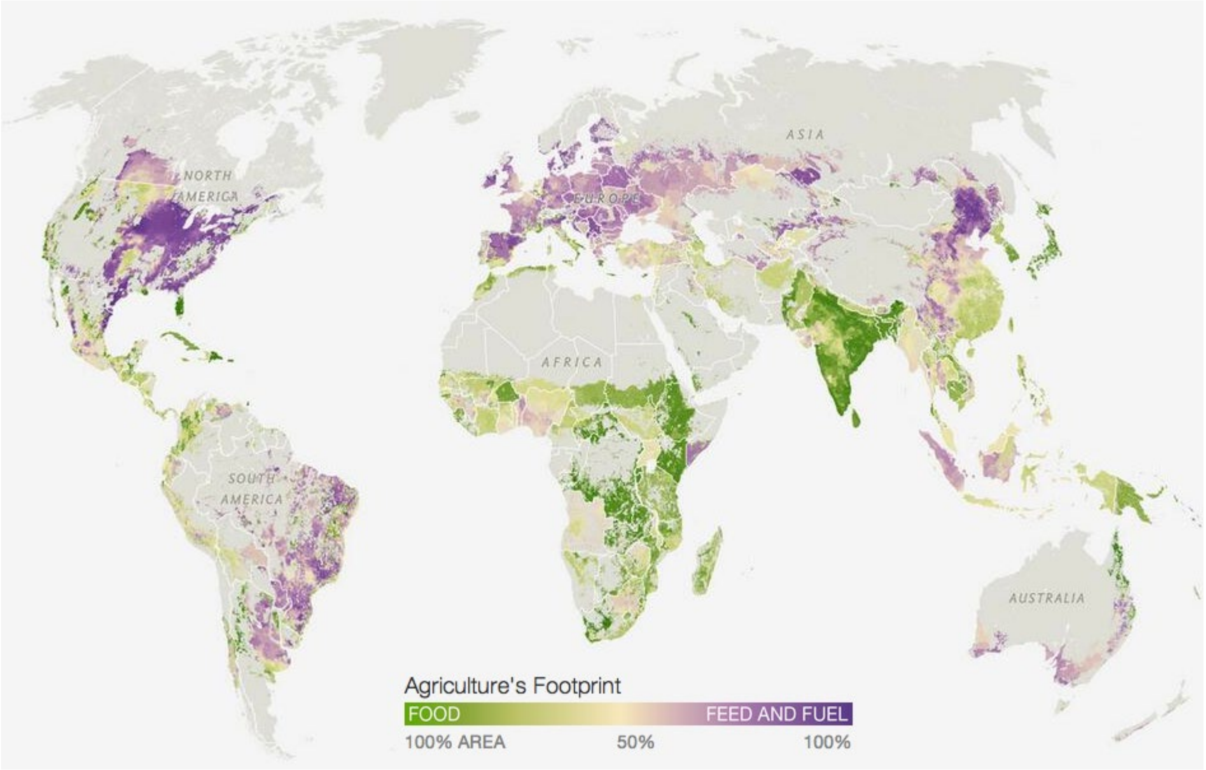
Crops grown for food, animal feed and fuel



- 55% of crops are human food
- 36% animal feed
- 9% biofuels and industrial uses

Source National Geographic

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The demand for meat is increasing

- Demand for meat has tripled in the developing world in the past 40 years
- The demand for crops to feed livestock will double by 2050

Corn production in Brazil. Most of this is exported for poultry and pig production

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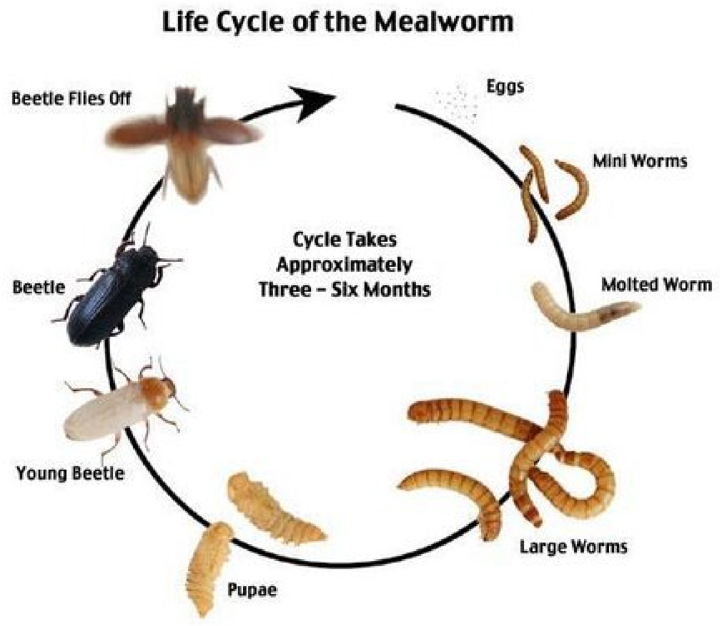
Could insects replace crops as animal feed?



Dried
Mealworms
(Tenebrio molitor)

Ÿnsect (France) "FARMYNG" facility capable of producing 200,000T mealworms

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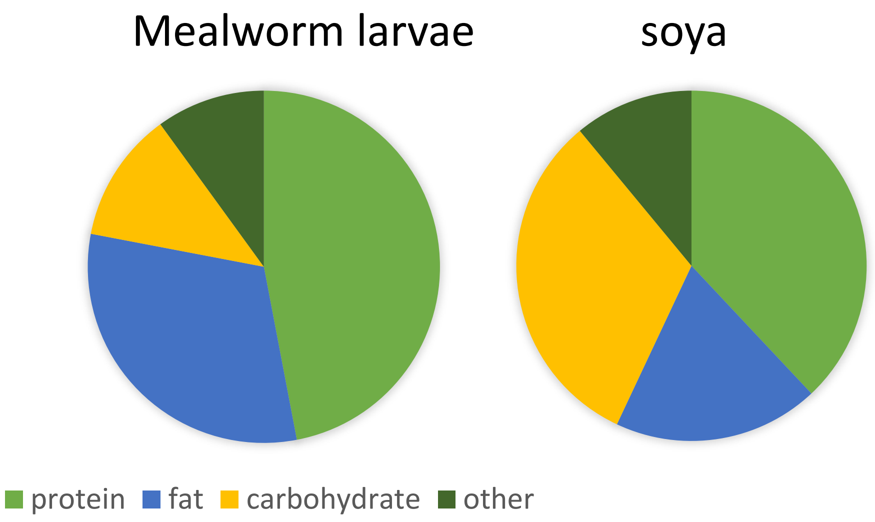
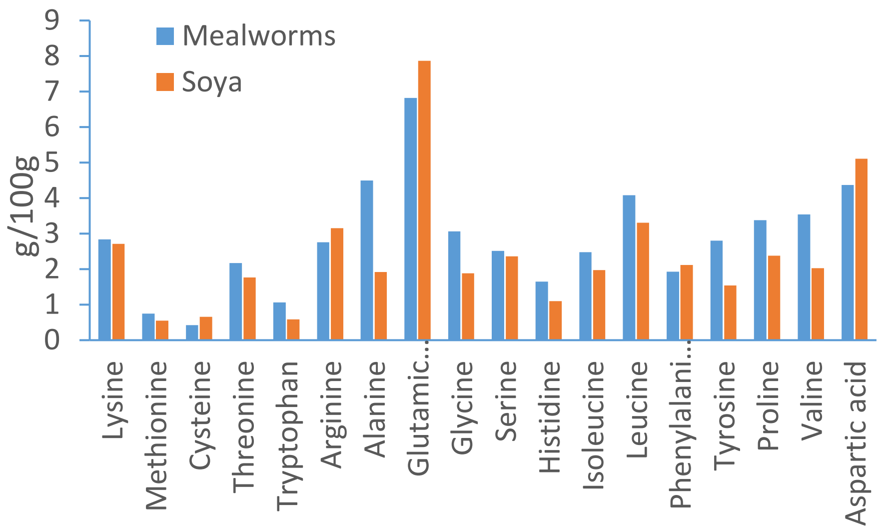
Could insects replace crop-derived proteins?





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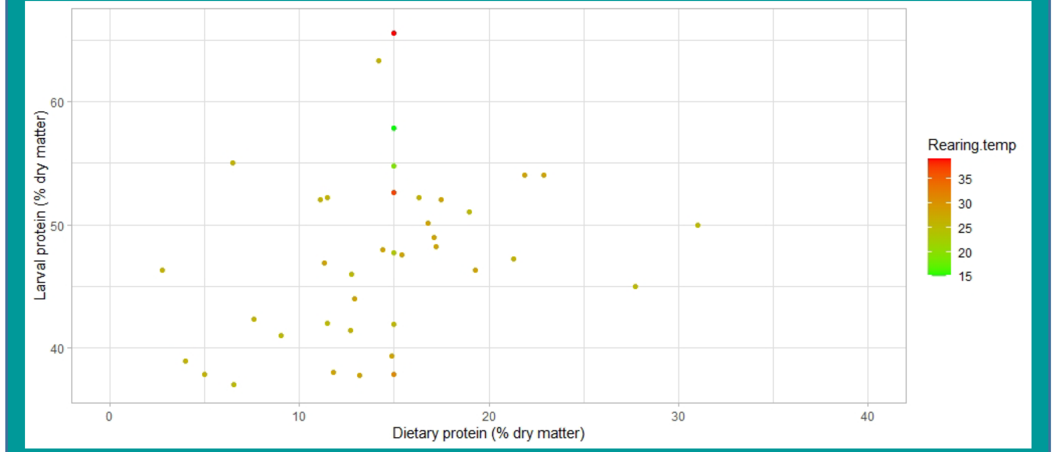
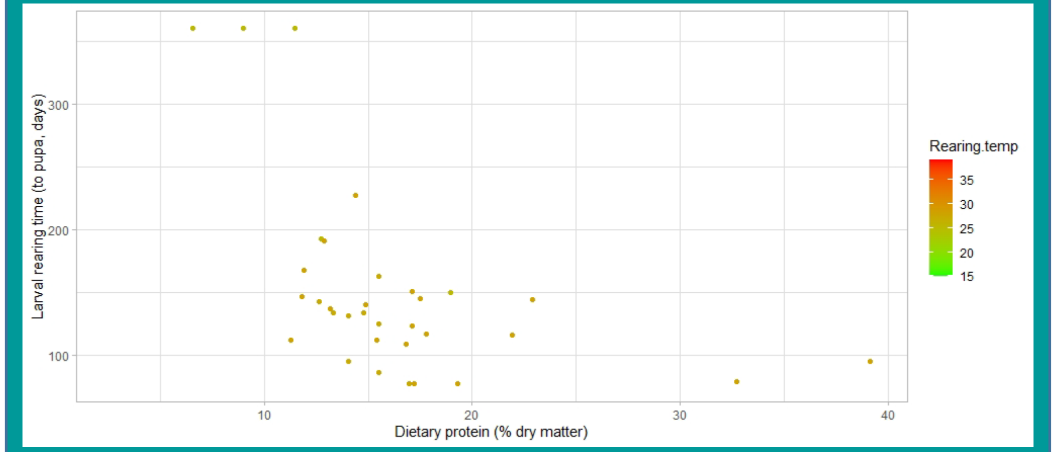
Food for insects

Mealworms can be reared on brewer's spent grains which are a waste product from the brewing industry.

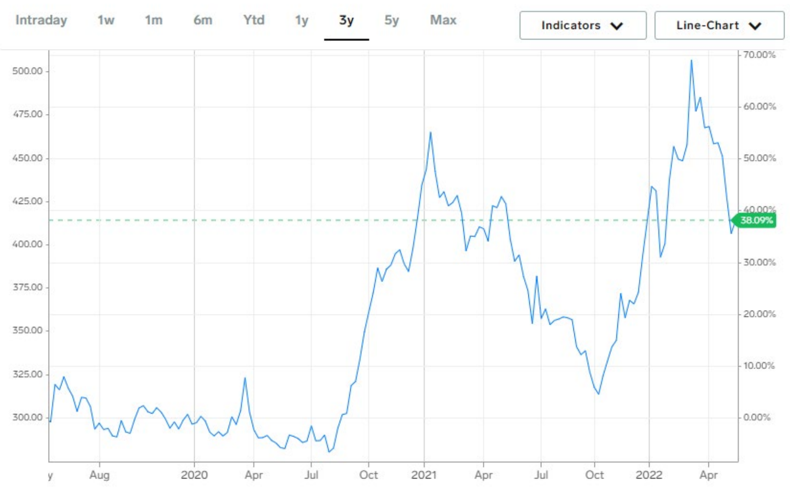
Nutritional geometry to select mealworm diets





But, insect protein is not currently price competitive;

- The current price of soya meal is £420/tonne.



- We calculate the cost of producing 1 tonne of mealworm meal is >£2,000/tonne.

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More than just a soya replacement……….

- **Dried and ground mealworms feed added at 0.3% – 5% to poultry**
- **No correlation between additive level and growth rate/FCR**

	IFA added	Weight gain	FCR change
	0.3%	+3.5%	=
	1%	+14%	9.5%
	4%	+2.4	=
	5%	+11%	=

"The variability of the results obtained in the previous studies may be related to the nutritive value of the insect meal used, which can be influenced by the species, the insect life stage and the insect rearing substrate" (Biasato *et al*. 2017)

How do insect supplements promote growth?

- Increase feed palatability?
- Beneficially change gut flora?
- Protect against disadvantageous microbes in the gut?
- Reduce stress behaviours?

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European Regional Development Fund
Investing in your Future

convergence for economic transformation

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Working with natural systems for sustainable futures

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Lunch

- Those on pre booked coach to Bennamann, please be ready to leave at 1.30pm just outside the ESI