THE VALLEY OF DEATH

To better valorise digestate and improve resource efficiency in agriculture a development pathway is required to connect policy makers, industry and academia, writes **Prof Ruben Sakrabani**

Anaerobic digestion (AD) is a key technology, vital for providing green energy and managing waste. It also provides a valuable resource that is suitable as an organic fertiliser; digestate, that can deliver both organic matter and nutrients, including trace elements other than NPK (nitrogen, phosphorus, and potassium) to soils.

One of the challenges in the use of digestate, however, is its high-water content. In addition to this is its highly available nitrogen content, causing ammonia emissions due to volatilisation during storage and use.

This creates two immediate problems. First, ammonia emissions cause air quality issues; hence digestate has been the focus of much regulation recently – most notably as a requirement for AD operators to have two months covered storage and for digestate to be spread using precision techniques, such as dribble bar/injection spreading technology.

Secondly, volatilisation also represents a waste of valuable nitrogen, which will invariably be replaced by mineral nitrogen to meet crop requirement. Producing ammonia fertilisers is responsible for about 1% of all global energy use and 1.4% of all CO_2 emissions – almost equivalent to the emissions of Germany (Carbon Brief).

A host of emerging technologies could address the environmental impacts associated with digestates. These include carbon capture, methane cracking, plasma technology and activated oxygen, which in combination can reduce moisture content, increase the readily available forms of nitrogen for soil and crop uptake and dramatically reduce the potential for volatilisation (through a reduction in the formation of ammonia, NH_3).

When these technologies are deployed onto digestate, however, its nutrient status is affected, demanding that more scientific work is undertaken for the full impact on soil health to be understood. For many such technologies this is where we enter the Valley of Death – a commonly used metaphor to describe the stage between research-based innovation and commercialisation (see Technology Readiness Level). The Valley of Death describes the period of real-world trials and proof of concept TRLs 4-7.

Innovation drag anchor

If we wish to better valorise feedstock and exploit suitable technologies to improve resource efficiency in agriculture, we need to develop strategies for more extensive and rapid uptake of novel technologies. We have started this work.

Over the course of this year Cranfield University has held a series of workshops to discuss how to overcome this challenge with policy partners in government - Department for Energy Security and Net Zero (DESNZ), Defra and the Environment Agency – and biogas stakeholders from across the industry (see participants below) to assess policy barriers to implement emerging technologies able to valorise anaerobic digestate as a nutrient supply in crop production.

Developing the programme was a cross-School initiative, involving Cranfield University's Schools of Water, Energy & Environment and Aeronautics, Transport and Manufacturing, indicating its far-reaching impacts.

Representatives of Defra, the Environment Agency, DESNZ, CCm Technologies and Greeneco discuss digestate valorisation at one of the three Cranfield University workshops.

Our principal objectives were to assess the existing emerging technologies that are being used to augment digestate quality, to boost its suitability for soil applications, identify challenges in current practices which are impeding the wide commercial use.

A specific challenge for technology providers with products in the 'Valley of Death' TRL range is a lack of access to the long-term funding required to push emerging technologies to the higher TRL's and subsequent commercialisation. The timeframe is particularly long, especially where a whole supply chain needs to put into place, or a market needs to be developed.

Aligning all the required parties to be able to present the case for funding is a drag anchor on innovation. A key outcome of these workshops was recognition of the need to improve interactions and communication between academia, industry and policy makers, to have a clear matrix of engagement to streamline these inputs.

AD and its outputs involve multiple cross departmental interactions by policymakers and it can therefore be challenging to implement the changes necessary to facilitate a new technology. At the workshops, policymakers illustrated their challenges in regulating new technologies coming to market, to help technology providers to better understand their options for improved engagement.

Further challenges to commercialisation also lie in the policy realm where, for example, digestates augmented using new technologies are deemed not to adhere to existing market and regulatory specifications (such as PAS 110 and Quality Protocol).

Risk and reward

Workshop attendees discussed the importance of the intent of a particular technology: if the end product is to be classed as a resource and not a waste, the technology should not deviate from its original intent. If any variation does occur, then in order not to be classed as waste, approval must be sought from the regulator, who will add a briefing note to the permit informing stakeholders that a modification is being sought and considered.

The workshops also included discussions on the yardstick that policy makers use to manage deployment of new technologies to valorise digestate use in agriculture. The Risk to Registry approach emerged as a potential way to assess technology and its required risk efforts.

If we wish to better valorise feedstock and exploit suitable technologies to improve resource efficiency in agriculture, it is necessary to consider the range of barriers and challenges, including those in the funding and policy realms in order to develop strategies for more extensive and rapid uptake of novel technologies.

We have started the conversation and already improved connections among stakeholders.

Now we need to start work on formalising a pathway from industry through academia to policy and regulation, in order to efficiently process product development trials, especially with regards to digestate, given its potential role in decarbonising agriculture and thereby helping to deliver food security. Interested in digestate valorisation? Contact Prof Ruben Sakrabani, who is happy to discuss the outcomes from the workshop series. He can be contacted at r.sakrabani@cranfield.ac.uk

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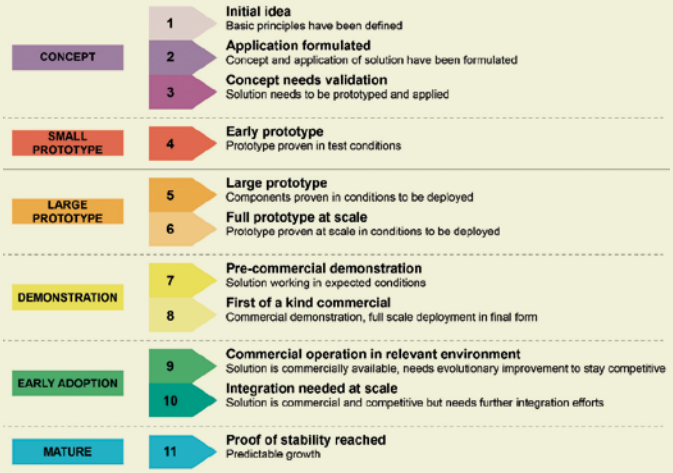
Acknowledgements

Prof Sakrabani would like to acknowledge valuable contribution from colleagues Prof Jane Rickson, Dr Jack Hannam, Prof Upul Gamage, Dr Kumar Patchigolla, Dr Stuart Wagland, Prof Phil Longhurst, Dr Yadira Bajon Fernandez and Prof Krzysztof Koziol. The interaction from policy makers and invited technology providers further enhanced the discussions during workshops, including the Anaerobic Digestion and Biogas Association (ADBA), Malaby Biogas, N2 Applied, CCm Technologies, Greeneco Technology, Atkins, Defra, the Department of Energy Security and Net Zero (previously BEIS), United Utilities. The funding obtained from Research England to Cranfield University under the Policy Support Fund is gratefully acknowledged which covered staff time and cost of hosting workshop in London.

TECHNOLOGY READINESS LEVELS

Originally developed by NASA in the 1970s, Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology. Each project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. The IEA has refined the approach for energy systems - and is the basis for assignments within the article - as below.



GGSS DIGESTATE REVIEW

A report, jointly written by WRAP and Aquaenviro "Identifying Impacts from Food and Farm Digestates" was published in March, having been commissioned by the Department for Energy Security & Net Zero to inform the mid-scheme review for the Green Gas Support Scheme (GGSS). Digestates considered in the report included those from food waste AD plants, as well as those from farm-based plants run on a combination of livestock manures/slurries and crop residues.

The report outlined the evidence gathered for options to 'mitigate ammonia emissions from digestate during storage and use; methane emissions during digestate storage; plastic contamination of digestates; and the lack of value associated with digestates'. It considered numerous mitigation options, including digestate stripping/scrubbing, de-/nitrification, in-store and in-field acidification and other technology options for both whole digestate and its separated fractions (liquid and fibre).

Additionally, the report identified a number of 'valorisation end points' such as compost, fertiliser/fuel pellets, fulvic acids, ammonium nitrate (and other) solutions, animal bedding and more. Such end points are important in regulatory terms, as they identify a specific product for which 'end of waste' status might be obtained, which helps to increase the chances of sufficient sales income and/or cost reduction to justify the implementation costs of any particular valorisation option.

Indeed, one of the report recommendations was to 'engage with regulators and operators to develop end of waste positions for specific digestate-derived materials, particularly for farm digestates. These include nutrient concentrates and soil improvers.'

The WRAP report focussed primarily on relatively high technology readiness levels (TRL's) of 7 and higher, i.e., those in the commercial and near-commercial realm. Although there are still knowledge, costing and data gaps associated with such TRL's, it is still possible to create a useful technoeconomic model. The report therefore offers a freely available model in Tableau, available here: https://tinyurl.com/3z4wmsb5

Whilst many of the conclusions of the WRAP report apply equally to lower technology readiness levels, these also come with their own specific set of challenges. The report recommended engagement with the research community to develop a better understanding of the potential of lower TRL and under-represented potential mitigation options such as gas-permeable membrane recovery of ammonia, hot microbubble ammonia stripping and others. **Angela Bywater**

Identifying impacts from food and farm digestates: WRAP report (https://tinyurl.com/yc77wkpn)