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Sustainable Solutions, Assured

Nutrient Recovery in the Organic Waste Sector

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Focusing on Market Development projects for innovative material recovery technologies and environmental permitting requirements, within the waste and renewables sector.

01

Market Drivers

NET Zero & Circular Economy

NET Zero

- Recovered fertilisers minimises the need for synthetic & industrial fertilisers, which have a high carbon footprint (e.g., nitrogen fertilisers account for 8.3% of farm-gate global emissions, 2022). Additionally, the UK agriculture sector emitted 47.7 million tonnes of GHGs in 2022 (11% of total UK GHG emissions).

- Biochar recovery methods enables carbon sequestration created from organic material and the subsequent generation of carbon credits.

Circular Economy

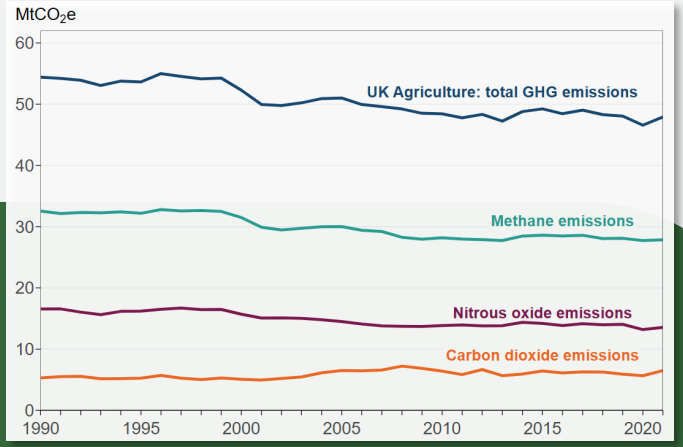
UK Environment Act 2021- *Relevant Aspects*

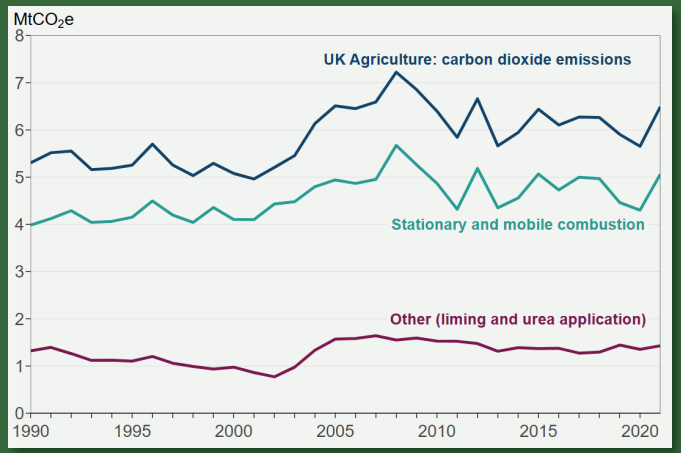
- Enhanced Wastewater Treatment: Implementing advanced treatment technologies to remove nutrients from wastewater, potentially allowing for the capture and reuse of these nutrients.

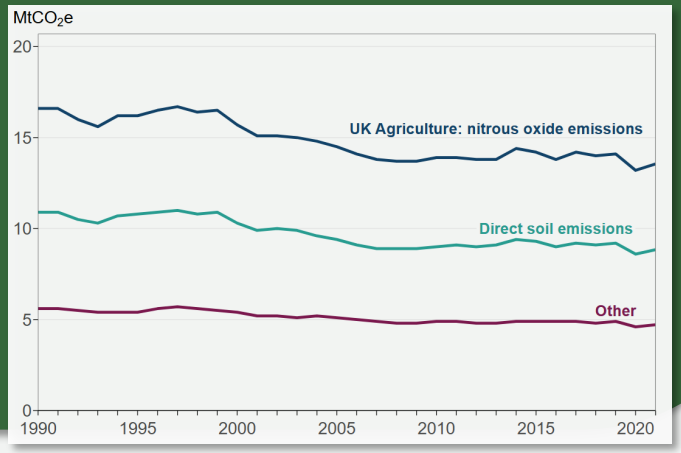
- Reducing nitrogen, phosphorus and sediment pollution from agriculture into the water environment by at least 40% by 2038 (against a 2018 baseline) & to cut wastewater pollution by 80% by 2038.

Resources and Waste Strategy – *Relevant Aspects*

- Sustainable Production: Encourages manufacturers to design products with their entire lifecycle in mind.





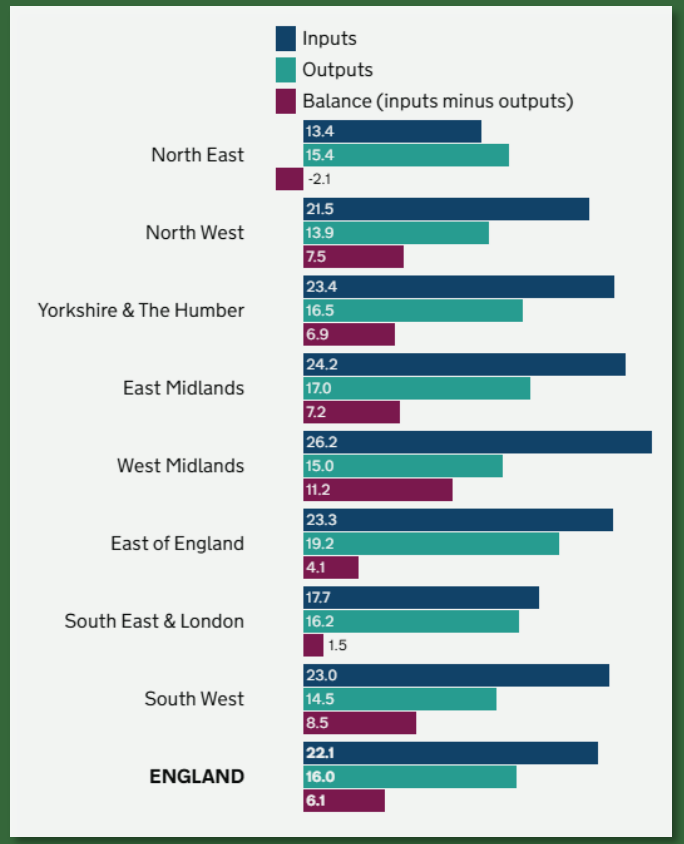


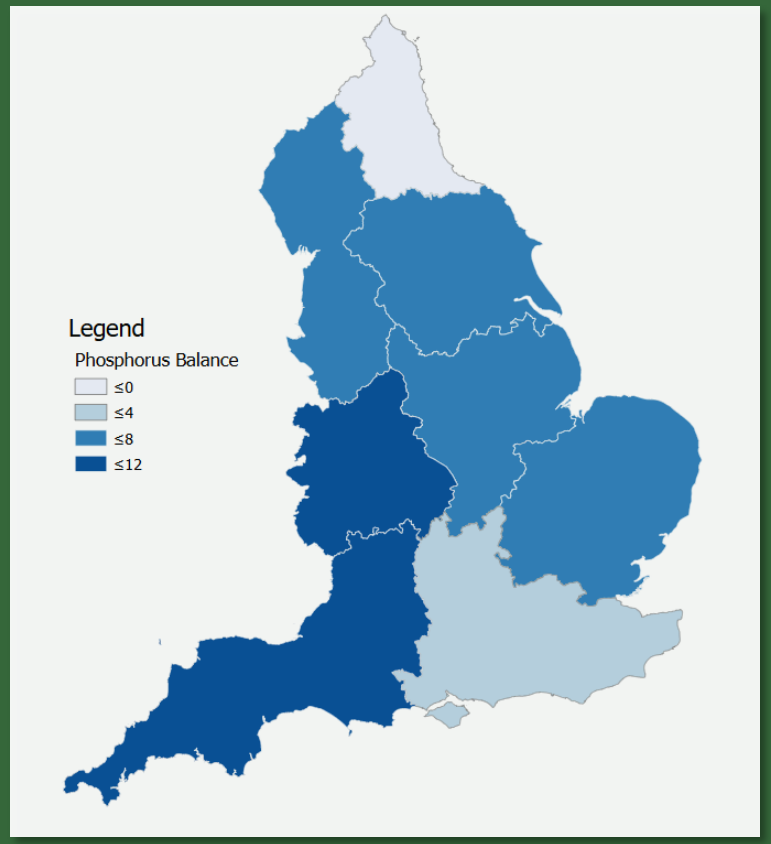
Source – Department for Energy, Security and Net Zero – Agri-Climate Report, 2023

Nutrient Loading in UK Soils

Phosphorous (kg/ha) Surplus in the UK Demonstrating Requirement for Future Phosphate Recovery

- The input sources: manures, mineral fertilisers, atmospheric deposition and biological fixation.
- The removals sources: crop production and fodder production for livestock, including grazing.





Source – Department for Environment, Food & Rural Affairs – Soil nutrient balances for the regions of England, 2022

UK Soil Deficiencies

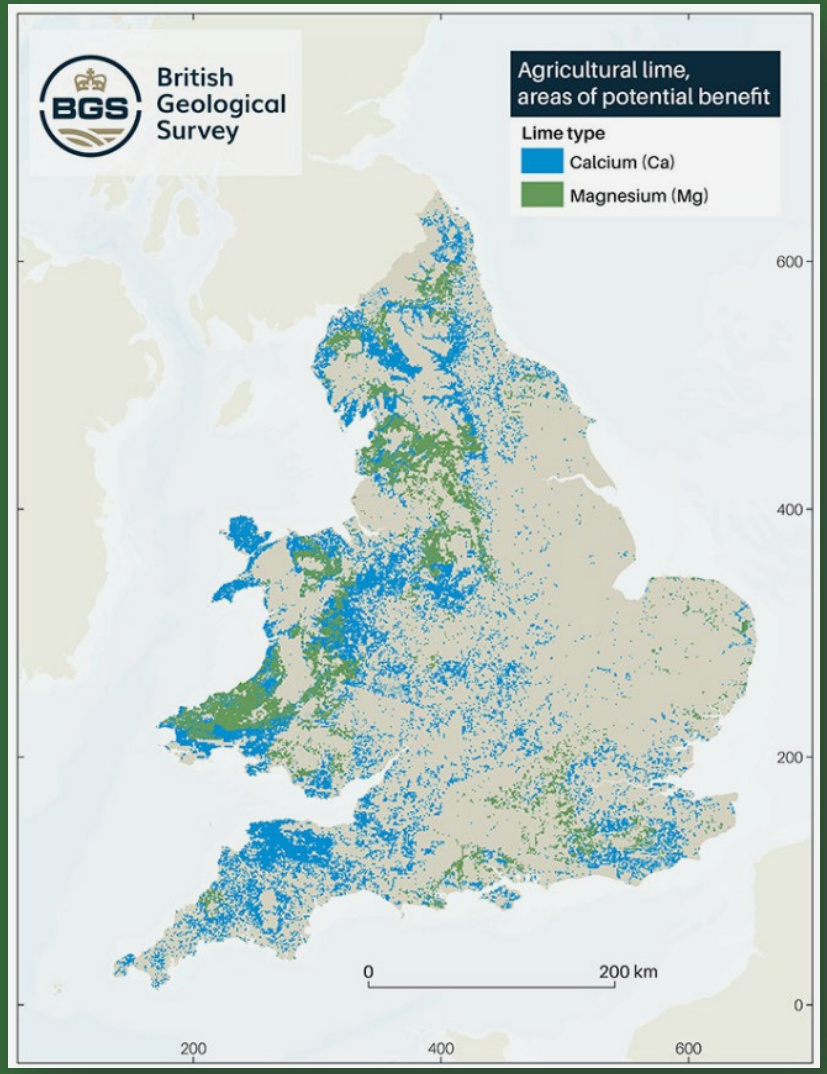
Areas with the Recommendation for Agricultural Liming of the Soil

- Demonstrating large UK market area where liming nutrients will be in demand.

Current Emissions Associated with Agricultural Lime Production

- Calcination Process - Reaction emits approximately 0.75 tonnes of CO_2 per tonne of quicklime, from heating of limestone in a kiln.

- Fuel Combustion - Additional CO_2 emissions result from burning fossil fuels to heat the kilns, contributing between 0.2 to 0.45 tonnes of CO_2 per tonne of quicklime.



Source – UK Soil Observatory, 2025

Financial Benefit

Reduced Fertiliser Cost

Recovering nutrients from waste sources, farmers and industries can reduce their dependence on synthetic/industrial fertilisers.

Recovered Ammonium Sulphate	Synthetic/Industrial Ammonium Sulphate
Up to £130 per tonne	Up to £290 per tonne

Revenue from By-products

Nutrient recovery can create new revenue streams by turning recovered nutrients into sellable product. Example of carbon credit values associated with biochar carbon dioxide removal (CDR) method:

Biochar Carbon Credit – Inhouse Project	Biochar Carbon Credit – Sale of 22,500 credits to Shell by The Next 150
Up to £140 per tonne CO_2	£87 per tonne CO_2 (Averaged)

Environmental Costs

Where there is ability to recover and store nutrients prior to land application or discharge to air, can help avoid potential fines or regulatory costs related to environmental damage and create savings by improving overall environmental compliance.

Improve Efficiency

Having nutrients in a stored and readily usable format can help with the rate, timing and application method.

02

Market Incentive

Geopolitical

Global Supply Chain Disruptions

- Geopolitical instability in key nutrient-producing regions external to the UK can have cascading effects on global supply chains. Disruptions in the supply of critical nutrients like phosphates, nitrogen, and potash can result in price increases and availability issues for the UK.
- The COVID-19 pandemic and the ongoing war in Ukraine have highlighted vulnerability of global supply chains.

Brexit and Trade Barriers

- Loss of access to the EU's single market created new trade barriers, tariffs, and customs checks.
- The movement of livestock feed, grains, and fertilisers from the EU has been slowed due to customs procedures and changes in trade agreements.

European Farm to Fork Strategy

- The European Farm to Fork Strategy is a key component of the EU Green Deal (first climate neutral continent by 2050).
- Due to excess nitrogen & phosphorous within soils the European Commission will act to reduce nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility. This will aim to reduce the use of synthetic fertilisers by at least 20% by 2030.

Global prices ($/Average) from 2017-2022

Source –World Bank (2022) Commodity Markets. The 'Pink Sheet' Monthly data. 4 April 2022 update & European Commission, Potash: Impact Assessment for supply security, 2022

UK Legislation

Nitrogen and Phosphorous Emission Reporting

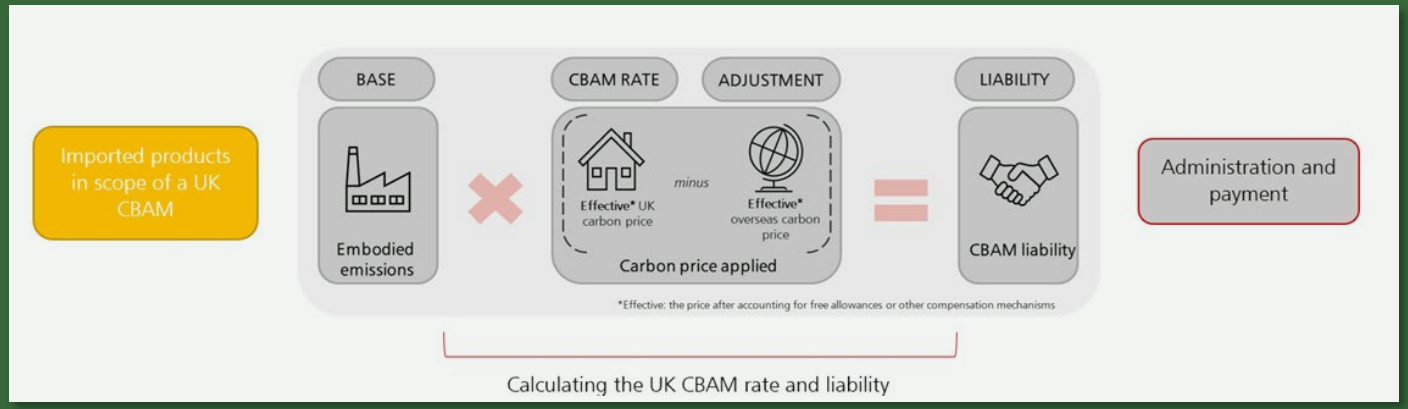
- From January 2025, certain permitted poultry farms (poultry farms with more than 40,000 rearing places) and all permitted pig farms across England will need to report their nitrogen (N) and phosphorus (P) excretion levels annually.
- Levels of nitrogen and phosphorus excreted must comply with BAT Associated Environmental Levels (BAT-AELs).

UK Carbon Border Adjustment Mechanisms (CBAM)

- Aim of the policy is to mitigate risk of carbon leakage from goods importation, with planned implementation in 2027.
- The UK CBAM will place a carbon price on some of the most emissions intensive industrial goods imported to the UK from the aluminium, cement, ceramics, fertiliser, glass, hydrogen, iron and steel sectors.
- Specific fertilisers considered - nitrogenous, phosphatic, and potassic.

CBAM will cover the Embodied Carbon

- Direct (Scope 1) Emissions: Emissions directly produced during manufacturing processes.
- Indirect (Scope 2) Emissions: Emissions resulting from the consumption of purchased electricity, heat, steam, and cooling used in production.



Source –HM Revenues & Customs and HM Treasury: Introduction of a UK carbon border adjustment mechanism from January 2027, published 2024

03

Nutrient Recovery Techniques

Recovering Nitrogen as Ammonium Sulphate – Stripping Columns

Process Steps

- Ammonia rich solution (digestate or scrubbing liquor) enters the stripping column.
- Steam introduced to volatize the ammonia through reducing partial pressure.
- Ammonia is collected in the gas phase whilst liquid moves downwards to be removed from the system.
- Stripped Ammonia is absorbed in sulphuric acid in a separate scrubber forming ammonium sulphate.
- Product provided can either be sold in liquor form or undergo further valorisation to be crystallised.

Recovery Technology

Stripping Columns

Example Technology

NSI Byosis - Netherlands

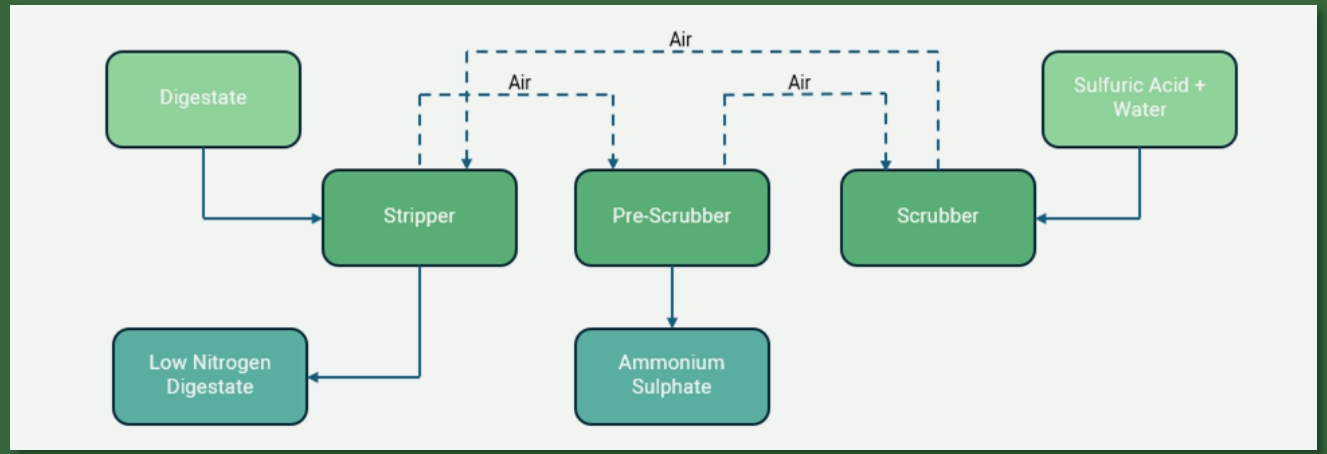
- ByoFlex system

Nijhuis Bouw B.V – Netherlands

- Aeco-Nar system

Supply Opportunity

- **Agriculture** – Fertiliser



Phosphate Recovery – Struvite Precipitation

Process Steps

- Wastewater streams such as municipal sewage, livestock manure, industrial effluents, and anaerobic digester supernatants contain high phosphate concentrations.
- Magnesium (Mg^{2+}) and ammonium (NH_4^+) ions are introduced in specific molar ratios to react with the phosphate (PO_4^{3-}) sources.
- The pH is adjusted to 8.0–9.5 to optimise struvite precipitation.
- The reaction forms struvite crystals, which settle and can be separated from the liquid phase.
- The formed crystals are collected, dried, and used as fertiliser.

Recovery Technology

Fluidised Bed Reactor

- Wastewater is continuously fed into a reactor containing seed particles (like sand or recycled struvite).
- Magnesium, ammonium, and phosphate reacts with the wastewater under controlled pH (~8.5) to form struvite crystals, which grow on the seed particles.
- The recovered struvite settles at the bottom of the reactor and is periodically harvested.

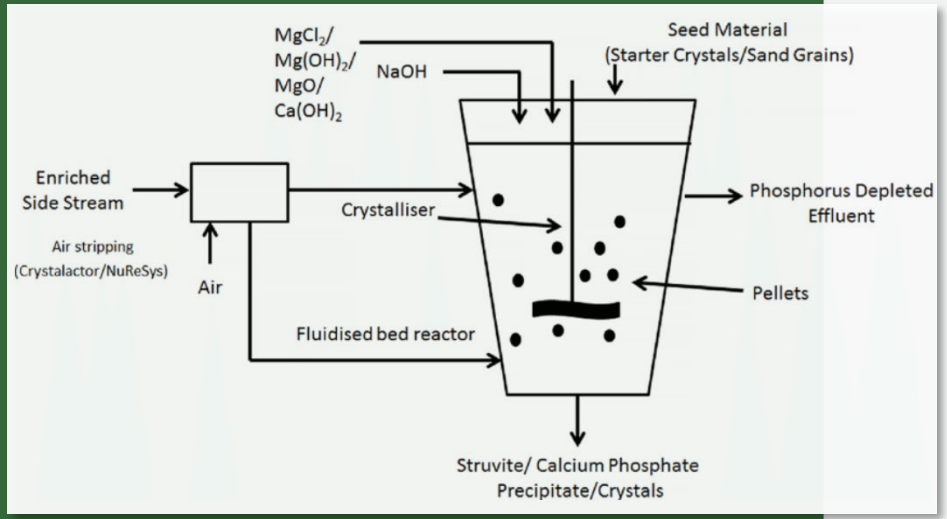
Example Technology Provider

Green Tile BV – Belgium

- NuReSys Fluidzed Bed Reactor – 80% phosphorous recovery at Slough WWTP

Supply Opportunity

- **Agriculture** – Fertiliser



Source – epa Research, Identification and evaluation of phosphorous recovery technologies in an Irish context, 2016

Biochar – Pyrolysis

Process Steps

- Wood chips, crop residues, manure and forestry waste act as applicable feedstock.
- Dry feedstock with low moisture content (<20%).
- Biomass is heated (500–800℃) in low or no oxygen, preventing complete combustion.
- Pyrolysis process produces biochar, syngas, bio-oil and heat energy.

Recovery Technology

Fixed Bed - Biomass is placed in a fixed bed within the reactor.
Rotary Kiln – Biomass is continuously rotated within a cylindrical drum (the kiln), which is heated externally to high temperatures.

Example Technology Provider

ONNU, UK -

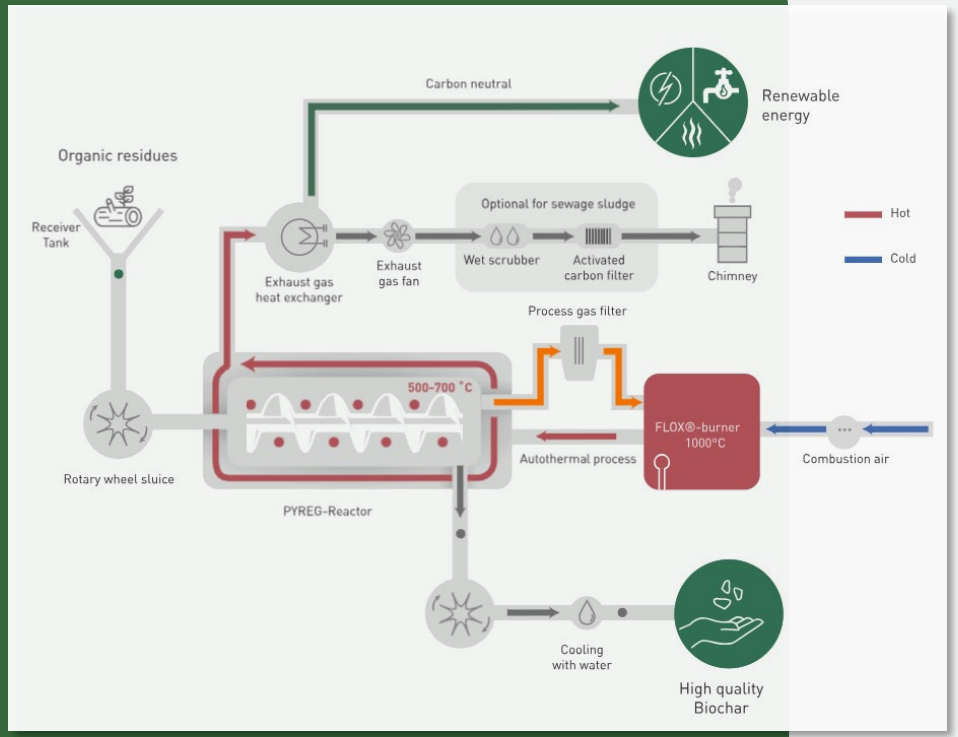
- Modular system (C-1000) 3,396 – 13,584tpa feedstock input

Pyreg GmbH, Germany -

- Modular system (PX500-6000) 1,100tpa – 13,000tpa feedstock input

Supply Opportunity

- **Agriculture** – Soil amendment, nutrient absorbent (e.g., phosphorous) enabling run off control.
- **Carbon Sequestration** – Carbon credits
- **Waste Water** – PFAS removal & Heavy Metal adsorbent
- **Anaerobic Digestion** – Biogas yield increase



Source – Pyreg, pyrolysis unit process flow.

Calcium Carbonate Recovery – Mineralisation

Process Steps

- CO_2 is captured from exhaust gases from CHPs via the use of chemical absorption (amine scrubber) or physical adsorption (membrane).
- CO_2 rich gas is reacted with calcium-rich minerals e.g., calcium hydroxide, calcium oxide and industrial waste (cement kiln dust, slag and fly ash).
- Combining these sources enables the precipitation of calcium carbonate, where particle size & purity can be controlled.
- The precipitated calcium carbonate is filtered, washed and dried.

Example Technology Providers

Mineral Carbonation International, Australia (Myrtle Plant Under Construction)

- Combines captured CO_2 with a mineral feedstock, including industrial wastes (steel slag, mine tailings or raw quarried minerals), to produce magnesium carbonate, calcium carbonate and amorphous silica.

Carbon Capture Machine, Aberdeen (Pilot Project)

- Dissolve CO_2 flue gas directly into slightly alkaline water.
- Faced with a suitable brine source containing dissolved Ca and Mg (and other) ions.
- A multi-stage precipitation technology is used to selectively separate and produce nearly insoluble Ca and Mg carbonate minerals.

Supply Opportunity

- **Agriculture** – Liming soils
- **Consumer Products** – Paper, paints, plastic & glass
- **Construction** – Low carbon concrete

Source – MCi Carbon, Newcastle Institute of Energy and Resources pilot plan.

Phosphorous and Nitrogen Recovery - Membranes

Process Steps

Anaerobic Membrane Bioreactors (AnMBR) - Following biological treatment, the mixed liquor from wastewater passes through submerged membranes or external (side stream) membrane system. These membranes act as a barrier, allowing clean water to permeate while retaining solids and microorganisms within the bioreactor.

- Microfiltration (pore size - 0.1 to 10µm) or Ultrafiltration (pore size 0.01 and 0.1µm) membranes within the AnMBR remove suspended solids and some microorganisms from the effluent.

Nanofiltration (pore size - 0.001-0.01µm) - Proceeding ANnMBR MF/UF phase, wastewater enters a nanofiltration membrane system, which further concentrates and removes dissolved nutrients like ammonium and phosphate.

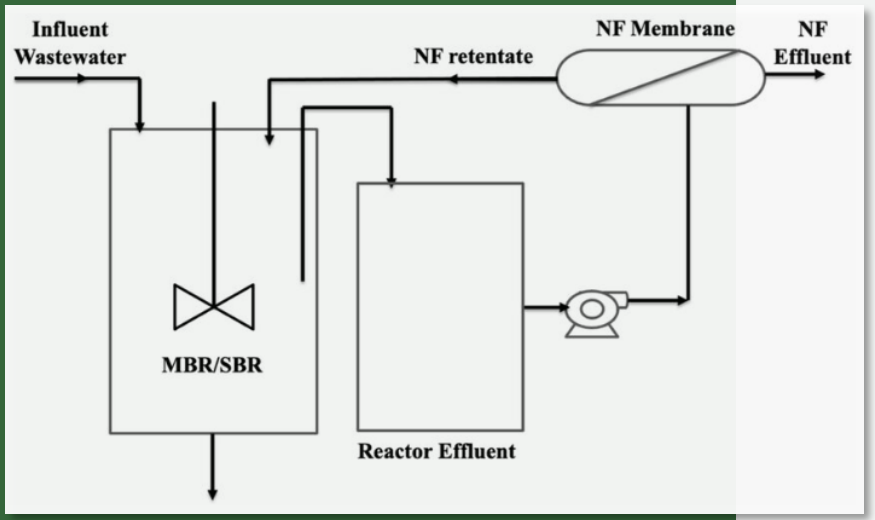
- This NF effluent can then be applied to the struvite crystal or stripping column process to capture the individual nutrients.

Example Technology Providers

Pentair, US – 55g tubular UF membrane module used for effluent treatment, membrane Bioreactors and leachate treatment.
Envirogen Group, Netherlands – PureSep NF Nanofiltration System.
Dupont, Sweden – Galve Water Treatment Plant utilised IntegraPac UF system in combination with FilmTec NF system for drinking water production from the Galve River, due to requirements for natural organic matter separation.

Supply Opportunity

Agriculture – Fertiliser



Source, Removal of Emerging Contaminants from Wastewater Streams Using Membrane Bioreactors: A Review, 2021.

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