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CASE
Centre For Advanced Sustainable Energy

UTILISING NI'S AGRICULTURE SECTOR TO DECARBONISE HEAT

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DECARBONISATION OF HEAT

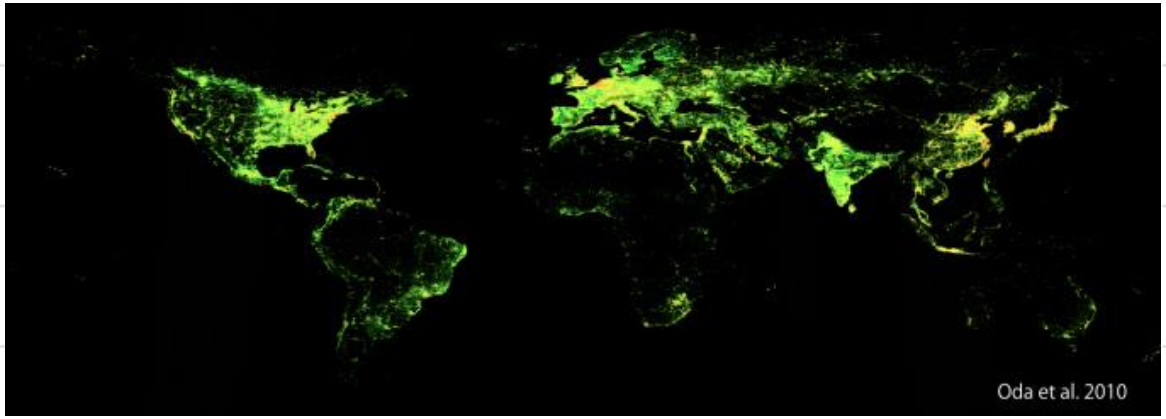
DAVID ROONEY

PROFESSOR

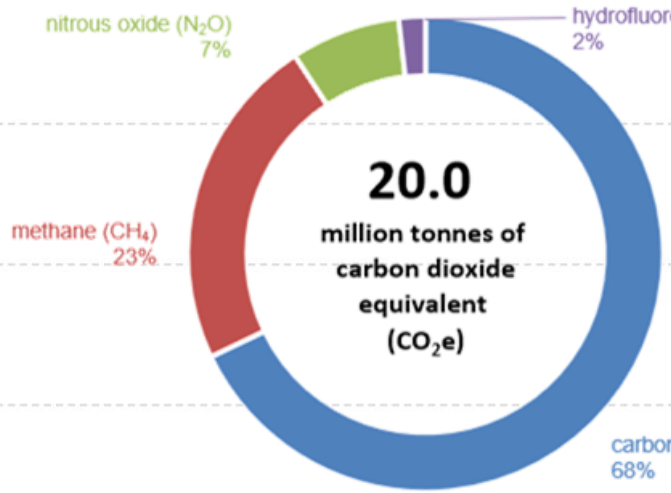
9th May 2022

Annual CO_2 emissions from fossil fuels, by world region

Our World in Data



Greenhouse gas emissions by gas
Northern Ireland,



THE CHALLANGE

Source: Global Carbon Project
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY
Note: This measures CO_2 emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.

Climate Change Committee

The UK's independent adviser on tackling climate change

Edwin Poots MLA
Minister of Agriculture, Environment and Rural Affairs
Dundonald House
Upper Newtownards Road
Ballywiscaw
Belfast BT4 3SB

Climate Change Committee
1 Victoria Street,
Westminster, London,
SW1H 0ET
w theccc.org.uk

24th March 2022

Dear Edwin,

My Committee has followed the progress of climate legislation through the Northern Ireland Assembly closely. Now that the Climate Change Bill has been passed, I write to highlight the implications of the new legislation and to offer the Climate Change Committee's full support in its achievement.

Our assessment of feasible pathways for the UK led us previously to recommend that Northern Ireland should aim for an 82% reduction in greenhouse gas emissions by 2050. We assessed that to be the appropriate contribution to the UK's Net Zero 2050 target, reflecting the specific circumstances in Northern Ireland. The new target of Net Zero greenhouse gas emissions by 2050 goes well beyond our recommendation, but we commend the ambition. The priority is now to deliver the statutory goal.

Northern Ireland's first carbon budget period, 2023 to 2027, starts in less than 10 months. The implication of the new 2050 target is that Northern Ireland must outperform all of five of the Net Zero Pathways that my Committee developed for our advice on the 6th UK Carbon Budget, requiring a major step-up in policy and rapid progress over the 2020s.

It may be instructive to consider the implications of our previous advice. These might now be considered minimum requirements under the new legislation:

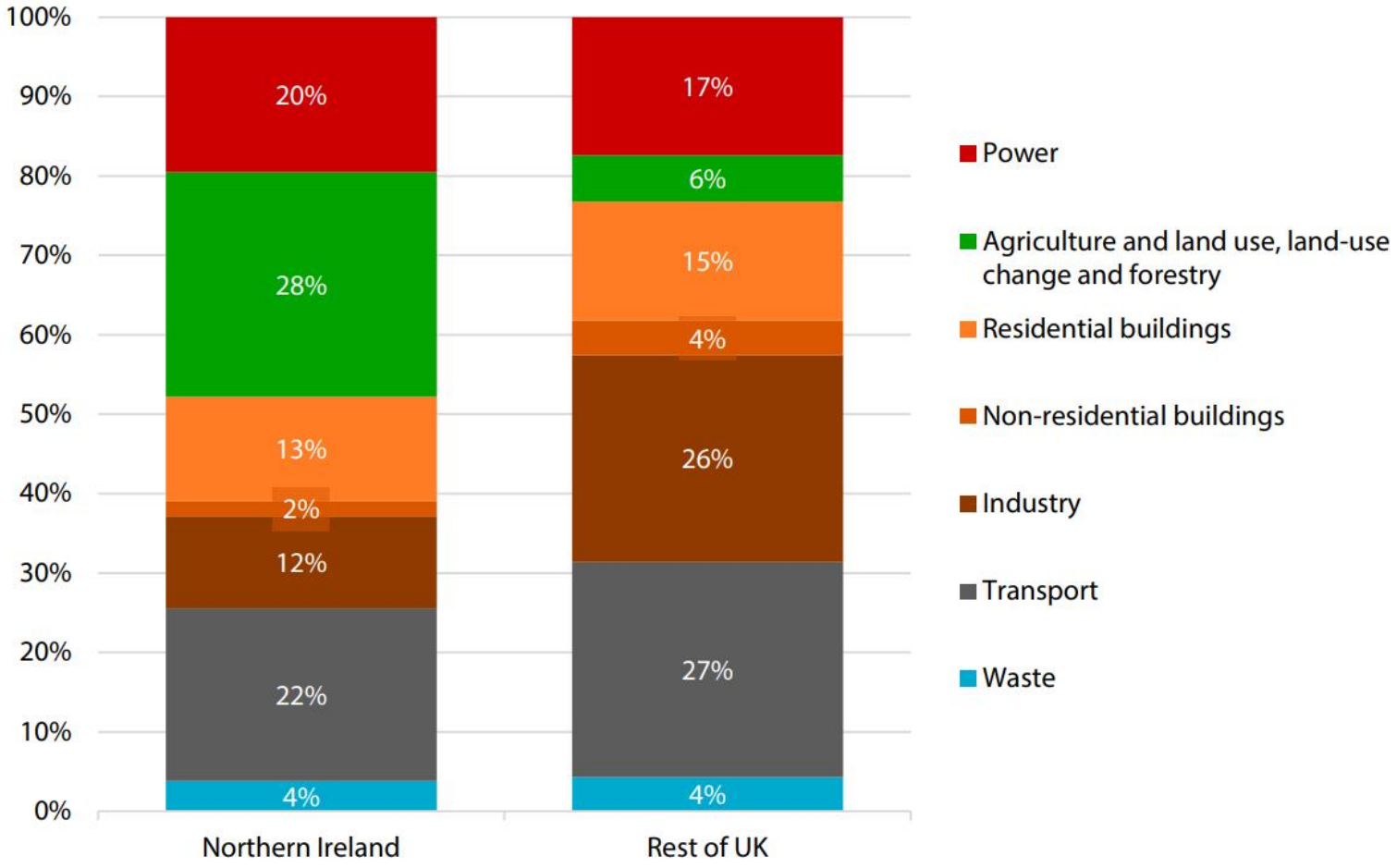
- **Energy generation.** Deployment of new renewable electricity generation is required at scale, with appropriate energy storage and decarbonised back-up solutions (e.g. gas turbines burning hydrogen manufactured from low carbon sources) to allow the carbon-intensity of electricity generation across the Irish electricity system to fall to around 50gCO_2/kWh by 2030, on the way to fully phasing out unabated fossil-fired generation by 2035. Demand for electricity will grow, perhaps doubling by 2050, given the crucial role of electrification to replace fossil fuels. Production or imports of hydrogen from low carbon sources will also be important, for use in industry, electricity generation and more widely.

- **Surface transport.** By the end of this decade, or 2032 at the latest, every new car and van sold in Northern Ireland should be zero-emission. This implies substantial investment to expand the electric vehicle charging infrastructure in Northern Ireland, and major scale-up of plug-in vehicles' share of new vehicle sales from the current 11% to 100% within a decade.

- ***Agriculture.*** *Reductions in methane emissions are given special protections in the new legislation, but very significant reductions in emissions from Northern Irish agriculture are still necessary. This will only be achieved through widespread adoption of low-carbon farming practices and with better farm productivity. CCC pathways rest on a reduction in meat and dairy consumption of around 20% by 2030, which in turn leads to healthier diets and lower emissions from livestock. Farmland freed-up by this change can be turned towards greater carbon sequestration.*

- *Northern Ireland's first carbon budget period, 2023 to 2027, starts in less than 10 months. The implication of the new 2050 target is that Northern Ireland must outperform all of five of the Net Zero Pathways that my Committee developed for our advice on the 6th UK Carbon Budget, requiring a major step-up in policy and rapid progress over the 2020s.*

Emissions in 2016 by sector in Northern Ireland compared to the rest of the UK



Reducing emissions in Northern Ireland, Committee on Climate Change February 2019

Greenhouse gas emissions by gas within sector N. Ireland (2019, DAERA)

Sector	CO_2	CH_4	N_2O
Agriculture	0.6	3.7	1.3
Business	2.0	0.0	0.0
Energy supply	2.8	0.0	0.0
Industrial process	0.2	0.0	0.0
Land use change	2.0	0.3	0.2
Public	0.1	0.0	0.0
Residential	2.8	0.1	0.0
Transport	4.2	0.0	0.0
Waste management	0.0	0.7	0.0
Total	**14.6**	**4.8**	**1.7**

Species	Global Warming Potential (100 year time horizon, IPPC 4th Assessment)
Carbon dioxide	1
Methane	25
Nitrous oxide	298

IS THERE ENOUGH RESOURCE TO MAKE A DIFFERENCE?

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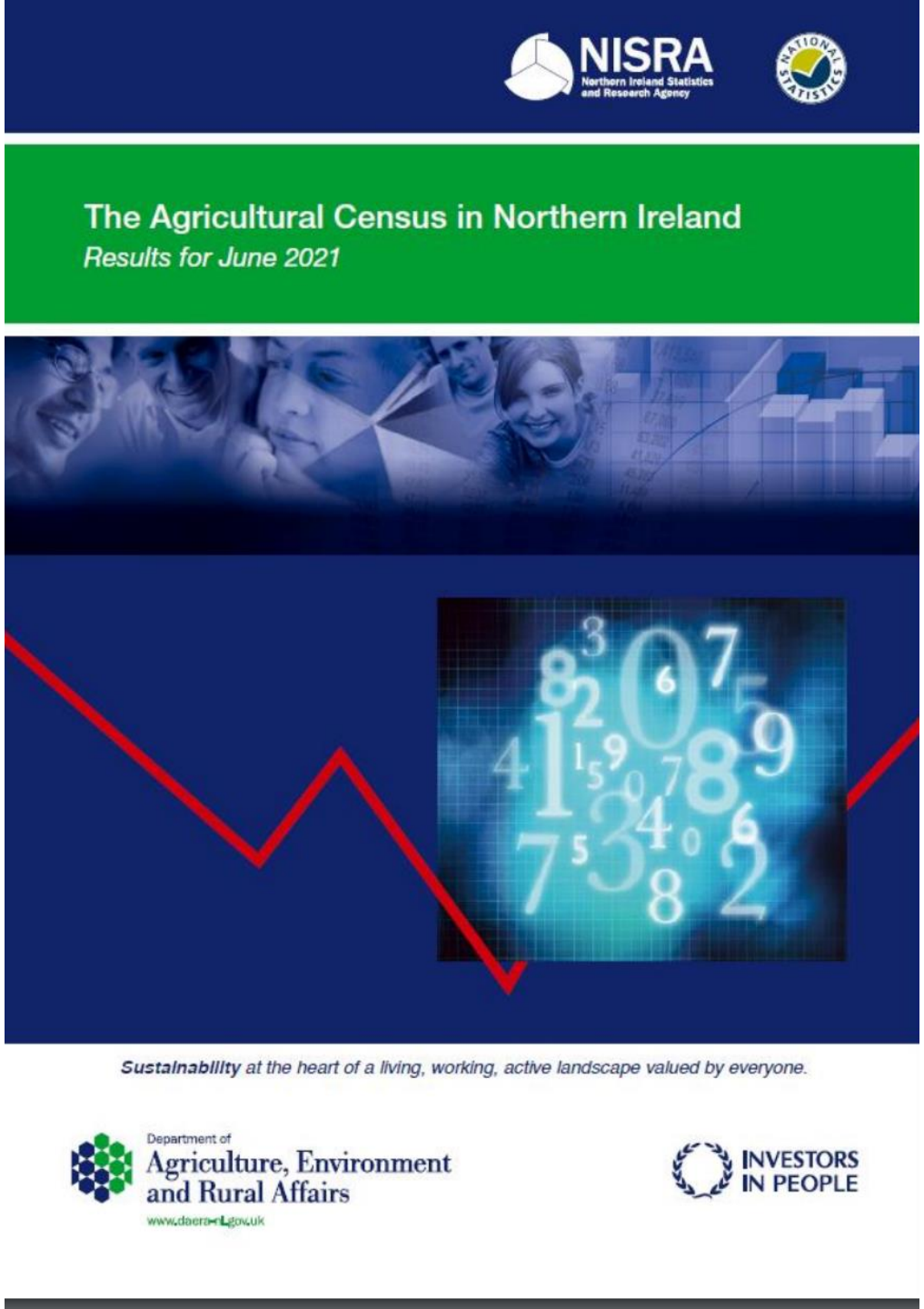


LIVESTOCK NUMBERS 2021

Cattle	1,681,991
Sheep	2,034,786
Pigs	716,798
Poultry	24,462,802

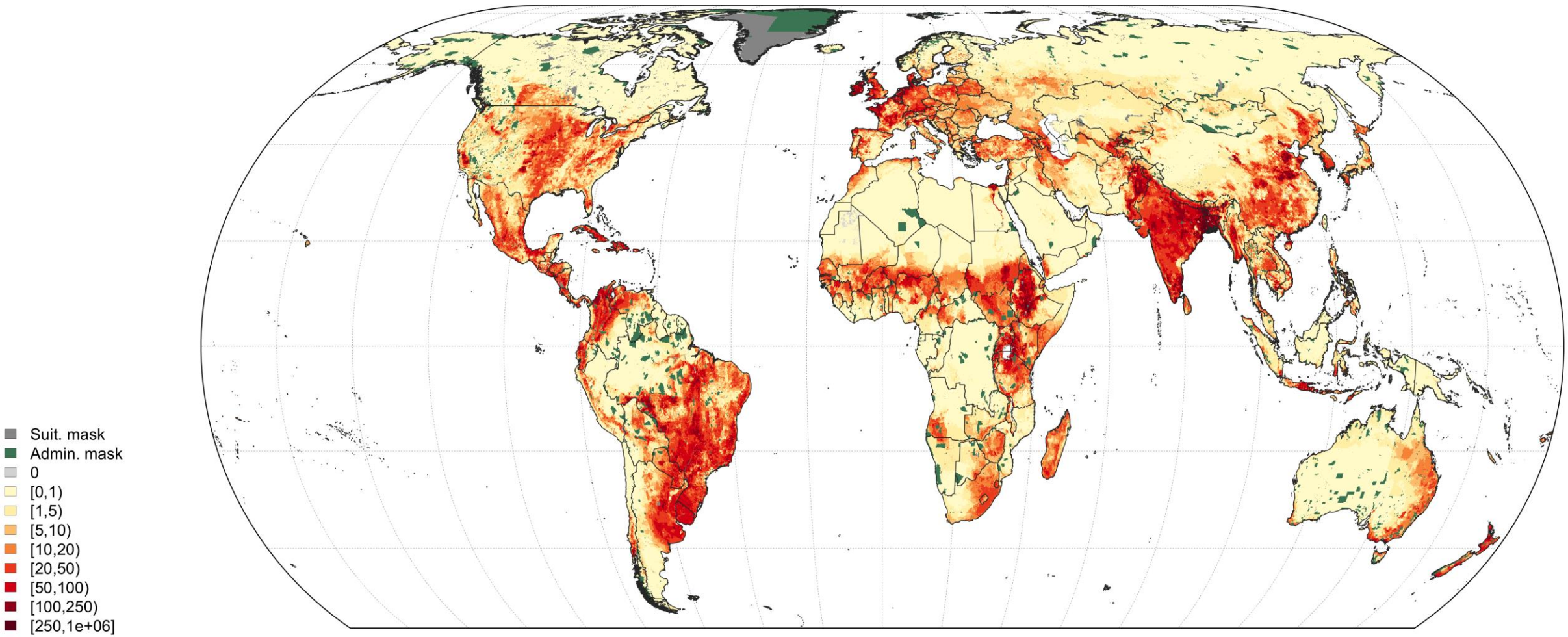
$$Number \times \frac{kg_{waste}}{head} \times captured \times \frac{kg_{vs}}{kg_{waste}} \times \frac{Gas(Nm^3)}{kg_{vs}} = Gas(Nm^3)$$

15 million Nm^3 → 260 million Nm^3 (Cattle, Pigs, Poultry)

260 million m^3 ≈ 2.53 TWh

2021 Total renewable electricity (NI) = 3.13 TWh

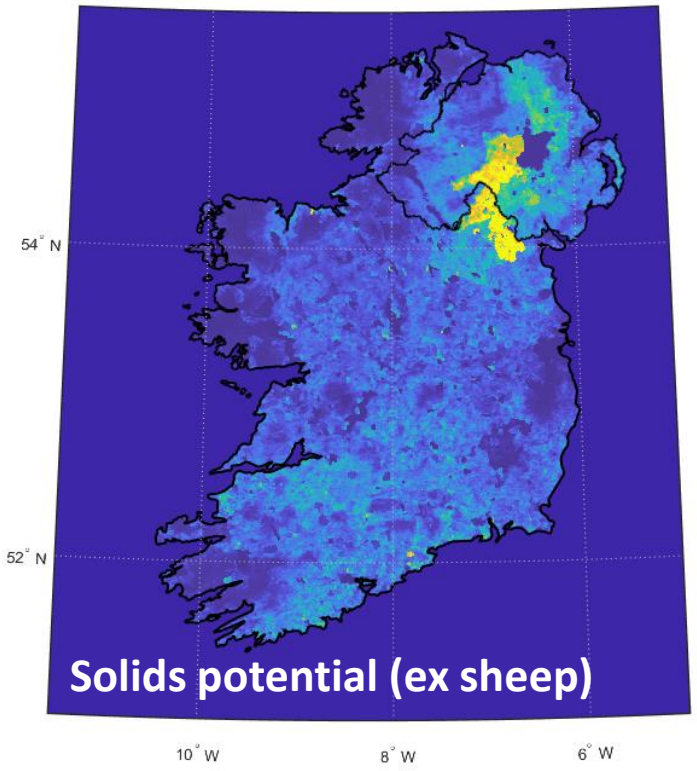
GRIDDED LIVESTOCK OF THE WORLD

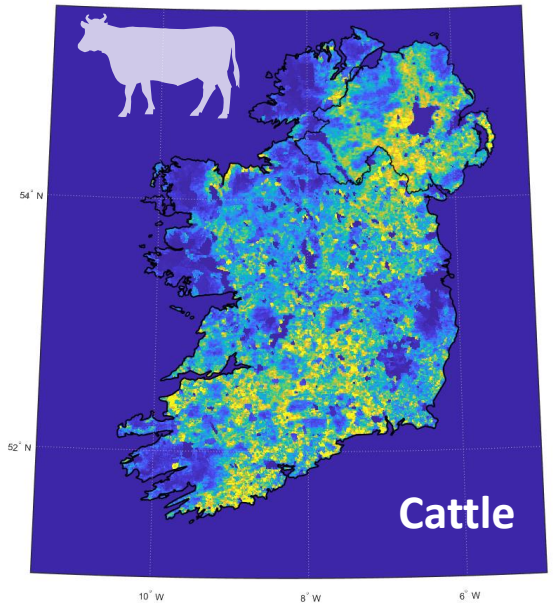


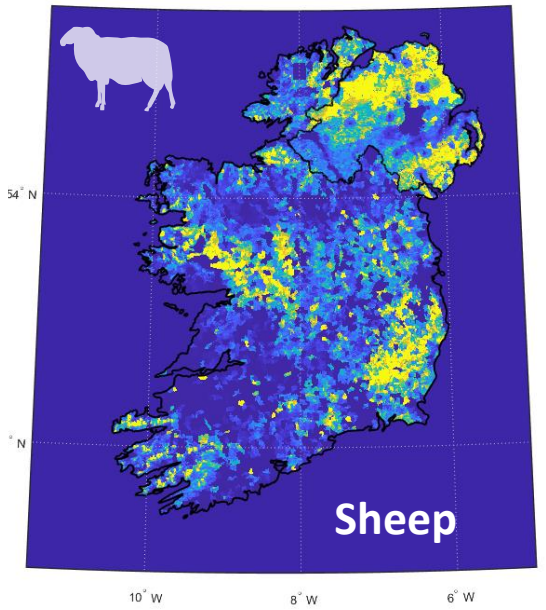
Gilbert, Marius; Nicolas, Gaëlle; Cinardi, Giusepina; Van Boeckel, Thomas P.; Vanwambeke, Sophie; Wint, William G. R.; Robinson, Timothy P., 2018, "2_Ct_2010_Da.png", Global cattle distribution in 2010 (5 minutes of arc), https://doi.org/10.7910/DVN/GIVQ75/0DDRHT, Harvard Dataverse, V3

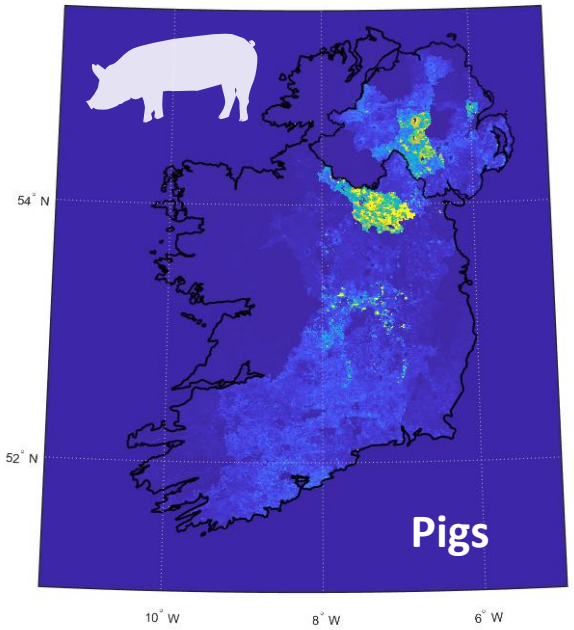
RESOURCES:

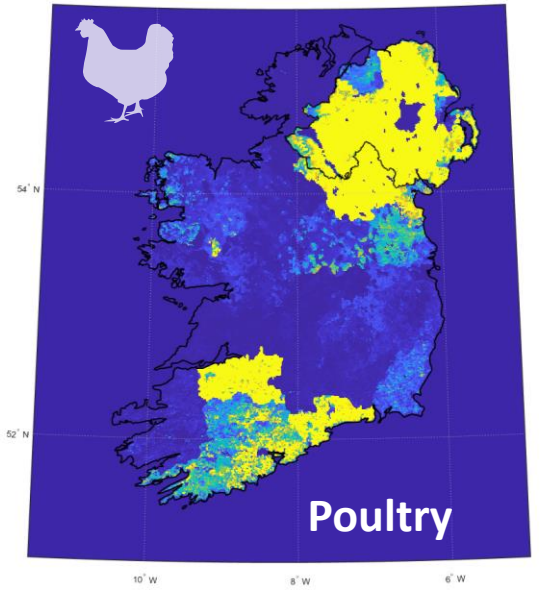
Carbon availability





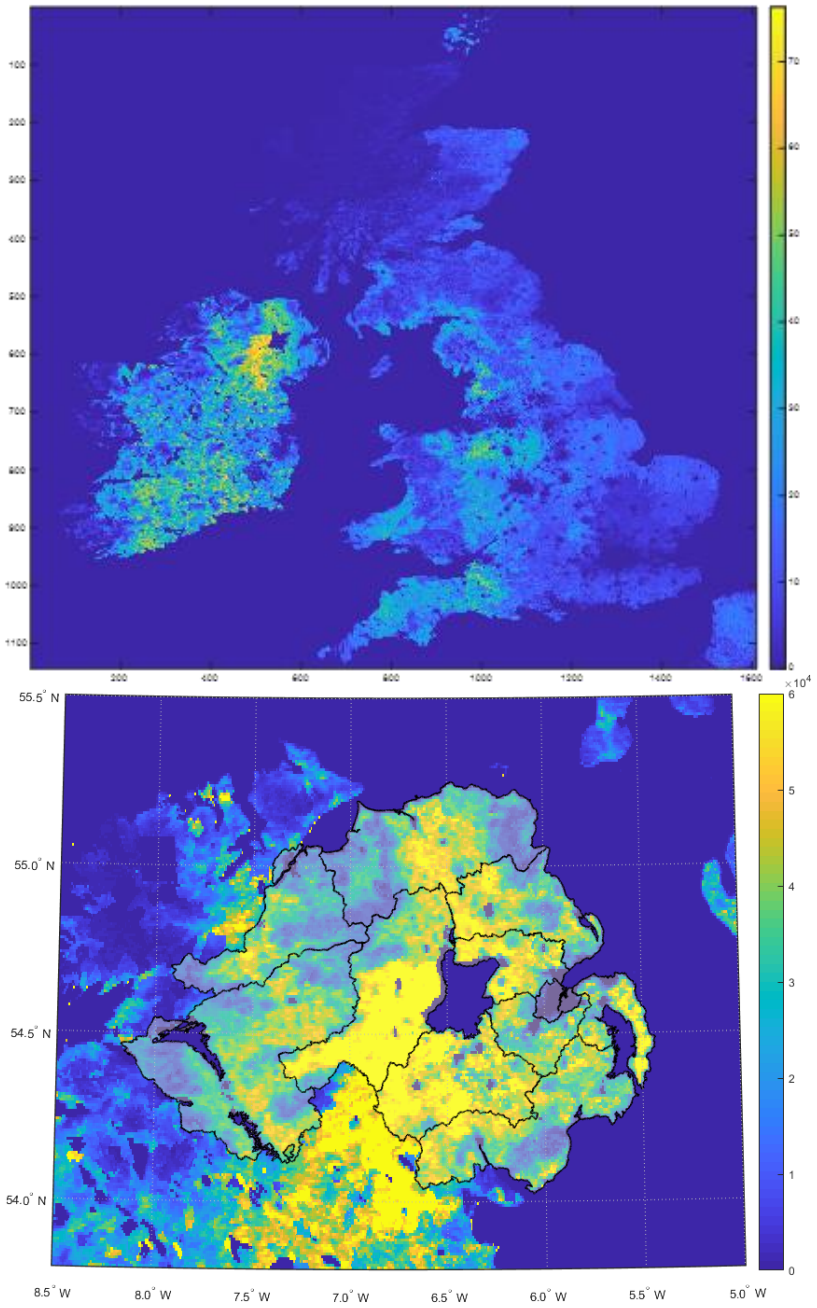


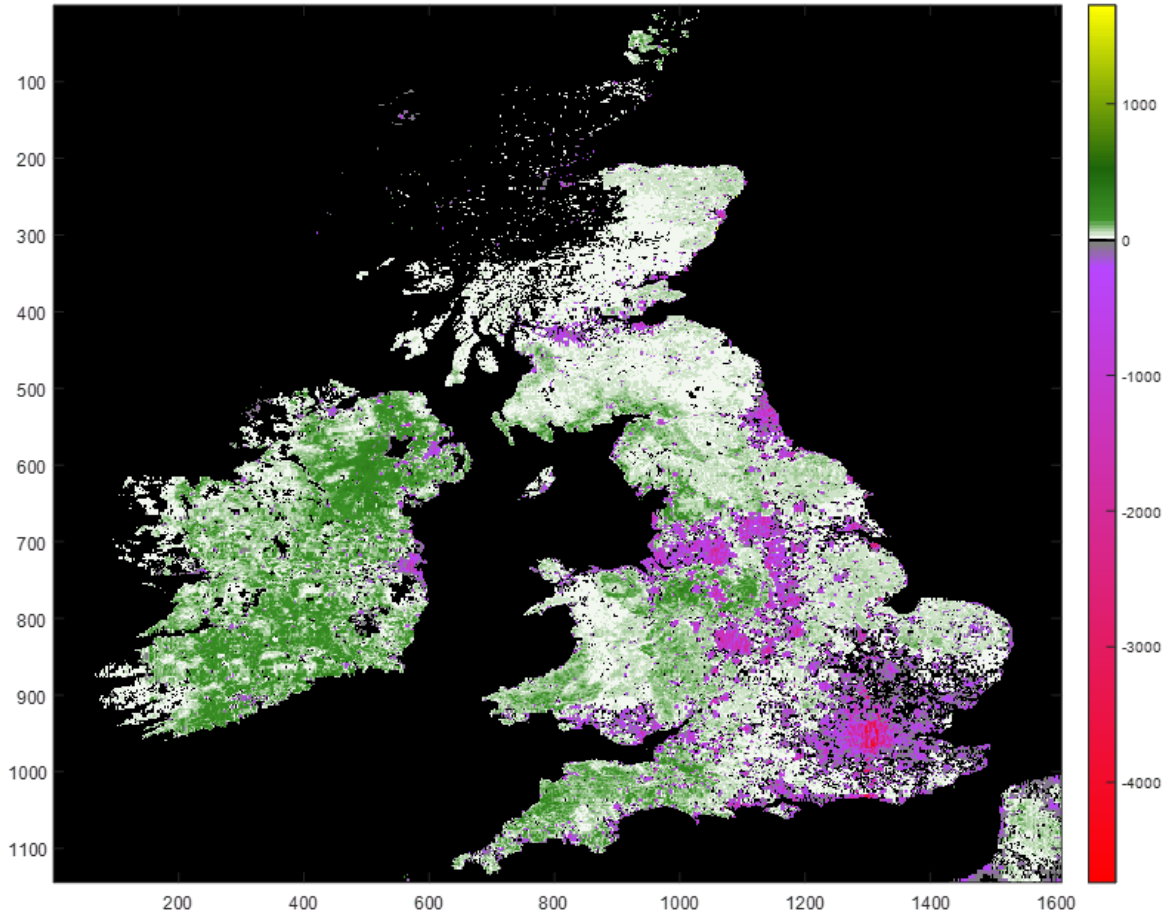




Headcounts

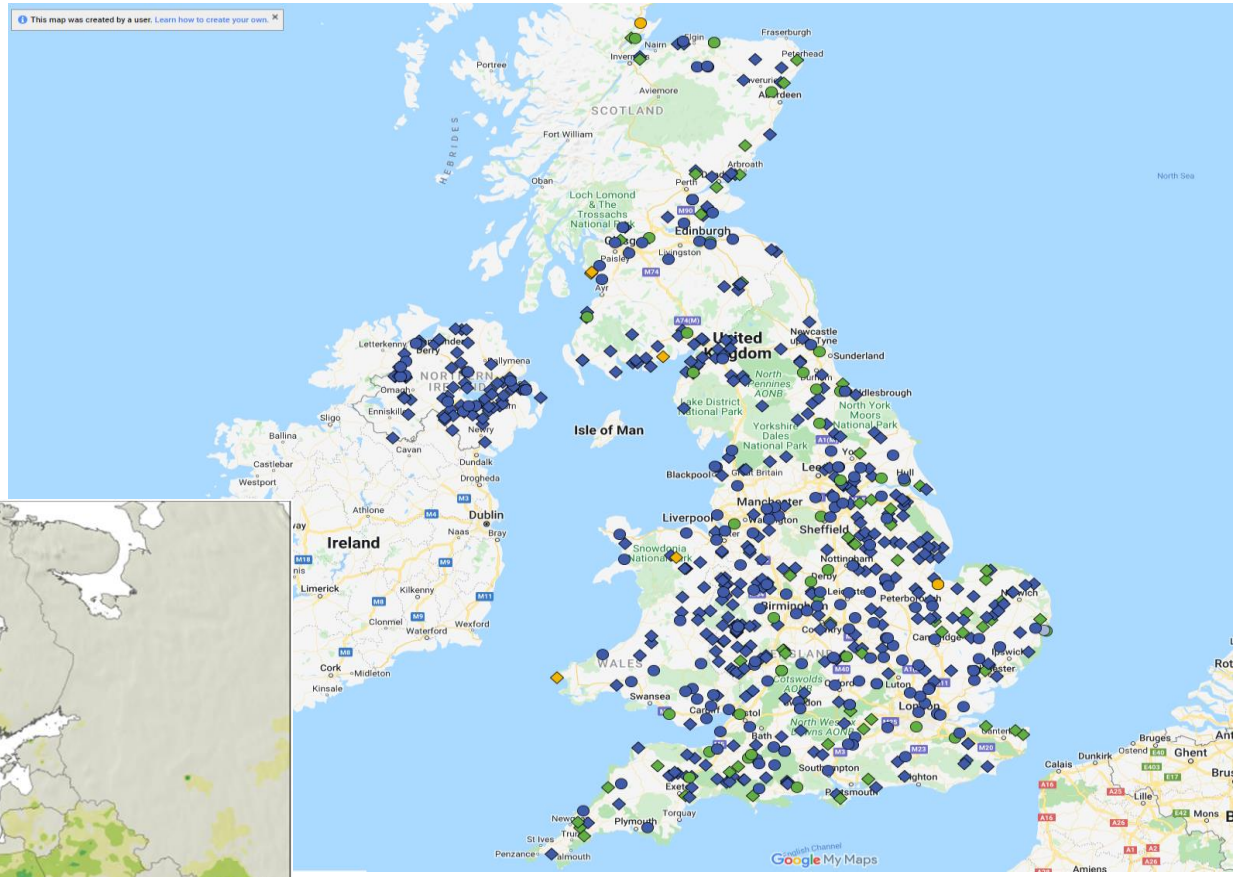
BIOGAS/ENERGY POTENTIAL

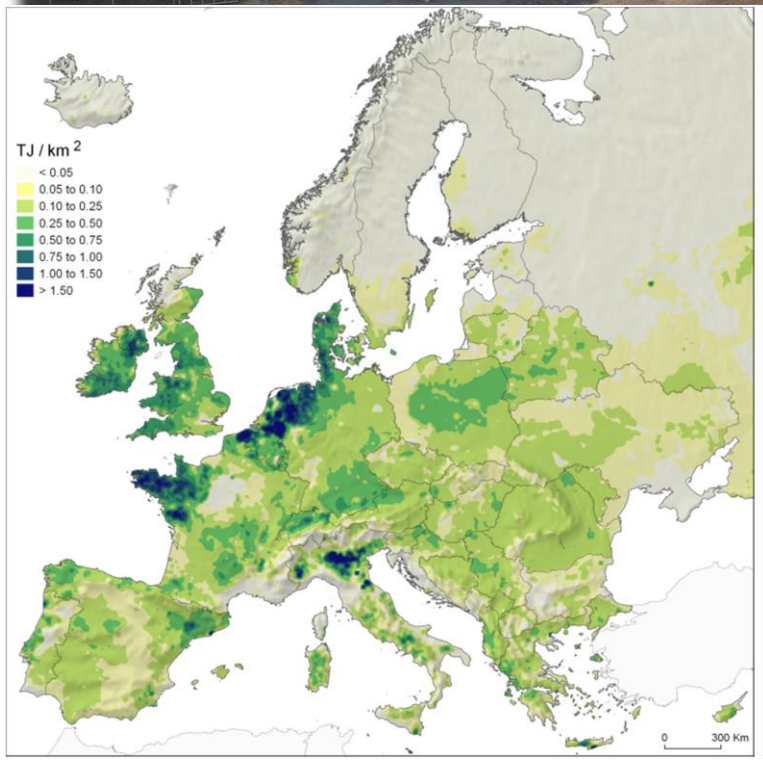


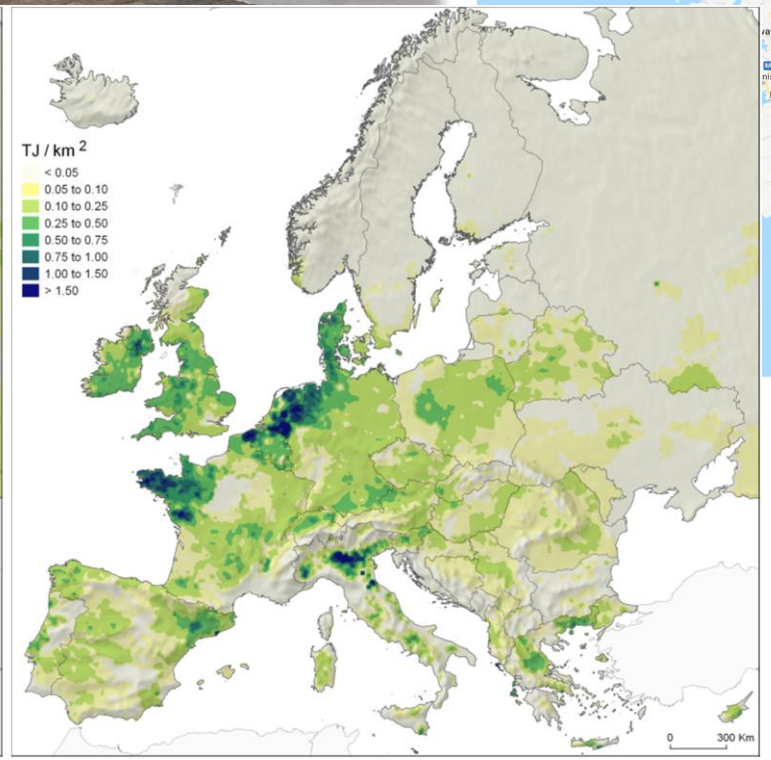


- Potential to increase *via* power to gas technology
- Average gas consumption 1190 m^3 per person

BIOGAS PRODUCTION







Biogas potential of produced (left) and collectible (right) farm manure.

Renewable and Sustainable Energy Reviews, 94, 915-930, (2018).

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

What is the most energy efficient route for biogas utilization: Heat, electricity or transport?

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[a] School of Chemistry & Chemical Engineering, Queen's University Belfast, Northern Ireland BT9 5AG, United Kingdom
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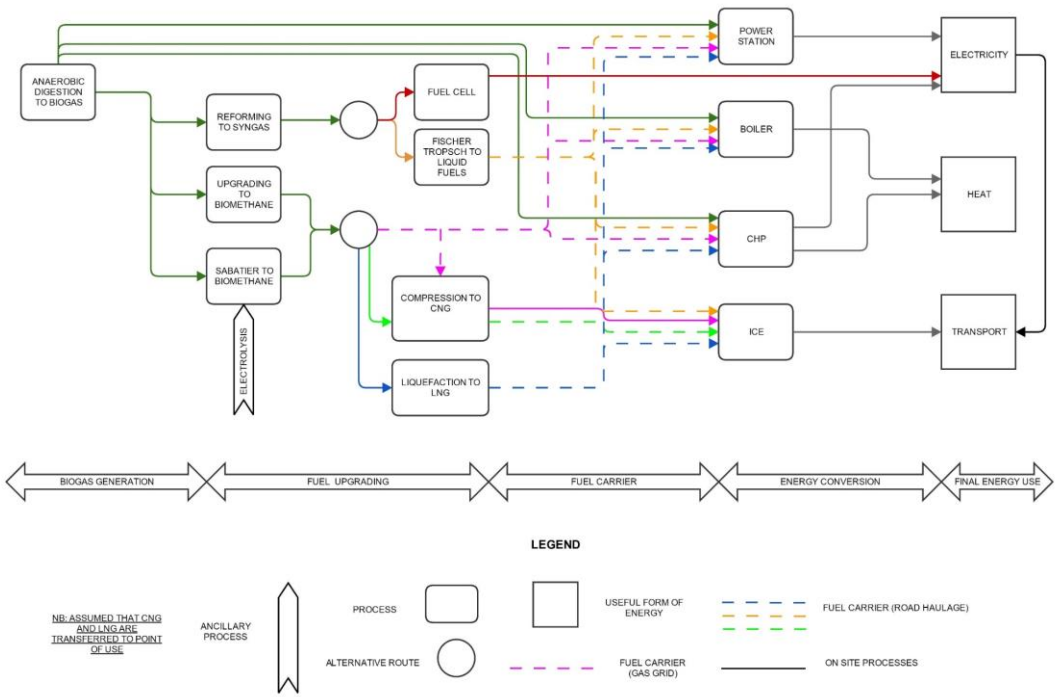
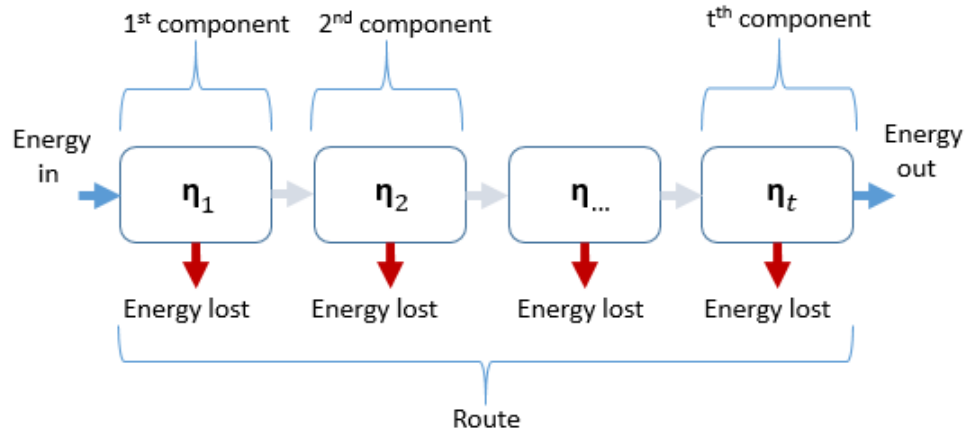
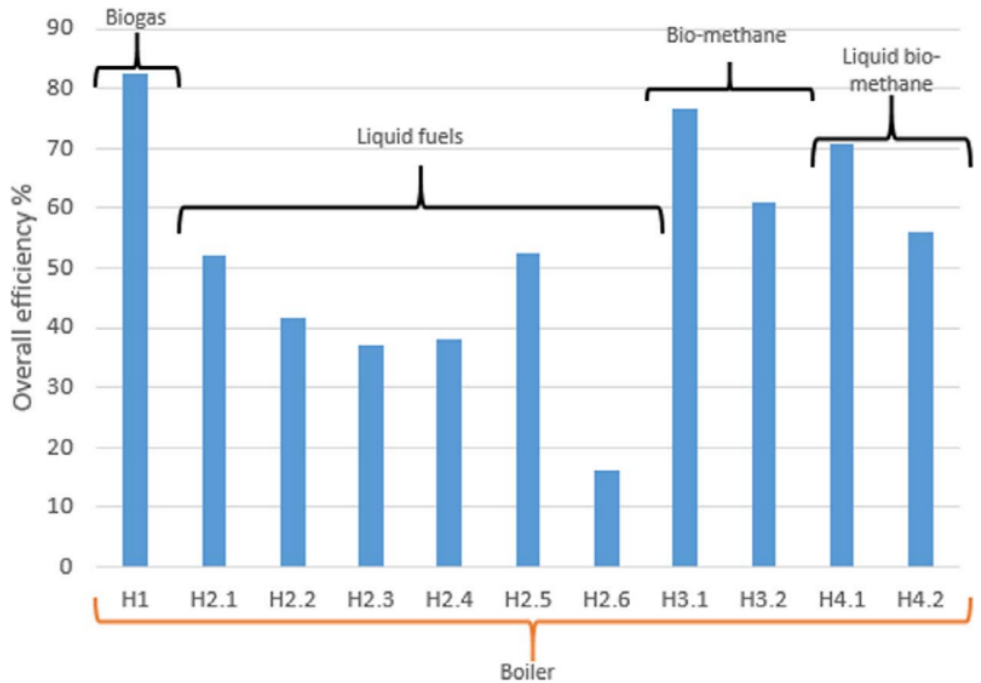
HIGHLIGHTS

- The paper developed an assessment tool for analyzing biogas utilization routes.
- The LCA methodology was used to allow a uniform assessment of the biogas system.
- "% energy efficiency" was used as the functional unit for assessment.
- 49 biogas-to-energy routes were assessed based on their final useful energy form.
- The framework aids policy makers in the decision process for biogas exploitation.





$$\eta_{route} = \prod_{x=1}^{t} \eta_x$$



IS THERE ENOUGH RESOURCE TO MAKE A DIFFERENCE?

WOULD THERE BE ENOUGH TO DECARBONISE THE GAS GRID?

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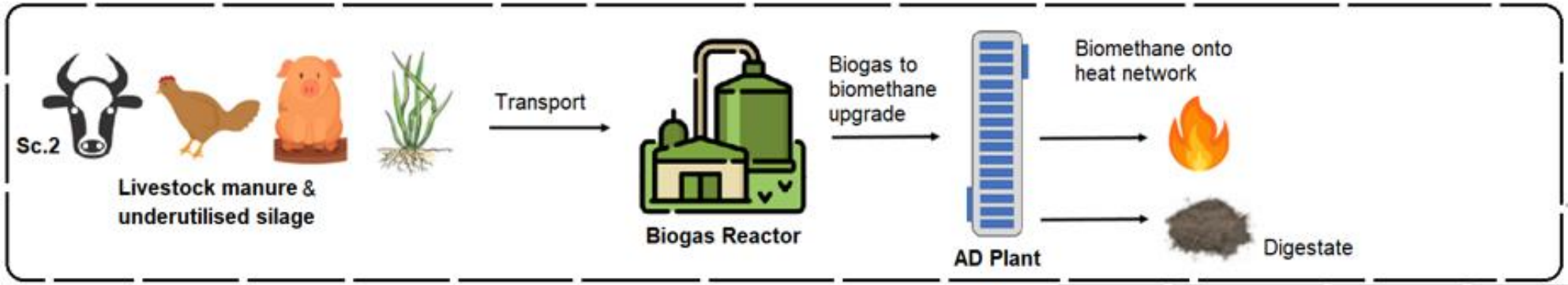
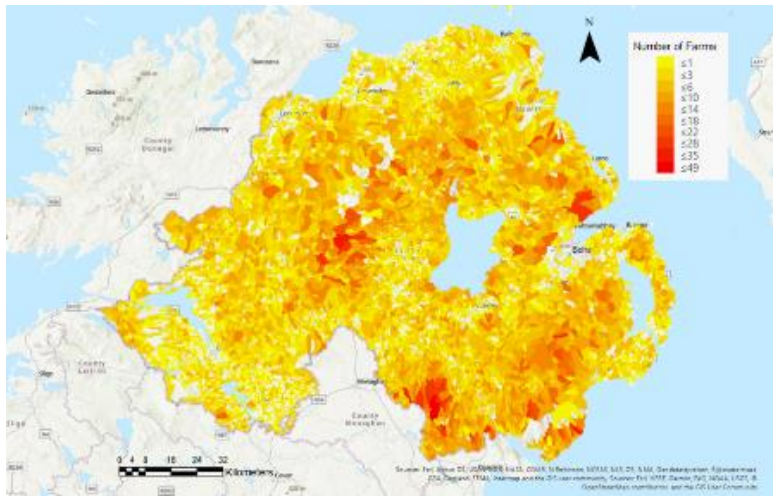
RECENT ANLYSIS

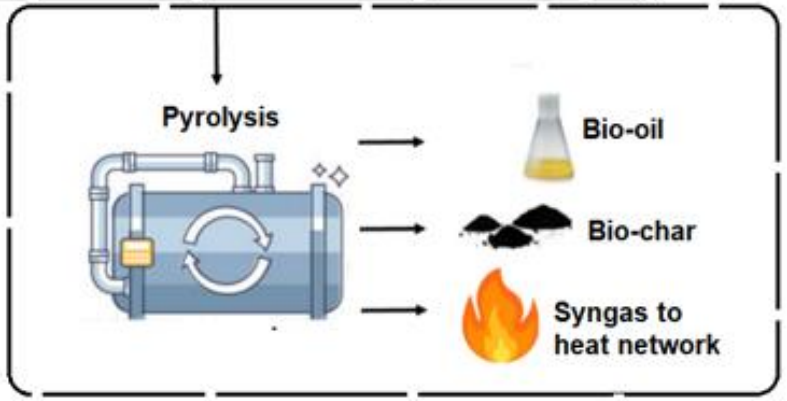
1. Geospatial analysis of biomethane potential
2. Life Cycle Assessment
3. Consideration of secondary benefits/risks

Current gas demand : 7.2 TWh

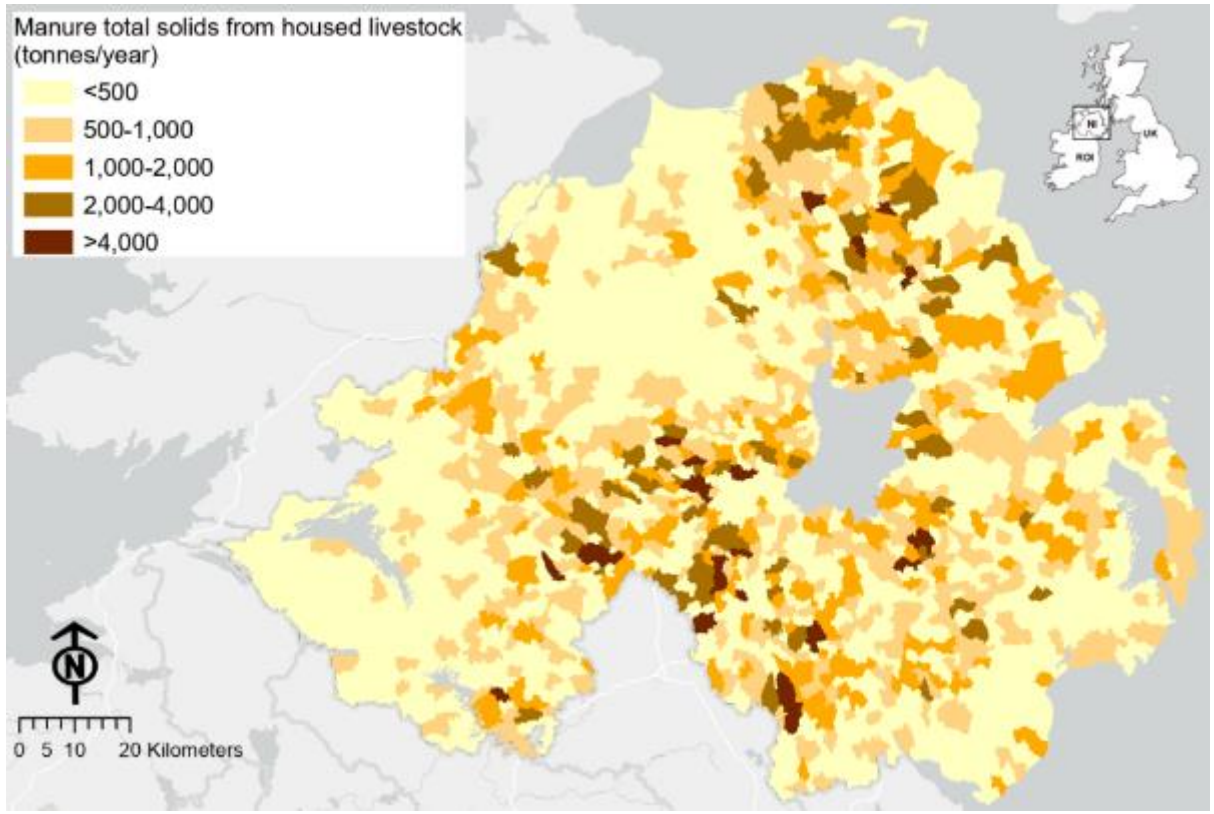


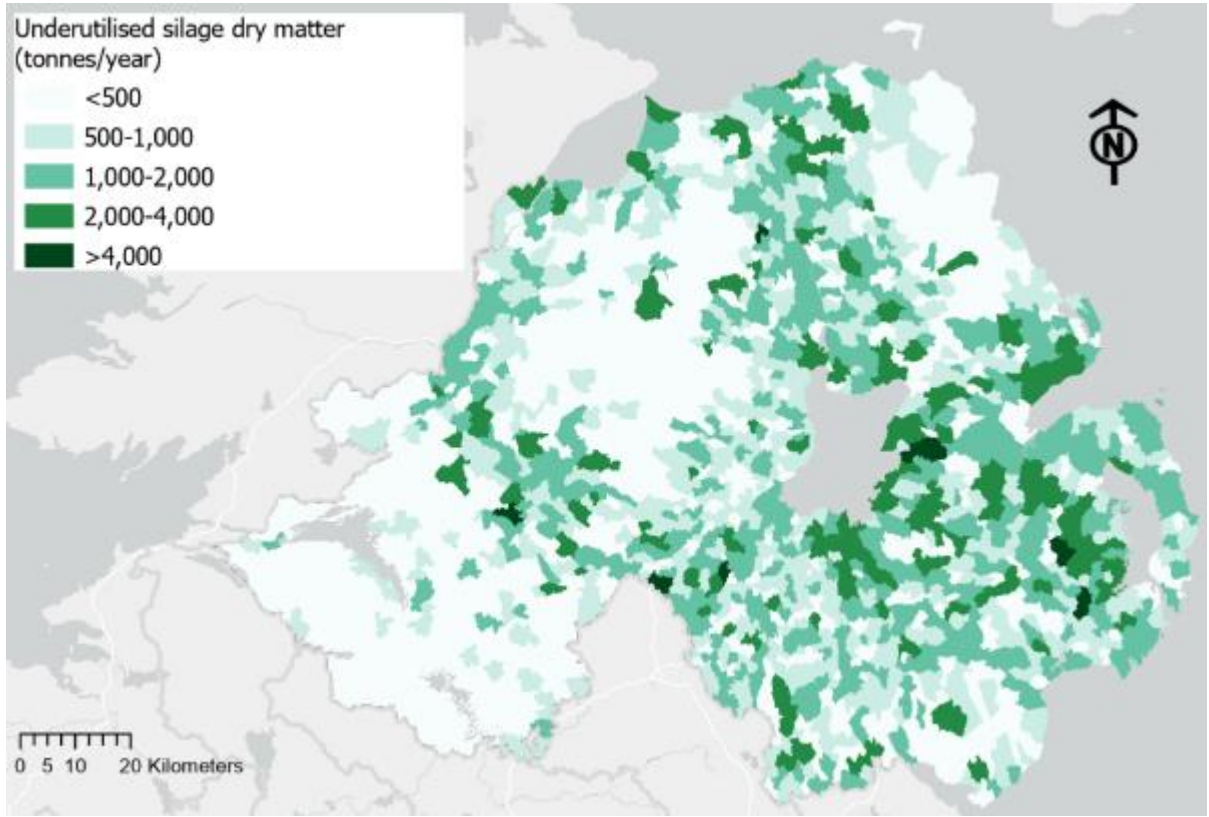


Sc.3 = Sc.2 +
Pyrolysis step



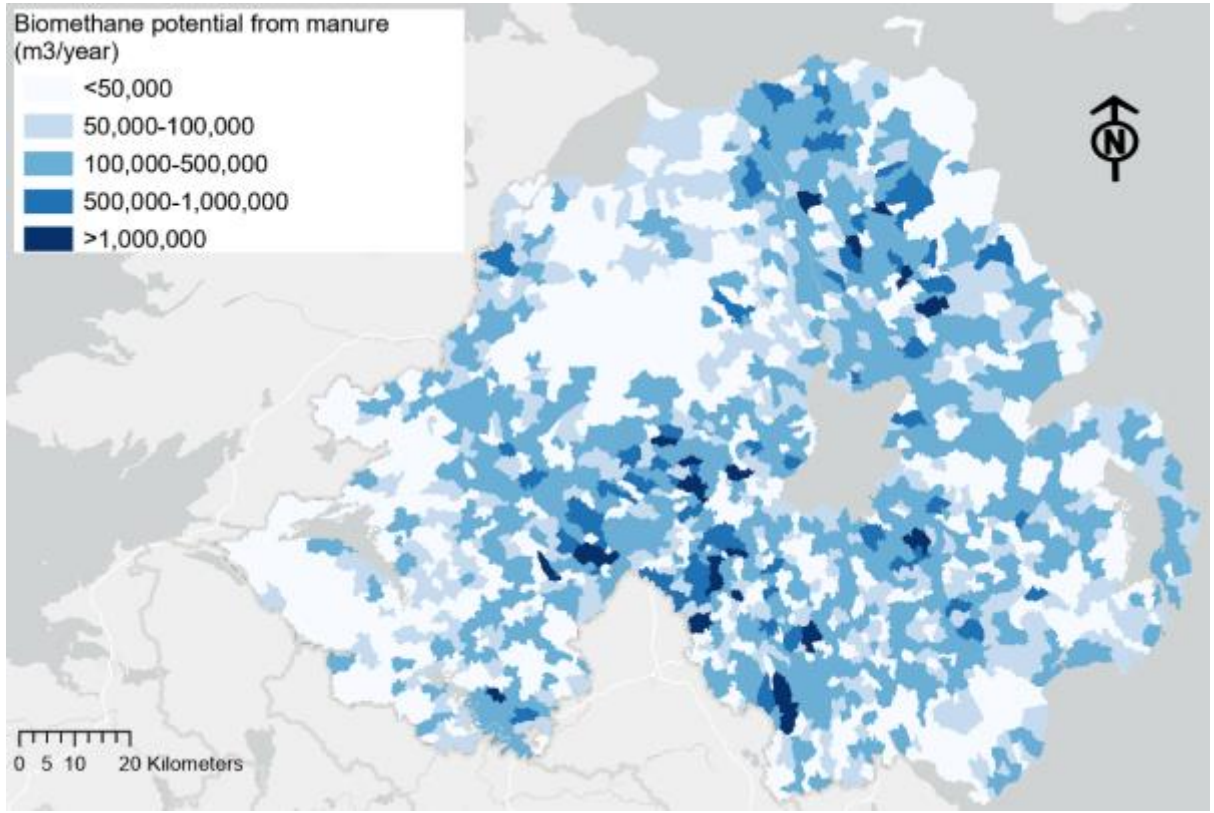
RESULTS FROM THE GEOSPATIAL ANALYSIS

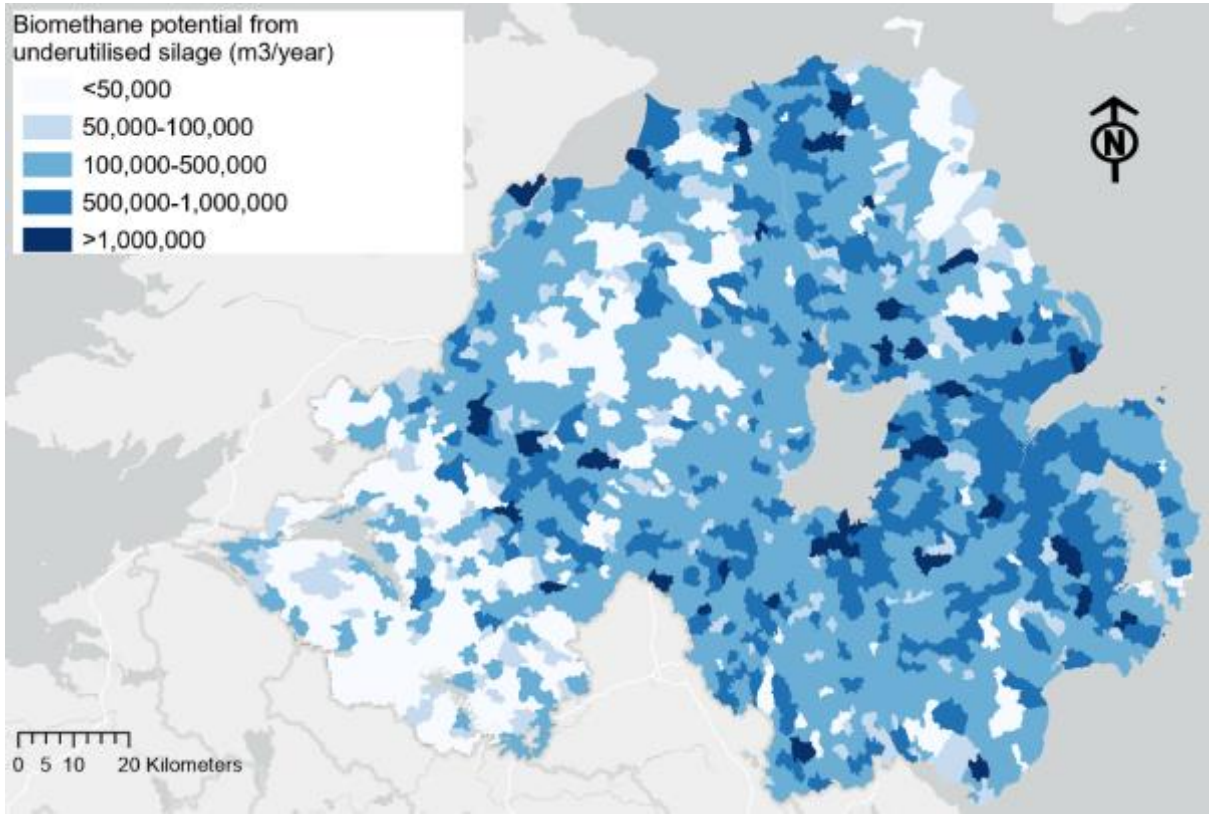




Housed Manure
9218 kt in total (collected)
1162 kt Total Solids

Underutilised Silage
4693 kt in total (fresh weight)
1374 kt Dry Matter



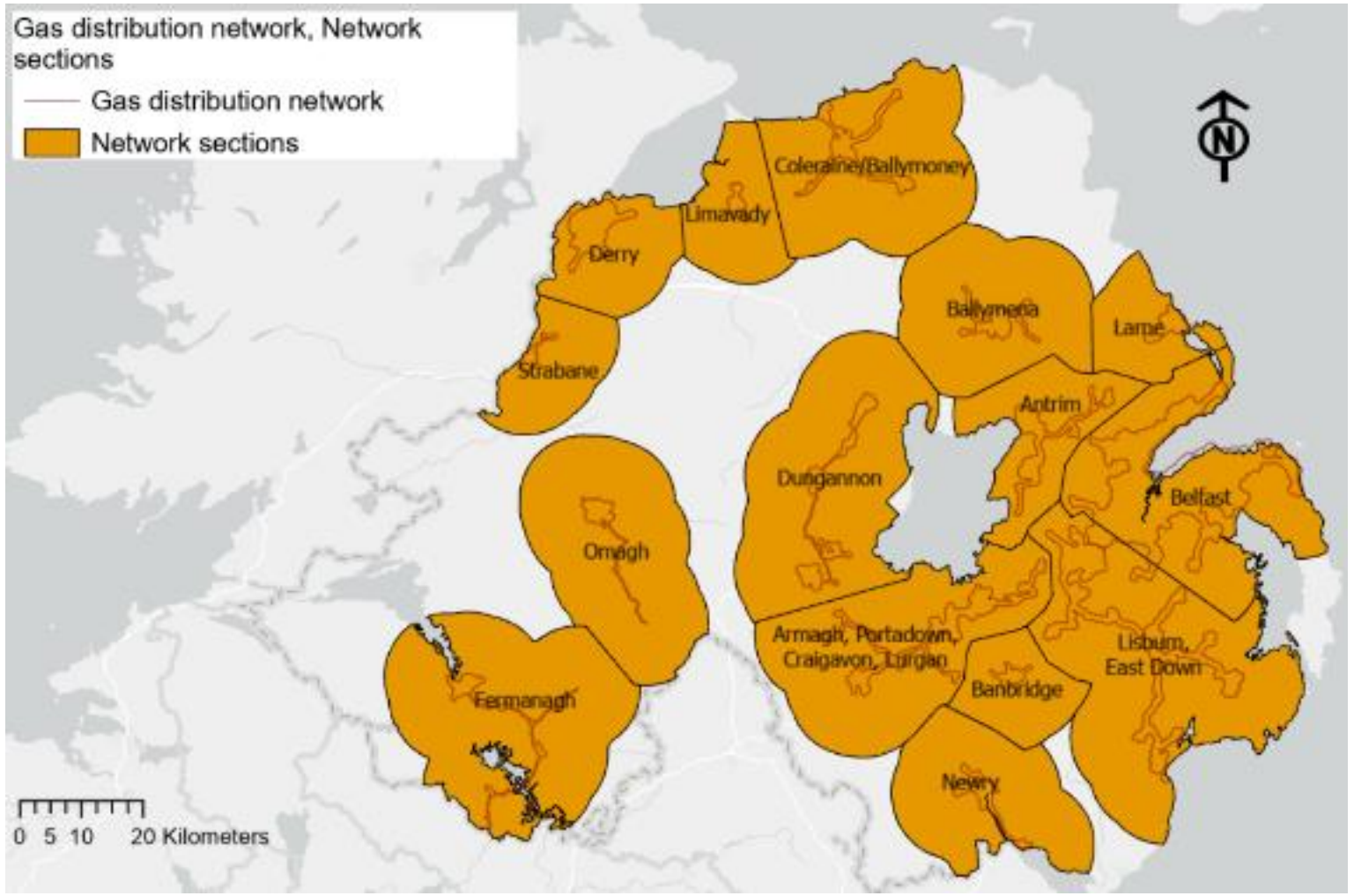


Housed Manure
253 million m^3 CH_4

753 million m^3 CH_4
7.5 TWh

Underutilised Silage
500 million m^3 CH_4

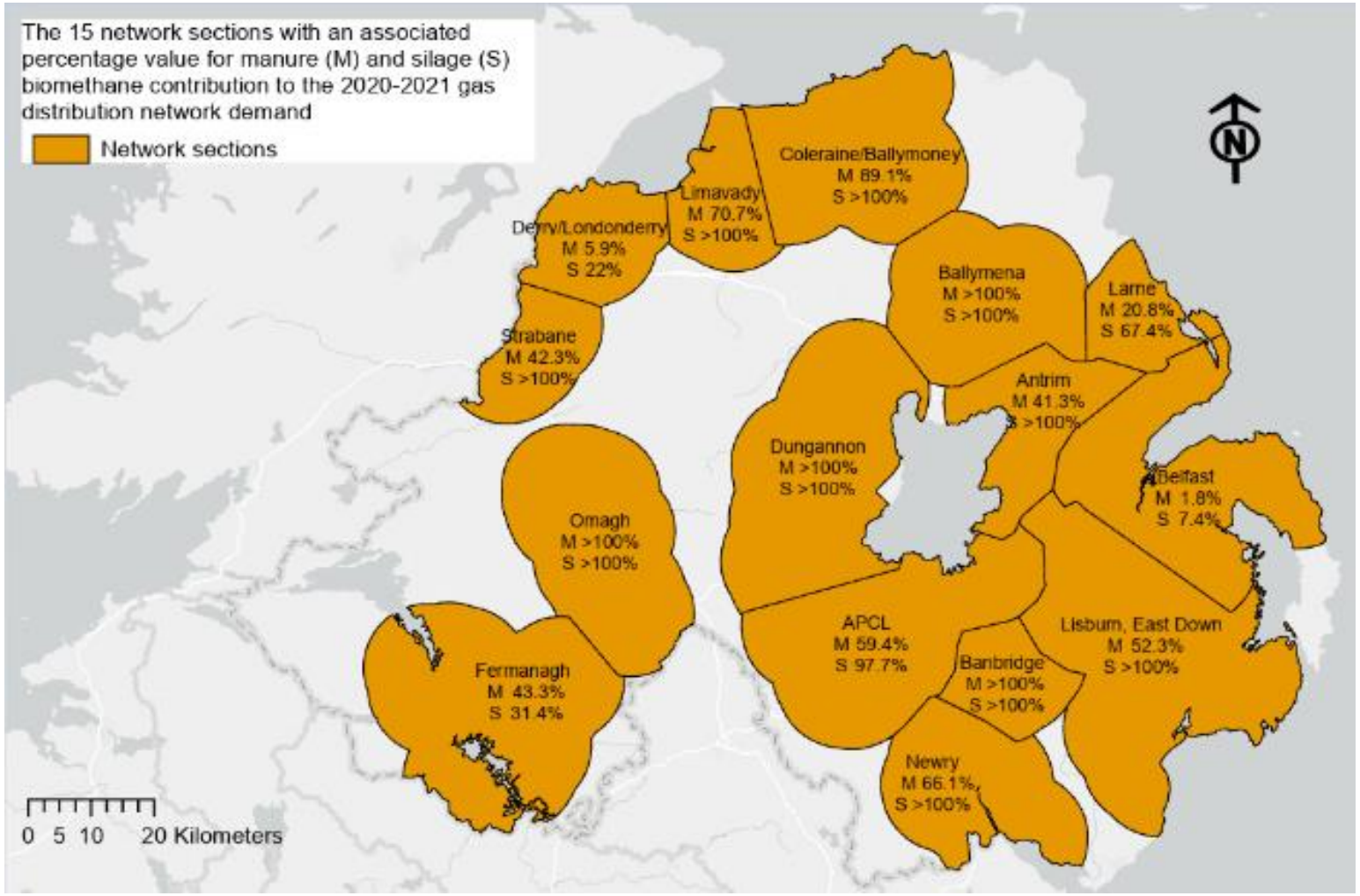
**10km from gas distribution network*



Manure in the zones:
209 million m^3 CH_4
2.1 TWh
27.3% of gas demand

Silage in the zones:
418 million m^3 CH_4
4.2 TWh
54.5% of gas demand

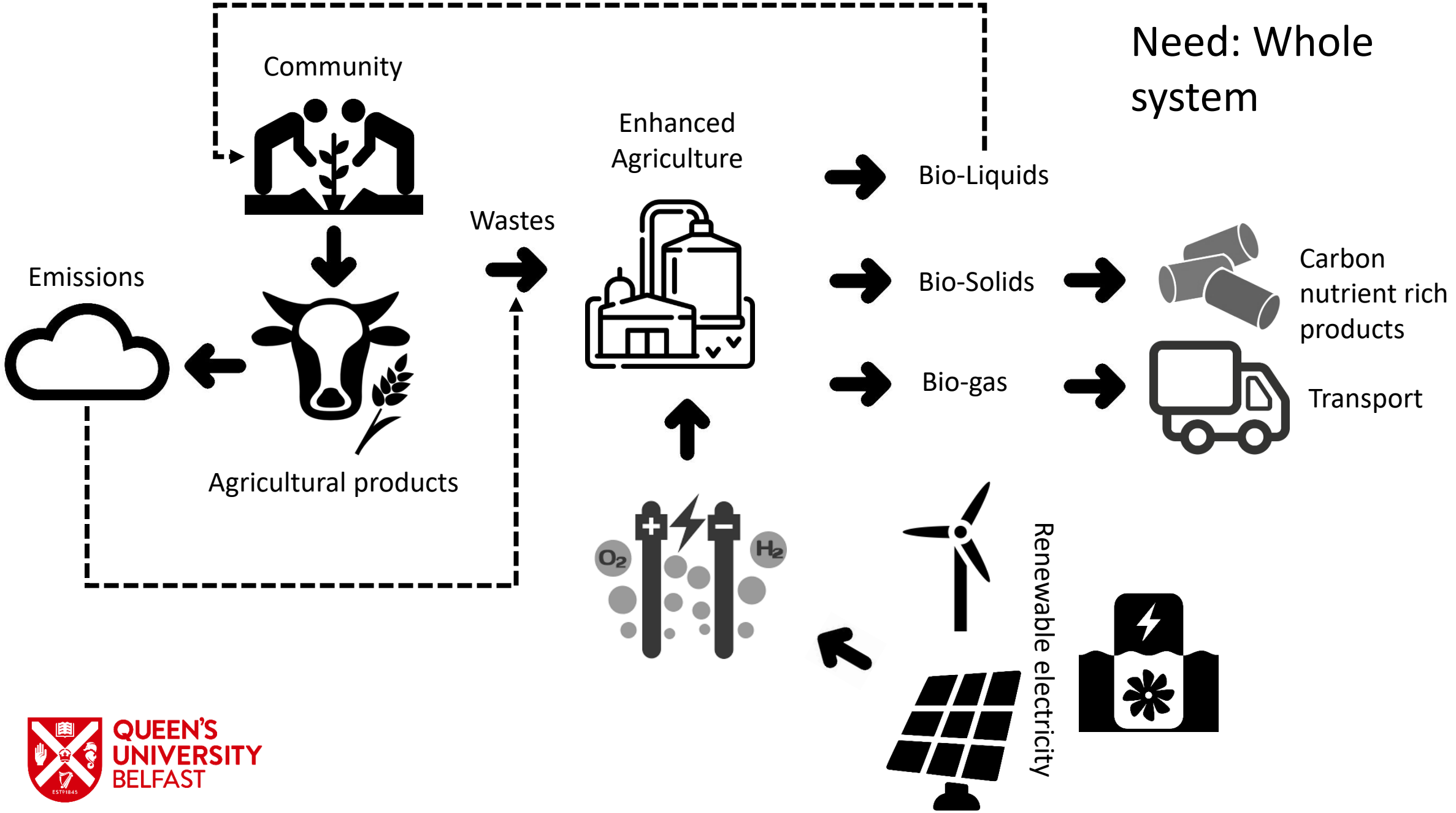
Total in the zones:
627 million m^3 CH_4
6.3 TWh
81.9% of demand



Out of the 15 zones

- 11 would have sufficient capacity to export to other zones
- Only Belfast, Derry, Fermanagh and Larne would be net importers of CH_4

Need: Whole system



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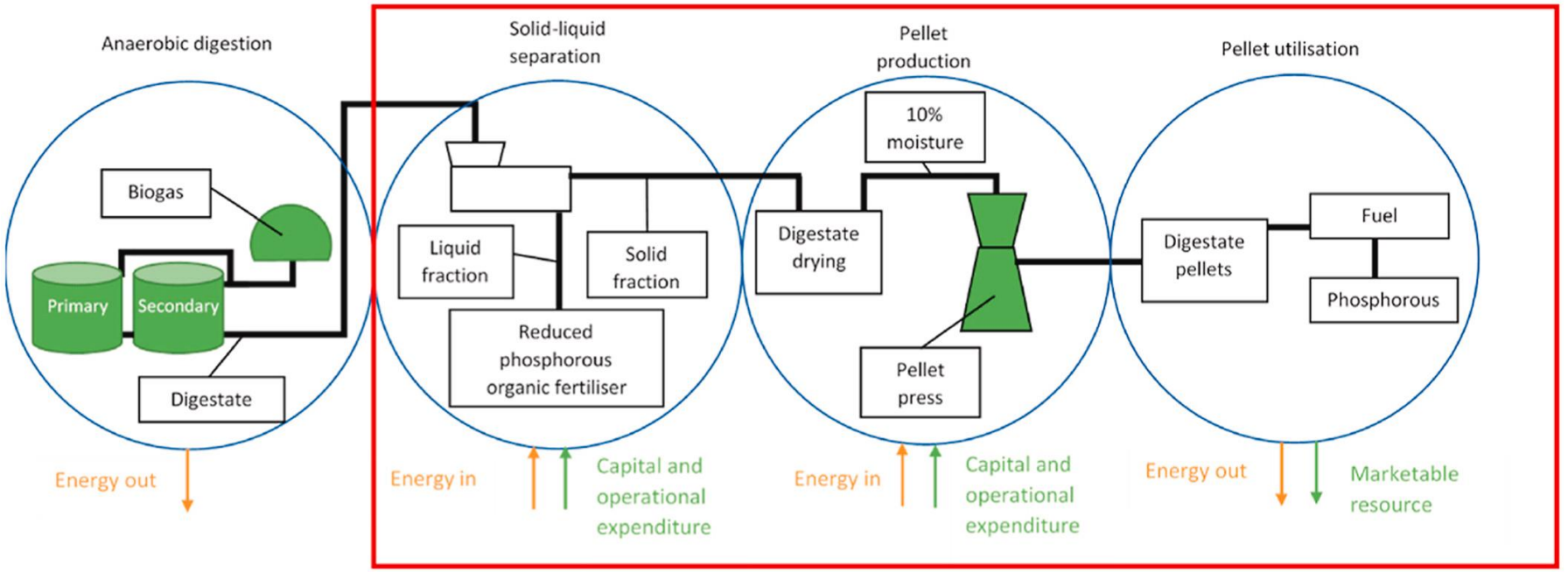
Cleaner Engineering and Technology
Volume 3, July 2021, 100098

An economic analysis of anaerobic digestate fuel pellet production: can digestate fuel pellets add value to existing operations?

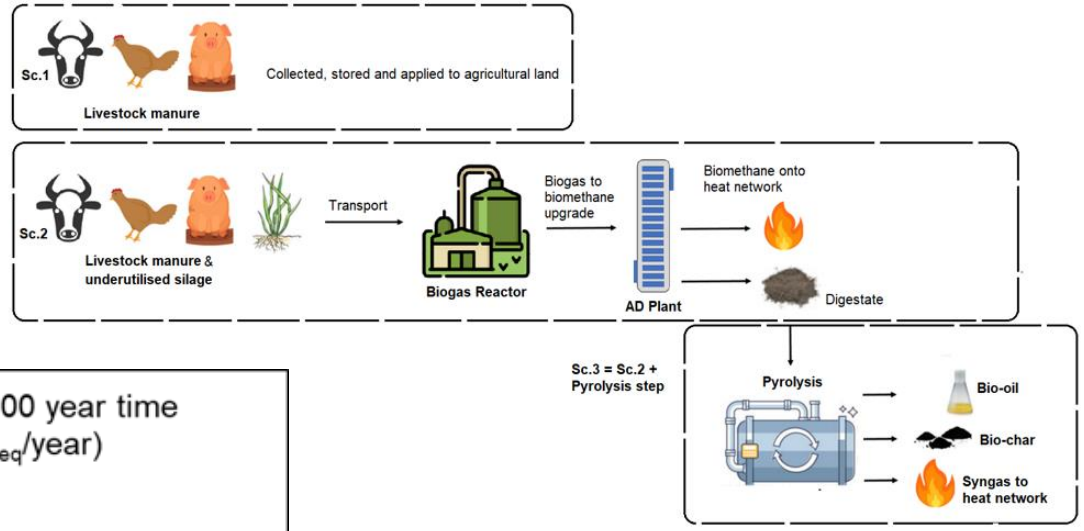
Ashley Cathcart [a, b], Beatrice M. Smyth [a], Gary Lyons [b], Simon T. Murray [c, d], David Rooney [d], Christopher R. Johnston [b]

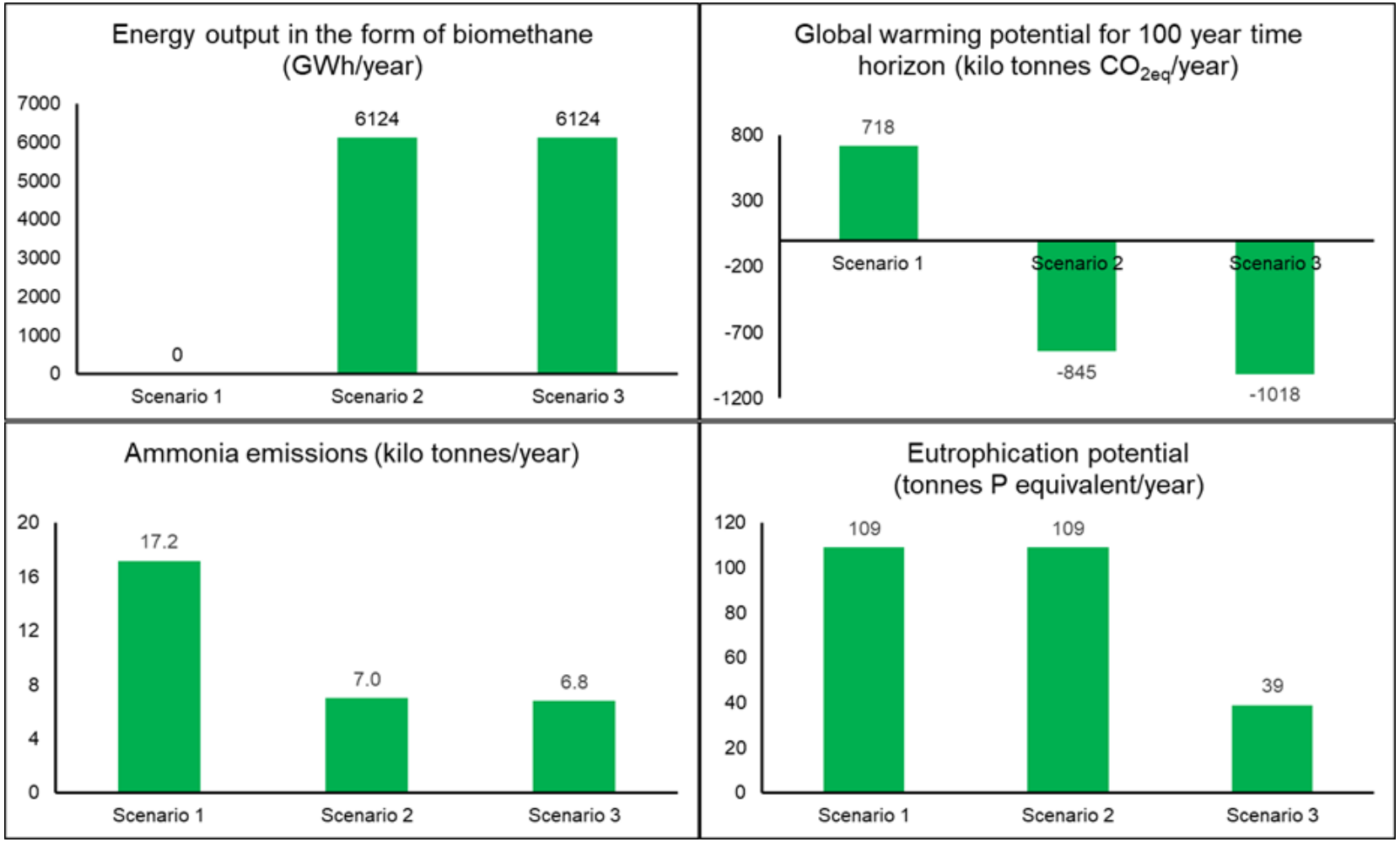
Show more



Economic analysis

ADDITIONALITY





Significant reduction in GWP

Ammonia emissions decreased by 10 kT/year

Biochar production estimated at 200 kT (retaining 64% of phosphorus from manure)

CONCLUSIONS

- There is a significant opportunity for utilising anaerobic digestion and the secondary treatment of livestock manure and grass silage to decarbonise gas infrastructure (≈80%)
- Secondary benefits in ammonia and phosphate control could be realised.
- Further work needed on nutrient balances to achieve targets and overall economic cost/benefit needed.

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THE BRYDEN CENTRE
ADVANCED MARINE AND BIO-ENERGY RESEARCH

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Agri-Environmental Technologies Unit

Environmental benefits of slurry management via AD and digestate valorisation

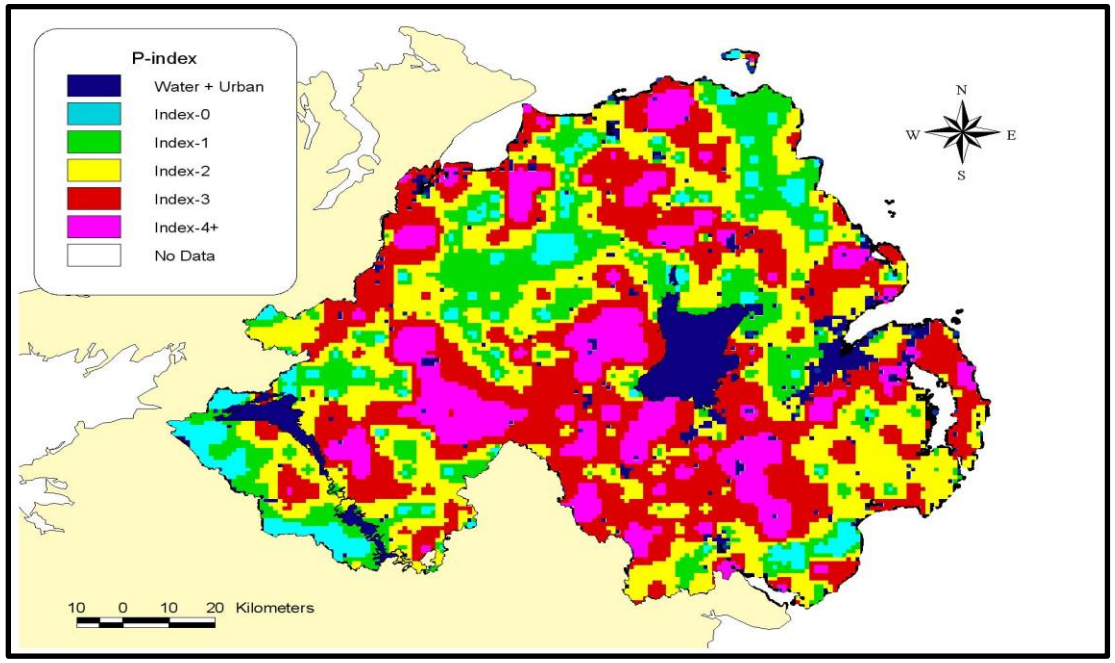
Chris Johnston

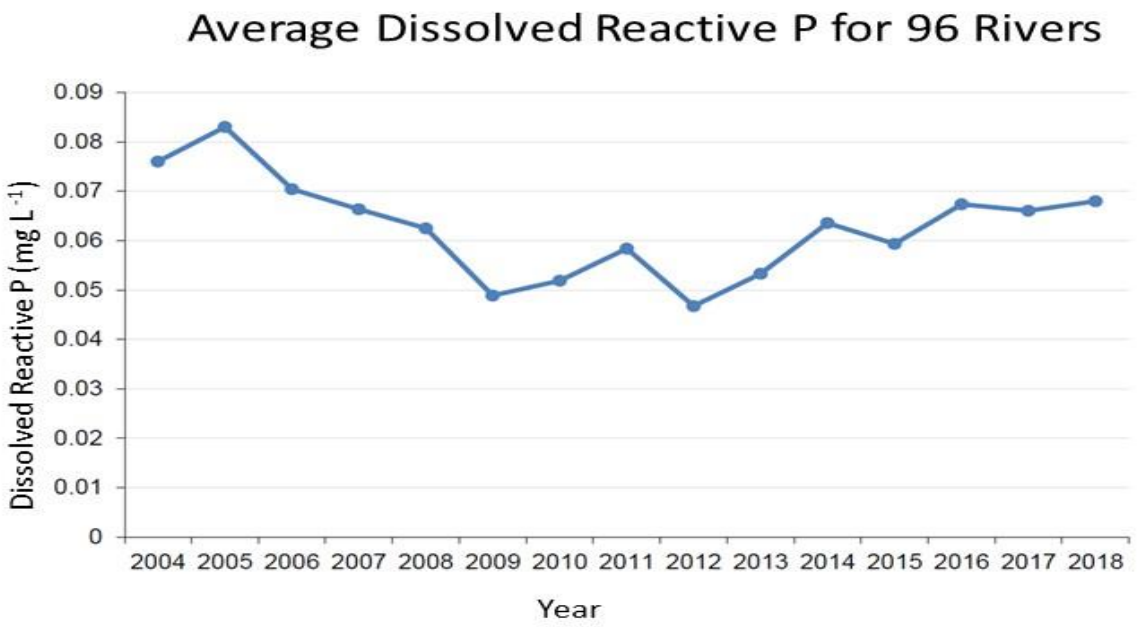
9th May 2021

afbini.gov.uk

Impact of P Loss from Soils

Soluble Reactive Phosphorus (SRP) (127 NI rivers, NIEA)





- Until recently, P concentrations in NI rivers had been declining.
- In the past 5 years, however, P levels appear to have been rising again.
- 55% of waterbodies at ‘good’ or high status based on DRP only

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Runoff Risk Modelling

Surface Runoff

Surface Runoff and Soil P Loss

- For water quality – target mitigation at high soil P and high risk areas in catchments.
- Avoid nutrient application to risky areas unless weather and growing conditions optimal.
- Use farm risk maps to focus P application and water protection measures

THE BRYDEN CENTRE

CatchmentCARE
Community Actions for Resilient Ecosystems

Interreg
Northern Ireland - Ireland - Scotland
European Regional Development Fund

Special EU Programmes Body
Foras Um Chláir Speisialta An AE
Boord O Owre Ocht UE Projecks

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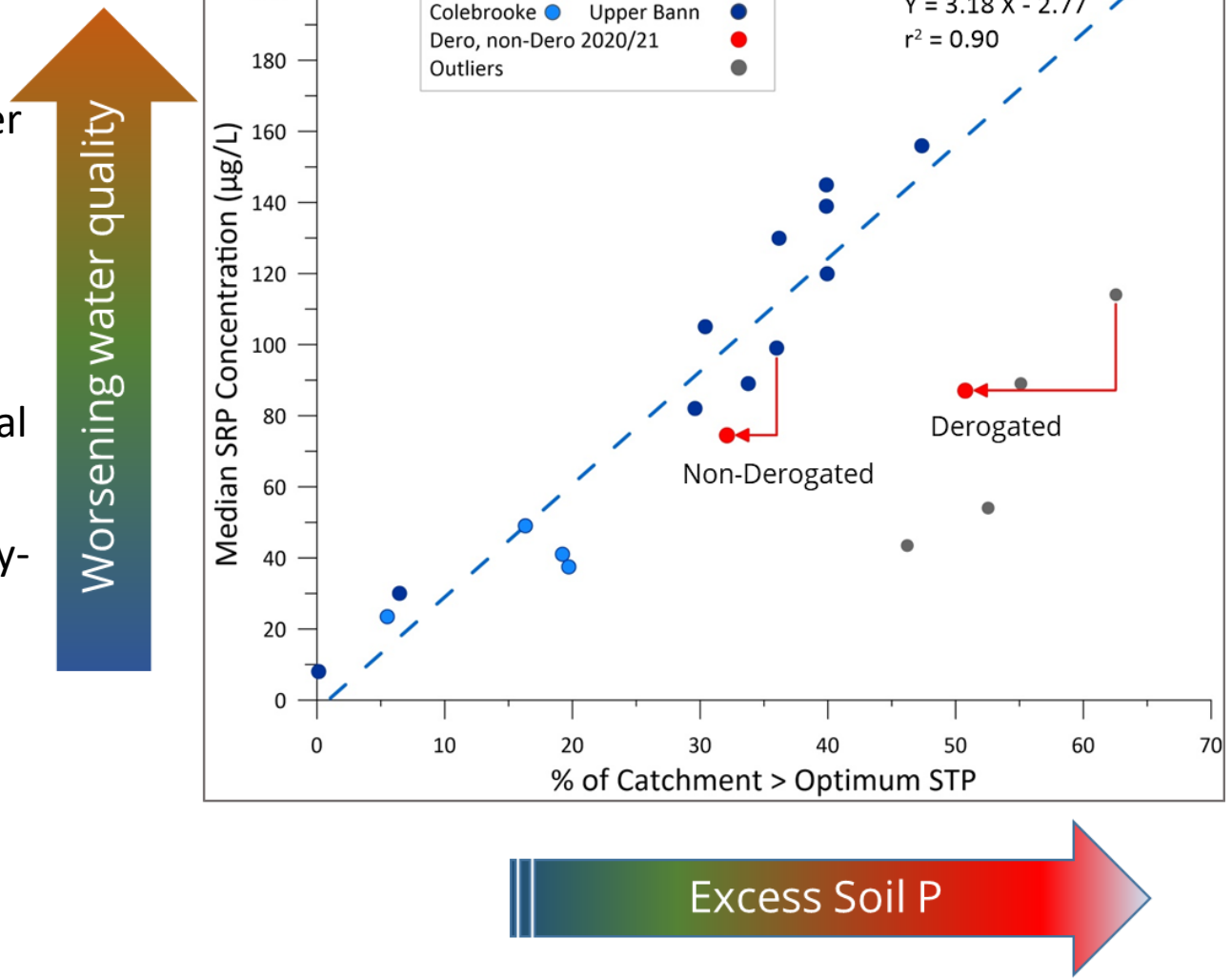
Changing Water Quality ?

- High P soils and deteriorating water quality (SRP)
- By redistributing slurry P, evidence shows that water quality can improve some.
  - Increased liming – optimised nutrient utilisation
  - Reduction in soil P – less excess, less potential loss to the environment
  - Very low P soils need addressed on a farm-by-farm basis
- Still significant land with excessive P



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Slurry & Digestate Recycling

- Roughly 1 billion
manures are 'co
- There are multi
nutrient availab
- There are many
this, and plenty
- Solutions and n
'viable' due to l
- The same has h
treatment
- Nutrient remov
of the business

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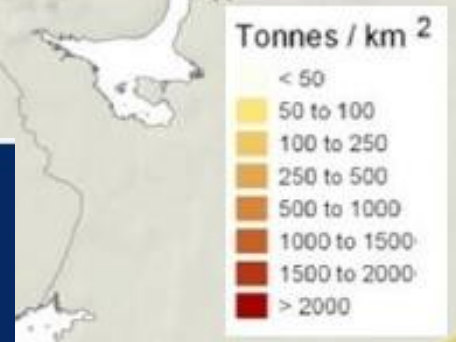
Poo overload: Northern Ireland could be forced to export a third of its animal waste

Country looks to export excess manure from intensive pig and poultry farms to combat rising pollution and emissions



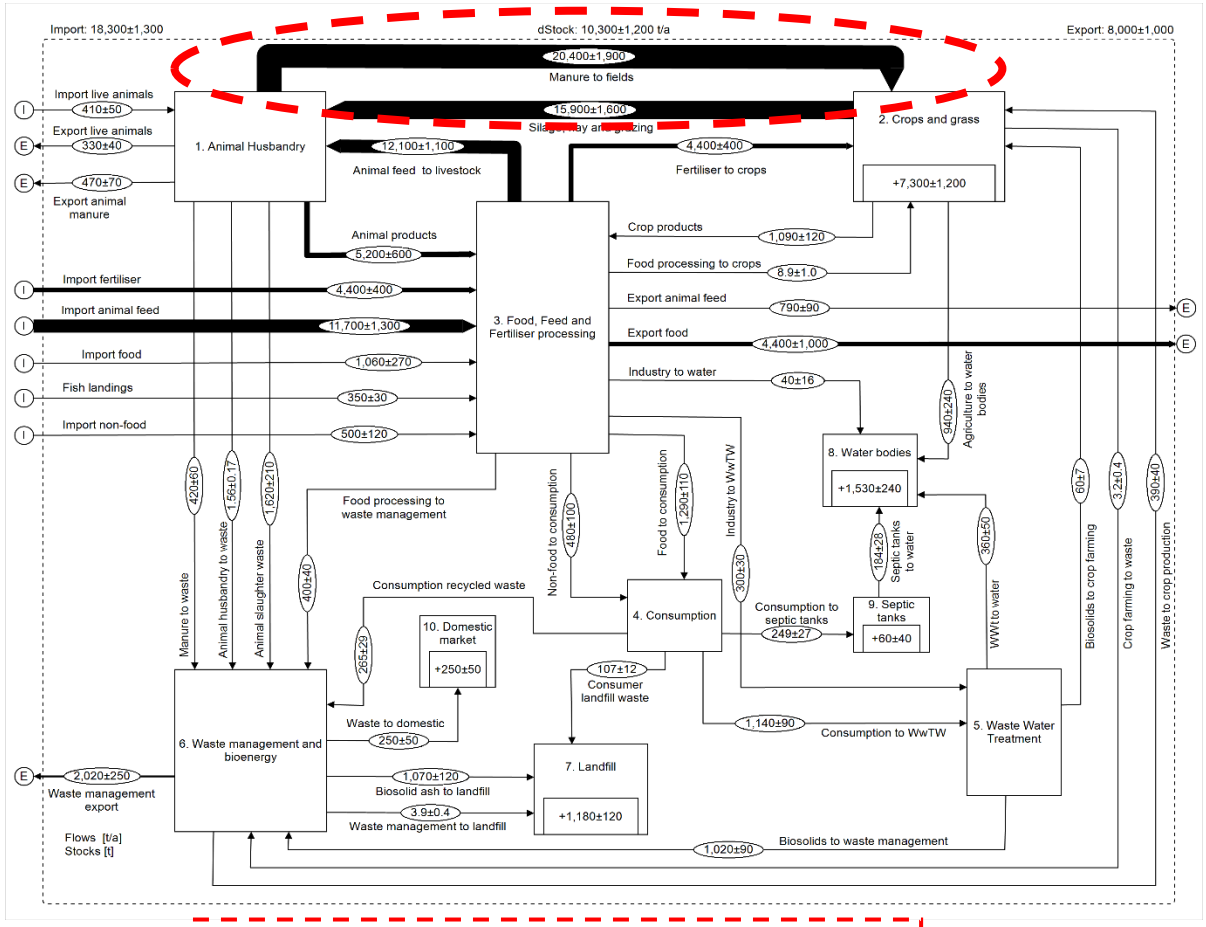
Scarlat *et al* (2018). A spatial analysis of biogas potential from manure in Europe. *Renewable and Sustainable Energy Reviews* **94:** 915-930

AquaEnviro

Shane Rothwell, Donnacha Doody, Chris Johnston, Kirsty Forber Paul Withers

Current Scenario:

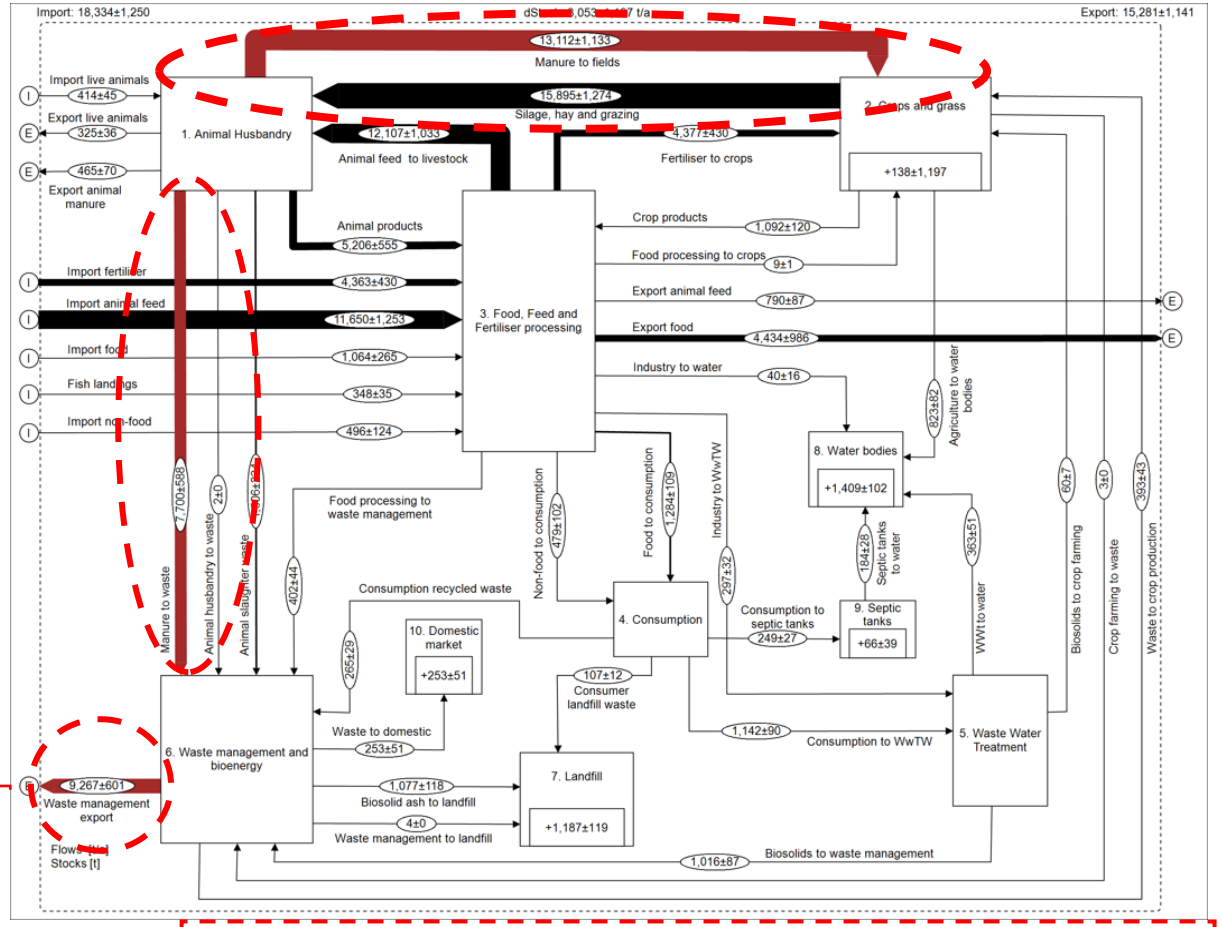
SFA 2017



Key metrics	
Surplus (kg/ha)	8.5
Predicted river SRP (ug/l)	58
P import (t/y)	18,337
Food system efficiency %	38

Manure export:

35% of manure P is 'processed' and exported



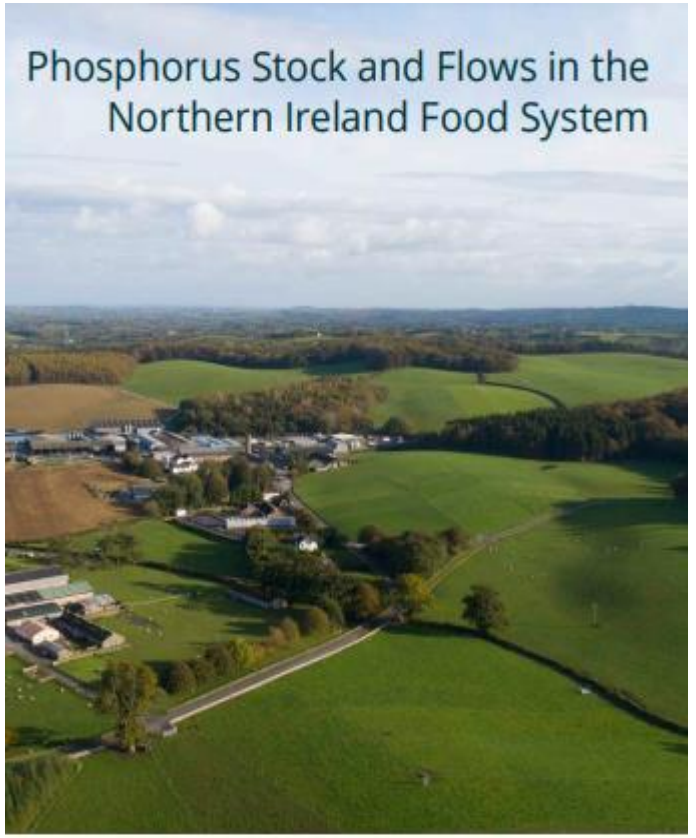
Export

Key metrics		% change from current
Surplus (kg/ha)	0.16	-98
Predicted river SRP (ug/l)	31	-46
P import (t/y)	18,334	0
Food system efficiency %	38	0

How to Achieve a Sustainable P Balance

- A reduction in fertiliser and increase in manure export
- Exporting slurries and manures outside of the NI food system
- NI poultry manure being processed for energy and e.g. horticultural products demonstrates the potential
- New processing technologies (physical and chemical separation of N, P, K, C) could make future export & markets of manures more viable.
- Stakeholders highlighted how processing manure for nutrients and energy provided (jobs & value-added products).

Addressing the manure surplus in NI is central to achieving Green Growth within the agri-food sector without undesirable consequences.



RePhOKUs

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Processing technologies - Valorisation

Soil Improvers & Fertilisers

EU Fertilising Products Regulation 2019/1009

Reverse Osmosis, Membranes

Drying, Densification, Energy Recovery, Combustion, Pyrolysis, Gasification, Ash / Biochar, Composting

Nutrient stripping, Evaporation (NH_3), absorption, acidification, crystalisation - struvite, plasma treatment

Thickening & Dewatering, Centrifuge, Screwpress, Screening Microfiltration, coagulation and flocculation, Gravity, DAF

Bio-energy

Biomaterials

- What scale ?
- How centralized ?
- Regulatory matters ?

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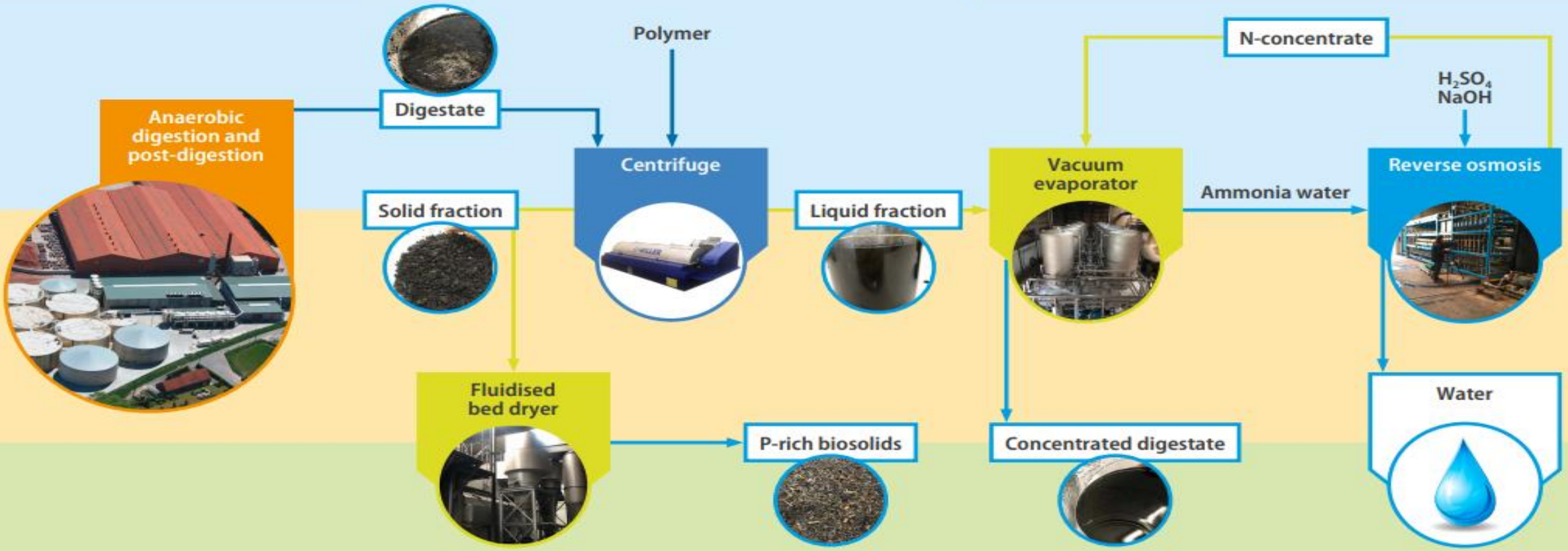
SYSTEMIC
Circular solutions for biowaste

AM-Power is part of the Horizon 2020 SYSTEMIC project which is demonstrating a variety of technologies for the recovery of mineral nutrients (N, P, K) and works on the production of a number of (nutrient-depleted) organic soil improvers and fertilisers. The implementation of nutrient-recovery technologies allows plant owners to process biowaste into user-specific products for the regional market.

www.systemicproject.eu

@systemic_eu

AM POWER



SYSTEMIC receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 730400.

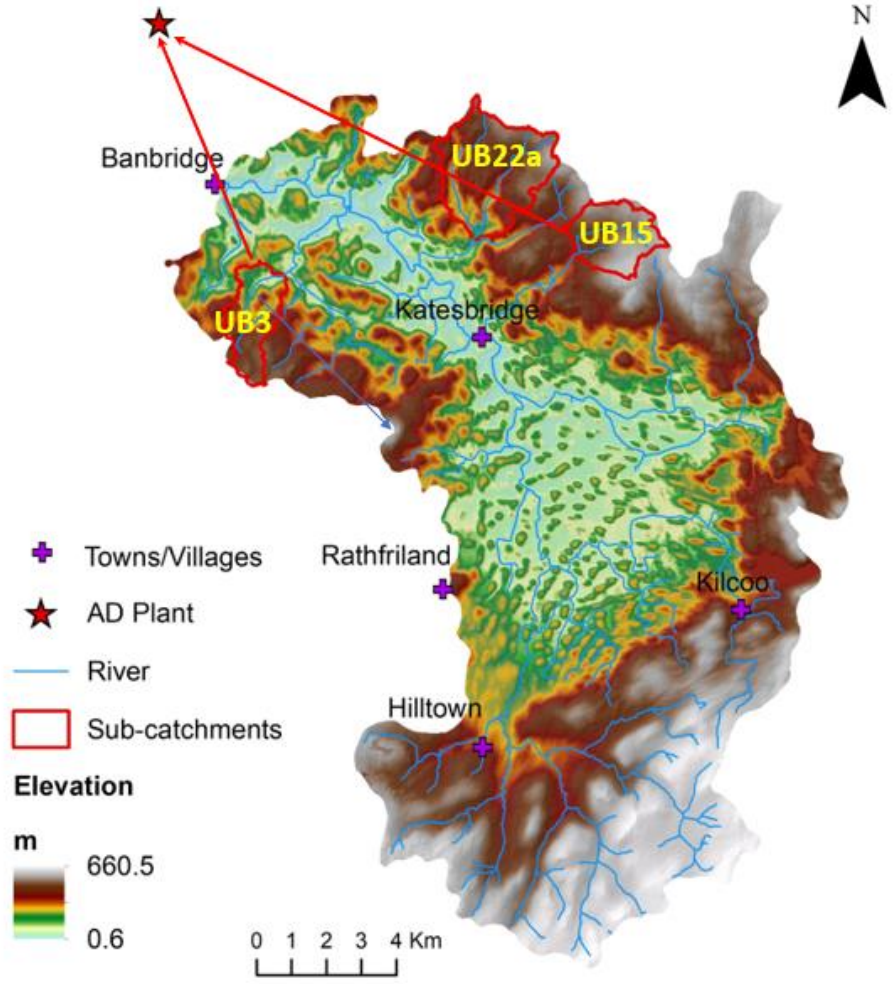
A developing concept trial for de-risking

Cause & Effect ?

Choosing a monitored sub-catchment to prove the concept …

- **Scoping Study (Farm Level Engagement and data collection)**

1. Monitoring and modelling of nutrient losses to water in agricultural catchments to evaluate the effectiveness of farm nutrient export
2. Nutrient monitoring and mass balance calculation
3. Energy recovery potentials at AD plant
4. Feedstock biomethane potential validation
5. Social Acceptance of methodology and any associated Regulation
6. Life Cycle Analysis (GHG balance, energy potential, eutrophication potential)
7. Link-up with Digestate Processing Projects
8. Economic assessment (proofing of estimates)



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First off - A Scoping study

Co-design a Proof-of-Concept pilot study with stakeholders

Different view points

Different requirements

Different expectations

Address these differences via a consensus on how a process of manure to energy / nutrient can work

Multi-agency,

Multi-scale,

Inter-departmental

How a pilot study can be used to evaluate the consensus approach.

Technology

Participation

Economics

Evaluation

By doing this now it will give stakeholders a greater buy-in and ownership of any future manure to energy & resource strategy in NI

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Thank you

Biomethane's potential to support Northern Ireland's Pathway to Net-Zero

May 2022

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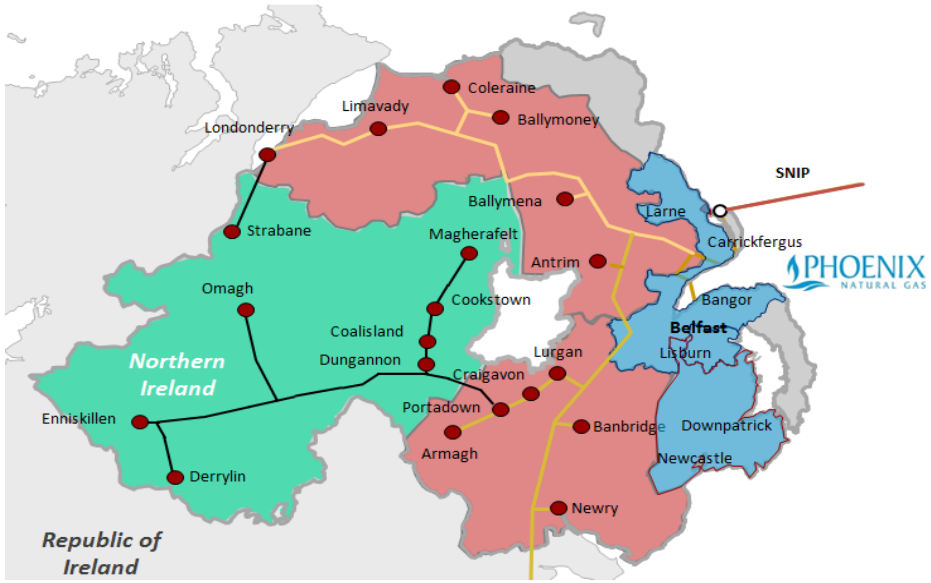
NI Gas Network – Background



As at 31st Dec 2022	PNG	firmus	SGN
Properties Passed	355,000	170,000	25,000
Properties Connected	250,000	60,000	9,000

Growing - By 2022 c.70% of properties in NI will have access to the gas network.

Flexible - Unique ability to manage seasonal energy demand and three times the current electricity peak demand, contributing to system resilience and energy security.

- 2020 NI Gas Distribution Network Demand – 7231 GWh
- 2020 NI Electricity Demand – 7416 GWh

Reducing emissions - By switching from oil, NI natural gas users currently prevent 1.2 million tonnes of CO_2 per year from entering the atmosphere. If the remaining properties who could connect, but haven't yet, up to a further 400,000 tonnes of CO_2 could be avoided.

Energy Strategy – recognises the gas network has a role in the pathway to net-zero

- *"We also intend to utilise our modern gas infrastructure and the potential to generate and import zero carbon gases. We will continue to engage with gas network operators on replacing natural gas with renewable gas."*
- *"There are a number of potential transition pathways available to consumers currently using heating oil. These include a switch to zero carbon heating technologies such as a heat pump or connection to the gas network (where possible) to take advantage of the plan to fully decarbonise the gas used in the network."*

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NI Gas Network – Pathway to Net-Zero (Projected Timeline)

Preparing for the Transition *(2021–2024)*

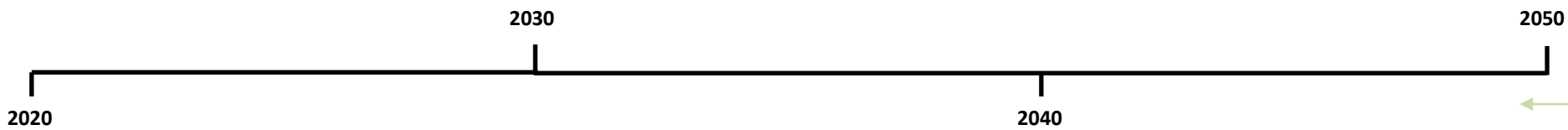
This initial phase of the Pathway primarily focuses on strategic planning and the technical, policy, legislative and regulatory preparatory workstreams required to facilitate the decarbonisation of the gas network

Establishing Supply & Demand *(2026–2030)*

This phase sees the first hydrogen & biomethane demand clusters emerge as production levels steadily climb – encouraged by ambitious Executive targets

Home Stretch (2040–2049)

This phase focuses on switching users not already benefiting from biomethane to a 100% hydrogen supply. Industry supports completion of energy efficiency programmes.



First Renewable Gas Connections *(2022–2026)*

This phase focuses on encouraging early Biomethane and Hydrogen producers to inject into the Gas Network. One-stop-shop with improved Energy Efficiency schemes is introduced and works closely with industry

Accelerating Ambition (2030–2040)

This phase focuses on building upon the foundations of the previous decade to facilitate a significant expansion of biomethane & hydrogen production.

A Zero-Carbon Gas Network (2050)

By 2050, natural gas is entirely replaced by hydrogen and biomethane offering zero-carbon fuel solutions to Residences, Services, Power, Industry & Transport Sectors.

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What are the advantages of utilising biomethane in the gas network?

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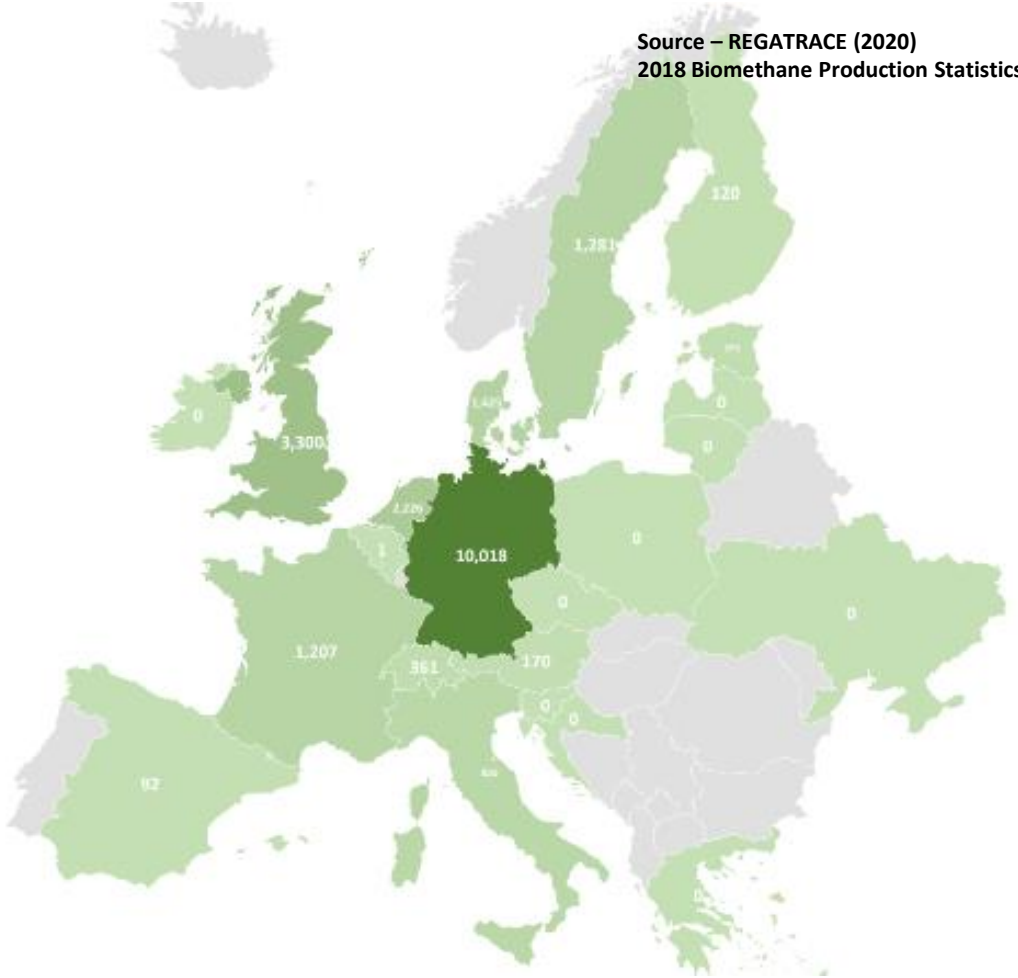
It’s a mature technology

Ireland

- Proposing a Renewable Heat Obligation
- Target of 1.6 TWh of renewable heat by 2030

Great Britain

- 3.3 TWh of biomethane injected into network in 2018
- 120 AD sites heat the equivalent of 750,000 homes
- New Green Gas Support Scheme launched in Nov 2021



France

- Injection target of 7-10% biomethane by 2030
- First injection took place in 2011 with over 200 AD sites in service in 2021

Denmark

- 25% of Danish gas consumption by the end of 2021 was biomethane
- 100% of all gas consumption is projected to be biomethane by 2034

REPowerEU plan doubled the 2030 EU biomethane production target from 17bcm to 35bcm

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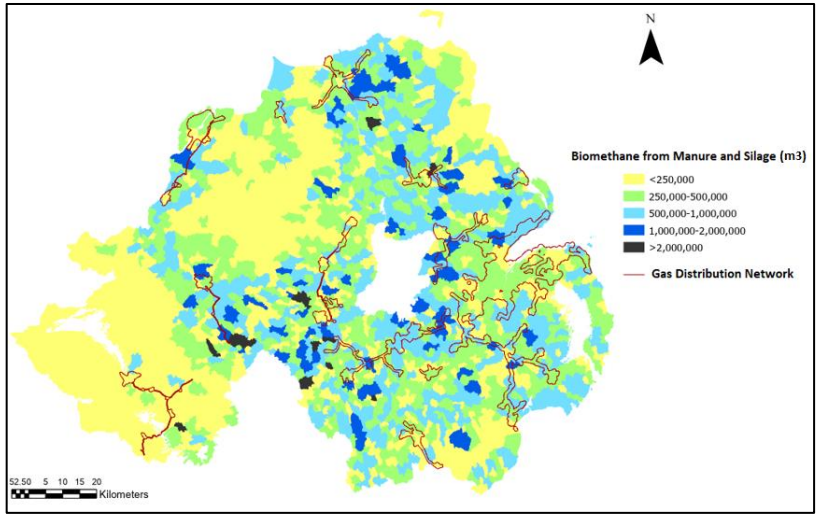
Scale of availability compared to demand

Northern Ireland's comparatively large livestock-dominated agriculture sector offers significant opportunity to produce significant volumes of biomethane.

- NI's total biomethane potential from (housed) cattle, pig and poultry manure plus underutilised silage is 753 million m³ or 7,527 GWh
  - The vast majority of this feedstock – 83% - is located within 10km of the NI Gas Distribution Network
- After considering the thermal energy requirements of the production process, a net value of **6,124 GWh of biomethane** is available.



Northern Ireland's gas demand profile is different to GB due the smaller size of its network and a comparative lack of very large industrial energy users.

- 2020 distribution network demand per capita in NI was only 3.8 MWh compared to 7.5 MWh in GB.
- 6,124 GWh of biomethane equates to **85%** of 2020 gas distribution network demand
- Equates to c.67% of projected 2030 gas distribution network demand

The scale of potential biomethane supply compares favourably with current and projected future demand but it will be difficult for biomethane to fulfil all of NI's future renewable gas demand. **Hydrogen & energy efficiency is expected to make up the difference.**

Distribution Network	Total 2020 Demand (GWh)	I/C 2020 Demand (GWh)
PNGL	4,658	1,931
firmus	1,876	1,343
SGN	696	686
Total	7,231	3,961

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Benefits multiple sectors

Industry

- Supports the NI firm's competitiveness
- Biomethane can meet full I/C demand of c.4000 GWh
- *Energy Strategy* - 2022-2030 industrial decarbonisation pathway

Transport

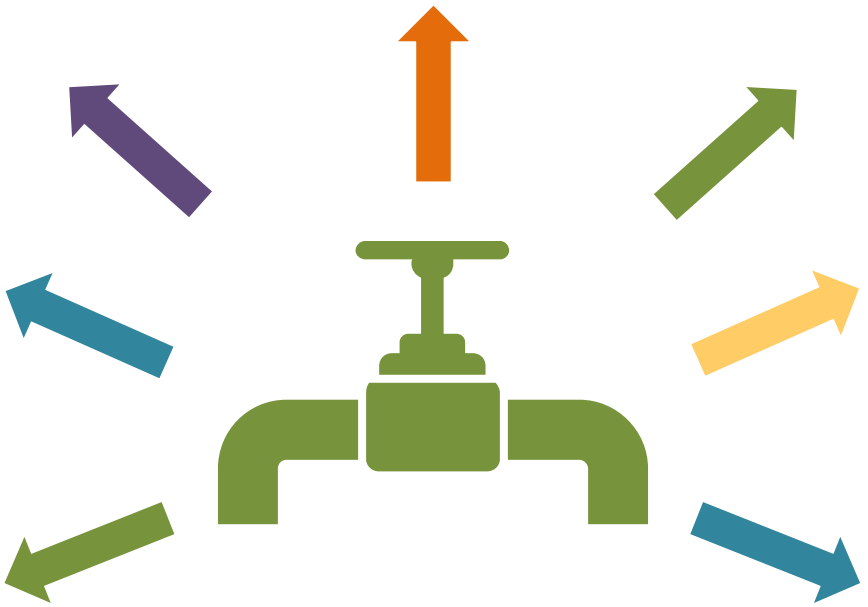
- Supports the decarbonisation of HGVs, the wider logistics sector, and ultimately NI firm's supply chains

Green Growth

- Supports job creation/retention in rural areas
- *Energy Strategy* - Target of doubling renewable energy economy by 2030

Buildings

- Like for like replacement for natural gas
- No need for domestic properties to change gas boilers/appliances



Decarbonisation/Environment

- Reduction of c.845,000 tonnes of CO_2 equivalent
- Routing manure through AD plants supports better nutrient management

Power

- Short-term – decarbonise electricity from CHP
- Long-term – potentially decarbonise supply to power stations

Agriculture

- Opportunity for agriculture to become part of the solution
- *NI Agri-Food Sector Report* – using slurry for biomethane production vital for livestock sector

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Next steps 2022 - 2030

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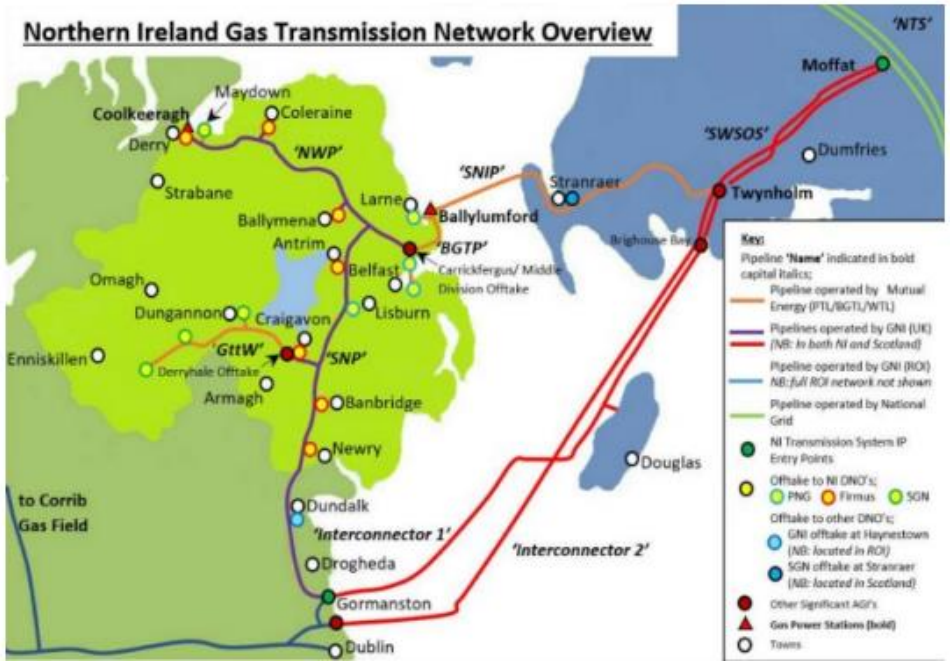
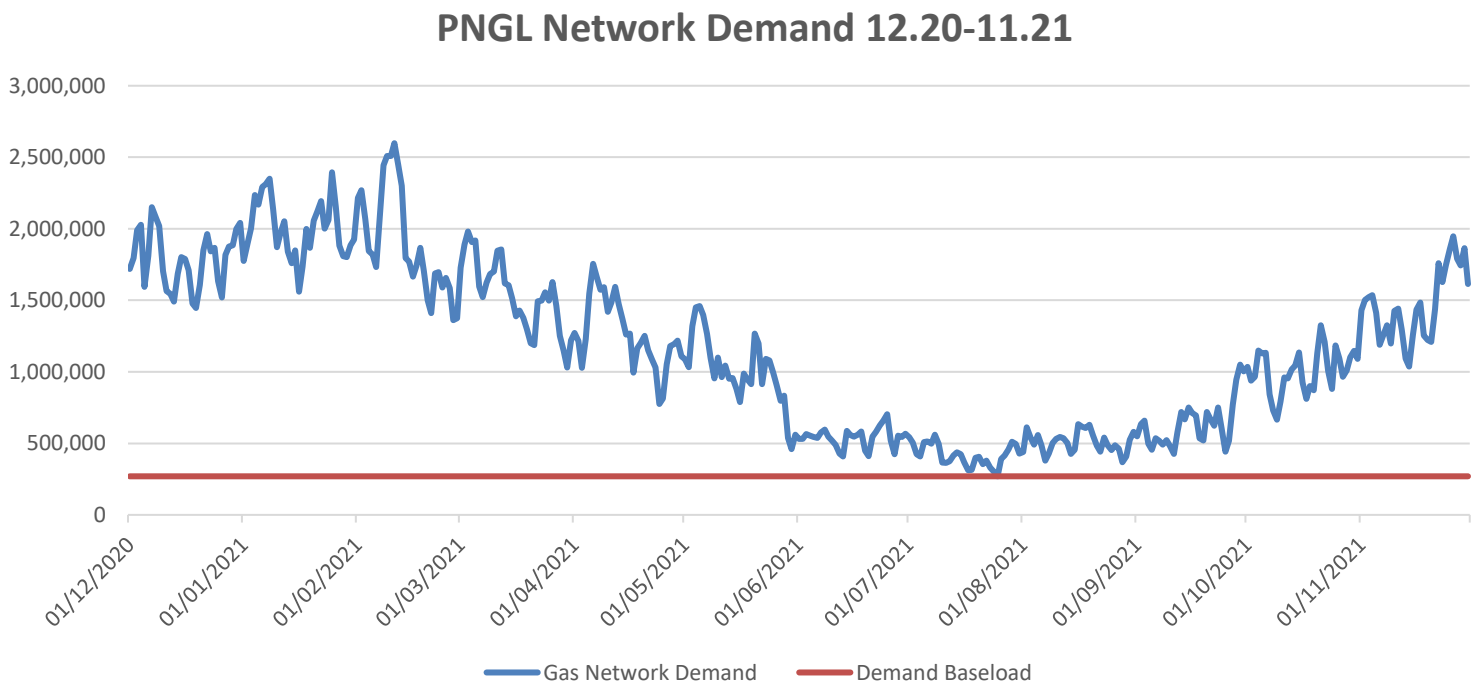
Biomethane into the NI Gas Network – Immediate capacity

Gas Network Capacity

- *Distribution Network* – Regulatory framework will soon be in place, but interseasonal demand variation limits capacity to accommodate a 24hr consistent biomethane supply from an AD plant
- *Transmission/Storage* - Injection into transmission network, and utilising storage, addresses capacity issues and work on the necessary regulatory framework is ongoing.

- PNGL Peak demand - 2,598,478 m³ (11/02/2021)
- PNGL Base demand - 270,116 m³ (25/07/2021)





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What's a realistic 2030 target?

In the short-term, the NI Gas Network can accommodate between 1000 – 1500 GWh* of the 6,124 GWh of biomethane available

Ambitious – Compares to proposed Irish Government 2030 renewable heat target – 1.6 TWh

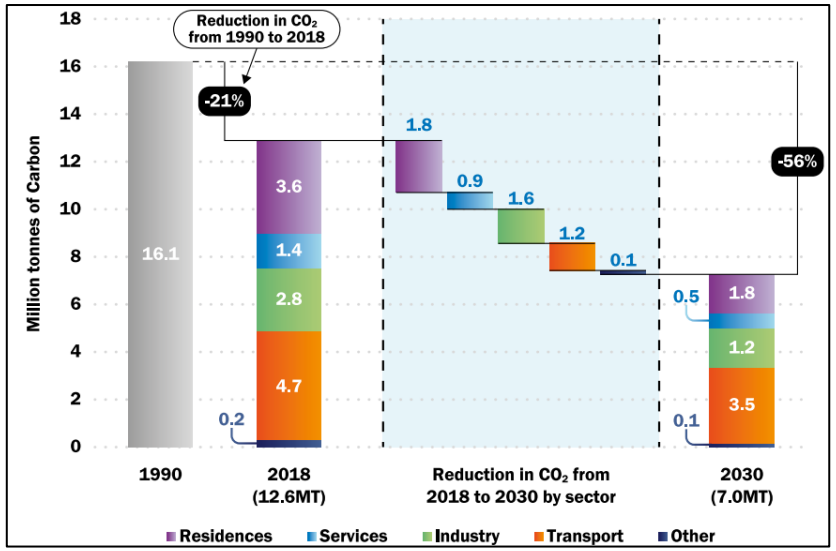
Achievable – Represents only 15%-25% of the total biomethane available (c.30-50 additional 400scmh plants)

Least regrets – Maximises existing injection capacity on the network without requiring additional infrastructure investment (storage, compression etc.)

Best value for the consumer – Offers significant decarbonisation of the gas supply (11-16%) at least possible cost (no significant additional infrastructure)

Impact – Large enough supply to provide an option for firms wishing to decarbonise their energy supply (Heat & Transport) to remain competitive – supporting 2022-2030 industrial decarbonisation pathway (reduction of 140-200k tonnes of CO_2 eq)

Proof of concept – Opportunity to test existing research/concepts, test willingness of rural community to embrace biomethane injection, creates body of evidence to determine the most efficient role of Biomethane post 2030



Further research required to determine exact target

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What comes next – a 5 step plan

Step 1: Complete technical/regulatory preparations for injection
UR/GNO Biomethane Regulatory Workstream will complete preparations to facilitate injection this year (Q2/Q3)

Step 2: Continue to improve our understanding
Conduct further research to better understand what's possible/desirable – KPMG, QUB/DfE & AFBI research

Step 3: Engage with stakeholders
Build upon the research by encouraging greater stakeholder engagement – events, workshops, call for evidence – supported by IDBG

Step 4: Identify a 2030 target
Utilise the research and stakeholder engagement to identify a 2030 biomethane production target which achieves the desired outcomes

Step 5: Design & implement support measures
Utilise the research and stakeholder engagement to identify a best value support mechanism to encourage investment in Biomethane production

ADBA Anaerobic Digestion and Bioresources Association

Utility Regulator ELECTRICITY GAS WATER

Department of Agriculture, Environment and Rural Affairs

Department for the Economy www.economy-ni.gov.uk

Ulster Farmers' Union

afbi AGRI-FOOD & BIOSCIENCES INSTITUTE

Queen's University Belfast

The Consumer Council

The Consumer Council

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UTILISING NI'S AGRICULTURE SECTOR TO DECARBONISE HEAT

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