The Renewable Energy Association's response to the Department for Environment Food and Rural Affairs and the Department for Business, Energy and Industrial Strategy's call for evidence on standards for bio-based, biodegradable and compostable plastics

1. About the Renewable Energy Association

The REA is a not-for-profit trade association, representing British renewable energy producers and promoting the use of renewable energy in the UK. It has around 550 corporate members, making it the largest renewable energy trade association in the UK. The REA helps its members build commercially and environmentally sustainable businesses whilst increasing the contribution of renewable energy to the UK's electricity, heat, transport and green gas needs.

The REA's Organics Recycling Group comprises 207 members, numerous of which operate commercial **composting** facilities, and its 'Biogas Group' comprises 215 members, numerous of which operate commercial scale **anaerobic digestion** (AD) facilities. The REA also represents the energy from waste sector, with members involved in the delivery of advanced conversion technologies and traditional energy recovery projects.

The REA works with stakeholders with the aim of achieving policy and regulatory frameworks for renewables and organic waste recycling that deliver an increasing contribution to the UK's electricity, heat, recycling and transport needs. The Wood Heat Association is a subsidiary of REA, the largest renewable energy industry association in the UK. More info about the REA is at https://www.r-e-a.net/about

The REA is a member of the following British Standards Institution committees:

- MI/002 Bio-based products
- PKW/000/0-/01 Packaging - Biodegradability
- PKW/000/0-/10 Packaging – Plastics
- AW/020 Topsoil, other growing media and turf

This response is written and submitted by Emily Nichols, REA Organics Recycling Group Technical Manager (enichols@r-e-a.net, 07771 556231). The REA would be pleased to discuss the issues covered in our response if requested by Defra and/or BEIS.

The REA has contributed to the Bio-based and Biodegradable Industries Association's (BBIA) response to this call for evidence. Our answers to some of the questions are wholly or partially the same as the BBIAs and where they are we have made this clear and included those same answers for the convenience of REA members who may read this response.

2. Terms and definitions used in this call for evidence

For the convenience of REA members who read this response the REA has transferred and re-ordered the terms and definitions from:

- the review of standards report published at https://www.gov.uk/government/consultations/standards-for-biodegradable-compostable-and-bio-based-plastics-call-for-evidence) and
- the government's call for evidence document.

Near the end of this section we have added brief comments in the hope that those who read our answers to this call for evidence clearly understand which plastics are discussed.

Degradation (as defined in IBioIC's standards review report)
A plastic (or a polymer) is considered degradable when it breaks down to smaller (monomeric) subunits and loses its original properties.

Polymer (as defined in IBioIC's standards review report)
Made of many i.e. a material generated from multiple smaller building blocks (**monomers**). The final blend of polymers yields the material commonly referred to as **plastic**. The word "plastic" actually refers to the properties of the material rather than its composition.

Microplastics (as defined in IBioIC's standards review report)
Very small (< 5 mm) **non-biodegradable** plastic particles formed through mechanical degradation of larger pieces of plastics. Biodegradable plastic should not yield microplastics as these will be assimilated by microorganisms.

Biodegradable (as defined in IBioIC's standards review report)
'A plastic (or a polymer) is considered biodegradable when it breaks down to basic elemental components (water, biomass and gas) with the aid of microorganisms.
Plastic may be degradable, but **not** biodegradable – for example, if it is degraded by light.'

Definition in call for evidence document:
'**Biodegradable plastics** can be broken down into water, biomass, and gasses such as carbon dioxide and methane. Biodegradability depends on environmental conditions such as temperature, humidity, microorganisms present, and oxygen.'

Biopolymers / Bio-based polymers (as defined in IBioIC's standards review report)
'Polymers generated from natural monomers as formed by plants, microorganisms and animals. Can be either fully naturally derived or consist of a mixture of artificially synthesised and natural polymers. They are often**,** but not always fully biodegradable depending on additives and composition2'.

Definition in call for evidence document:
'**Bio-based plastics** are made using polymers derived from plant-based sources such as starch, cellulose, or lignin. Bio-based plastics can be engineered to be biodegradable, equally they can be made to function exactly like conventional fossil-based plastic (i.e. to have the same durability).'

Defra and BEIS's further comments in their call for evidence document's terms and definitions section:

'Bio-based and biodegradable plastics have a wide range of diverse applications. Bio-based plastics can be engineered to function exactly like fossil-based plastics, the only difference being that they are derived from non-fossilised biological organisms such as plants rather than petrochemicals.

'Biodegradable plastics on the other hand behave differently to conventional plastics, and can be either fossil-based or bio-based. A biodegradable plastic is intended to break down in a particular environment in a safe and timely manner. This could prove useful in specific circumstances where it is hard to recover the material for recycling, or when that material could otherwise enter the recycling stream but cannot be recycled due to contamination. This would therefore prevent a fossil-based plastic being landfilled, incinerated, or littered – where it will persist for an extended period of time. There are also materials that are designed from the outset to biodegrade in horticultural/soil environment (e.g. tree guards, mulch films) and marine environments (e.g. nets and lines).'

Compostable (as defined in IBioIC's standards review report)
Requiring specific conditions for total degradation, either by control of the environment or removal of residual materials. Plastic may be biodegradable but not compostable. For example, if the plastic biodegrades but leaves behind toxic residues it would not be suitable for compost.

Definition in call for evidence document:
'**Compostable materials** are a sub-set of biodegradable plastics that break down safely into water, biomass and gasses under composting conditions. Industrial composting conditions are the most optimal: temperatures of 55 – 70 ^{o}C, high humidity and oxygen. Materials that break down in industrial composters may not break down under home composting conditions.'

REA comments on definitions and descriptions of different plastics:

Importantly in this call for evidence, **where Defra and BEIS asks specifically about 'bio-based plastics'** they appear to mean plant derived polymers which <u>may or may not</u> be engineered to be <u>biodegradable</u> (industrially compostable and home compostable being a sub-sets of biodegradable). Consequently, in the REA's answers we intend to be specific about which parts of our answers are about which types of plastic.

The definitions provided focus on ***mechanisms*** of degradation but do not address how we assess whether an item degrades fast enough in a specific open environment or another environment controlled by humans, e.g. industrial composting.

Standards exist for evaluating an item's biodegradation in ***some*** natural environments and human-controlled 'environments', for example: European standard EN 17033 for biodegradable mulch films for incorporation in soil after use in agriculture and horticulture.

REA's working practice interpretation of **industrially compostable** plastic: one which complies with one or more of the following: European standard EN 13432, European Standard EN 14995 or American standard ASTM D6400.

REA's working practice interpretation of **home compostable plastic**: one which complies with one of more of the following: Australian standard AS 5810, French Standard NF T51-800, Italian standard UNI 11183 or TŪV Austria's OK compost HOME, Program OK 2, edition D, criteria for assessment and certification of 'home compostability of products'.

Compostable items: in this response when we use the term compostable items, this is our short-hand term for compostable packaging and non-packaging items made from a variety of materials, some of which to many people who aren't plastics or polymeric materials specialists look similar to conventional fossil-derived plastics and others of which don't, examples of the latter being those that include paper (recycled or not), (card)board (recycled or not), plant-derived starches (e.g. corn starch) and bagasse (a lignocellulosic material from sugar cane).

3. The REA's answers to questions in the call for evidence

Call for evidence's section 2 – Bio-based Plastics

NOTE: questions start in section 2 of Defra and BEIS's call for evidence document.

Qu 1. Government has made clear that we want to eliminate all avoidable plastic waste and to move towards a more circular economy. What role, if any, is there for bio-based plastics to play in achieving the outcomes listed in paragraph 1.7? How could the circularity of these materials be reflected or measured? What is the evidence in support of your view?

The REA's answer is the same as the BBIA's:

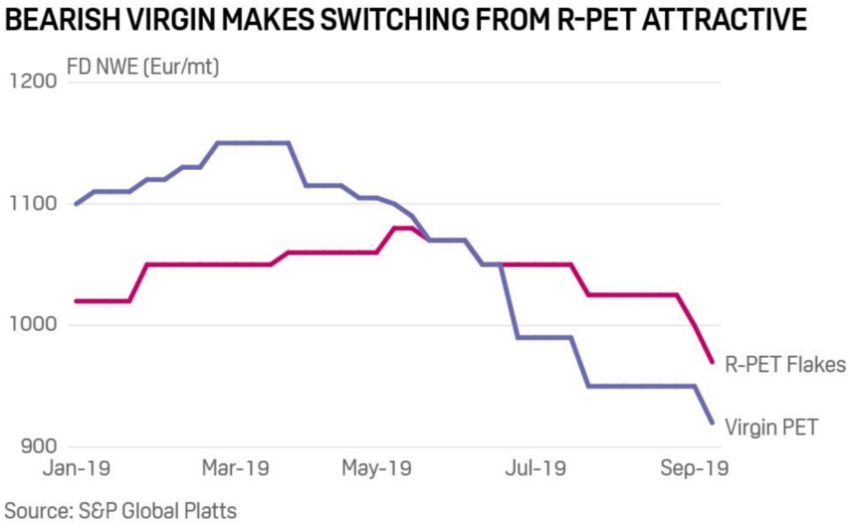
'Renewable energy, electric vehicles, bio-fuels; the global economy has begun taking steps towards a low carbon future. Over the last decades, outlines of global transition pathways have emerged in the buildings, power and transport sectors. These have been driven by legislation, technological breakthroughs and cost reduction. However, for industrial processes, such pathways are less well-defined. McKinsey & Company have called the decarbonization of industrial sectors "the next frontier"[1].

Globally, recent demand for plastics has outpaced all other bulk materials (such as steel, aluminium or cement), nearly doubling since the start of the millennium. The United States, Europe, and other advanced economies currently use up to 20 times as much plastic as India, Indonesia, and other developing economies on a per capita basis, underscoring the huge potential for further worldwide growth and risk in environmental damage. The petrochemical feedstocks that underpin this growth are rapidly becoming the largest driver of global oil consumption. They are set to account for more than a third of the growth in oil demand to 2030, and nearly half to 2050, ahead of lorry freight, aviation and shipping[2]. Assuming this trend continues, the greenhouse gas emissions from plastics will reach 15% of the global carbon budget by 2050[3], up from ~5% in 2017.

Whilst emissions from plastics are destined to rise, so conversely will the costs fall (assuming fossil fuel prices remain stable) as increasing scale and volumes will lead to prices falling for virgin plastics with evident repercussions upon recycling markets for used plastics and for

[1] Mckinsey&Company (2018): Decarbonization of industrial sectors: the next frontier
[2] IEA (2018): The Future of Petrochemicals Towards more sustainable plastics and fertilisers
[3] Ellen MacArthur Foundation, McKinsey & Company (2016) World Economic Forum: The New Plastics Economy—Rethinking the Future of Plastics

materials competing in certain sectors with plastics.[4] Increased collection for recycling of plastics will also lead to falling values of the recycled material as these volumes will struggle to find markets.



The scientific and policy development of strategies that can, on a global scale, mitigate the life-cycle GHG emissions of plastics are in their infancy. It is clear a multi-factorial approach will be required given the integration of plastics into global economies. The most compelling recent work on this using a dataset covering ten conventional plastics and five bio-based plastics and their life-cycle GHG emissions under various mitigation strategies concludes that aggressive application of demand-management strategies, renewable energy, recycling and (importantly in the context of this consultation) the use of biogenic feedstocks is required to ensure an absolute reduction from current levels by 2050[5].

On the 27th of June 2019, The UK passed into law a target for zero net carbon emissions by 2050, the first major economy to do so. This target shows Britain's ambition to be a global leader in the area of reducing CO_2 emissions and climate change abatement. To achieve this will require decarbonisation across the entire UK economy. In some areas the approach is becoming clear, but in terms of materials and specifically plastics there is much work to do; delivery will require decarbonisation of feedstocks, production processes and a transition from a linear to a circular economy

Considering the policy interests and the wider environmental landscape of the consultation in this context:

Clean Growth, including growing the bioeconomy – the plastic sector is important for the UK with 2015 data demonstrating that the plastics industry supported 6,200 companies, employing 170,000 people, turning over £23.5 billion and generating £7.5 billion in exports[6]. In this sector, the UK produced 0.5% of the world's plastic by weight but 6.7% by value, underlining its importance to our economy[7]. By virtue of this activity, there is a UK bio-economy growth opportunity in ensuring that UK plastics industry transitions to a low carbon future and,

[4] https://blogs.platts.com/2019/10/09/europe-plastic-recycling-consumer-demand/
[5] Nature Climate Change, Zheng and Suh: Strategies to reduce the global carbon footprint of plastics
[6] BPF: The UK plastics industry: A strategic vision for growth
[7] Grand View Research (2019) Plastics Market Size

arguably, a more significant export opportunity in ensuring that the bio-based plastic technologies of the future are first developed and then scaled-up in the UK.

The UK Governments bioeconomy strategy[8] identifies the importance of producing smarter, cheaper materials such as bio-based plastics as part of a low-carbon economy. The UK has a small foot-print of bio-based plastics businesses but recent demonstration and commercialisation of such technology at larger scale has occurred overseas [e.g. bio-polyethylene by Braskem(Brasil), PLA by Natureworks (USA) and Corbion (Thailand), PBAT by Novamont (Italy) and BASF(Germany), PBS by PTT(Thailand)]. Such investment is illustrative of the potential for global growth in this sector. The challenge is the alignment of regulatory, innovation and commercial drivers to ensure that the UK has a dominant role in this emerging space.

Two reports available on the BBIA website underline the potential for the use of bio-based and compostable plastics in the UK economy. [9,10] They measure the potential for new products as well as substitution of plastic packaging with bio-based and compostable materials and the potential for the creation of new jobs and GVA for the UK economy. CEBR's report from 2015 states that the potential for the UK from such new materials is 30,000+ new jobs and "*Cebr predicts that the gross output impacts of the bio-plastics sector will amount to £4.2 billion. From this, approximately 35,000 jobs are expected to be supported, and roughly £1.92 billion of gross value added is predicted to be contributed to the UK economy. Further, we estimate that the bio-plastics sector will pay around £1.01 billion in gross employment compensation".* [11] Both reports concur (at four years from one to the other) that the potential market for bio-based and compostable packaging in the UK is around 130,000 tons by 2025.

Circular economy – new bio-based materials that enter the marketplace can be engineered to be biodegradable or they can be made to function exactly like conventional fossil-based plastic (i.e. to have the same durability). Where biodegradation/compostability is designed into the materials, they can be organically recycled through AD/composting in specific conditions and the (often biogenic) carbon returned to the atmosphere or soil. In the case of the bio-based facsimiles of existing fossil-based plastics (eg. bio-polyethylene), they have the same potential to be mechanically or chemically recycled as the materials they substitute.

Estimates of global plastic waste currently reused or recycled vary from 9%[12,13] to 18%[14]. Recent Mckinsey and Company work on circularity has considered global scenarios of a "high" adoption model of both existing and novel mechanical/chemical recycling technologies reaching 50% rates by 2030 and 60% by 2050 but, despite these aggressive changes, still concludes that underlying global virgin plastics production will grow from the current 370mtpa to ~450mtpa[15] in the period. At the same time global plastic recycling values are falling as Far East markets close to imports of OECD countries waste and due to falling costs of virgin plastics.

[8] HM Government: Growing the Bioeconomy

[9] https://bbia.org.uk/reports/ See: Plastics in the Bioeconomy report published in 2019 by Ricardo E&E

[10] https://bbia.org.uk/reports/ See: The future potential economic impacts of a bio-plastics industry in the UK, published in 2015 by CEBR

[11] ibid

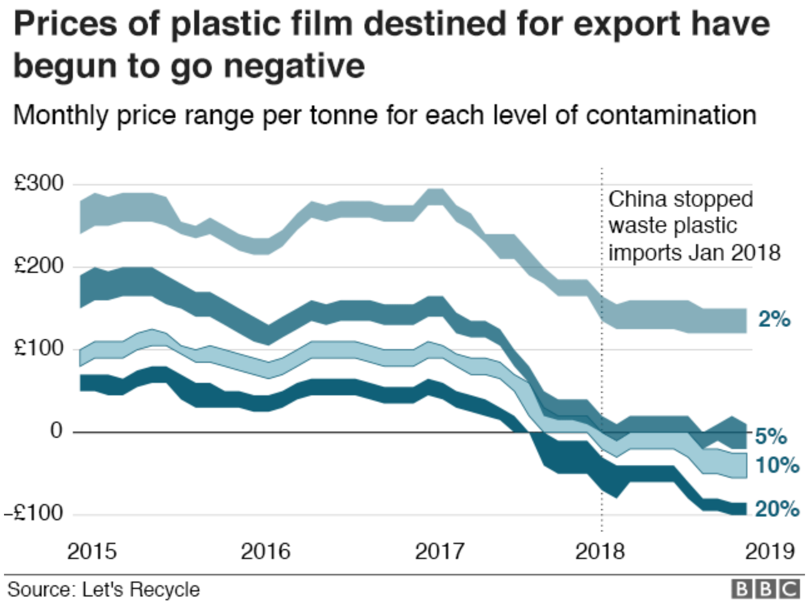
[12] https://www.nationalgeographic.com/news/2017/07/plastic-produced-recycling-waste-ocean-trash-debris-environment/

[13] https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data

[14] www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf+&cd=13&hl=en&ct=clnk&gl=jo&client=firefox-b-d

[15] Mckinsey&Company (2018): How plastics waste recycling could transform the chemical industry

Figure 1, Trends in Export Prices for UK Plastic Film Waste



This underlines the hypothesis that materials derived from non-fossilised living organisms are required in addition to recycling if the global plastics resource flows are to be made circular. For completeness, it is worth noting that there is a third class of materials that are novel, bio-based but not facsimiles of fossil-based plastics (e.g. PEF as a replacement to PET). Here some mixed approached to circularity maybe required; for example by allowing small and understood, percentages of these materials into existing recycling steams until critical mass for dedicated recycling is reached[16].

Environmental protection - bio-based plastics have a role in environmental protection in that the production of their underlying inputs change from an extractive model of oil and gas, often implicated in environmental damage on land and sea in their extraction and transportation, to a renewable model of using materials derived from non-fossilised living organisms
In the case of bio-based facsimiles of current plastics the consequences of deliberate or unintended release to both terrestrial and marine environment has the same impact as fossil-based plastics. In the case where bio-based and biodegradable properties are combined in individual materials (already exemplified by a number of commercial polymers such as PHAs, cellulosics and PBAT) such materials will degrade biologically in many environments[17].

It is to be noted that where such materials are biodegradable the embedded carbon turns to CO2 or microbial biomass and not persistent microplastics (exemplified by research work on biodegradation of PBAT in soil conditions[18]). Research published in 2019 by the University of Plymouth confirmed these findings, showing that certified compostable carrier bags degraded completely in marine and open environments in less than three months and disintegrated after being buried in soil. Conversely, those marked "biodegradable" or "oxo degradable" resisted

[16] Waste Management World: EPBP Approval for Synvina's PEF Plastic Packaging Material as Recyclable in Existing Systems
[17] *https://pubs.acs.org › doi › 10.1021 › acs.est.8b02963*
[18] Zumstein et al (2018): Biodegradation of synthetic polymers in soils: Tracking carbon into CO2 and microbial biomass

biodegradation in both the soil and marine environments after three years. [19] Accordingly, the research confirms the need for a certification of a material's biodegradability in a specific environment, before claims related to biodegradability may be made. Furthermore, the study illustrates the need to follow existing test methods for assessing biodegradation of plastics in soil, such as ISO 17556 and ASTM D 5988 in order to gain results that can be replicated by other researchers[20].

Citizen clarity – the BBIA recognises that there is demand from citizens for bio-based materials often on the perceived basis that "bio" may be better without apparent quantification at point of use. There are standards for bio-based content of products (e.g. European Standard EN 16785-1 and ASTM D6866 – 18) where analysis is determined by carbon-14 radioactive analysis. Such standards underpin some independent assessment and certification services, for example theTUV Austria's OK biobased certification which licences the use of "on-pack" certification marks that include a star rating (e.g. certified biobased content of 60% to 80% is awarded 4 stars[21]). BBIA is aware of the need to reform all packaging labelling including making bio-based and compostable packaging more easily identifiable to consumers and the waste management stream.

Standards for bio-based products covering horizontal aspects were developed by CEN TC 411 "bio-based products". CEN TC 411 developed consistent terminology, sampling, certification tools, bio-based content, application of and correlation towards life cycle analysis, sustainability criteria for biomass used, and communication

The published European standards are listed as below.[22]

https://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID,FSP_LANG_ID:874780,25&cs=1D63BAA7EABE56EB230DDAA05D6F2CE70

With regard to measuring circularity of materials we are not aware of metrics that have seen widespread adoption for either conventional plastics or bio-based plastics. The Ellen Macarthur Foundation has undertaken work to develop tools and methodologies to assess both product and company performance in the circular economy. Inputs cover where raw materials are virgin or recycled, how long the material is used for, destination after use and efficiency of recycling. The development and use of such circularity indicators are in their infancy[23].'

[19] https://www.plymouth.ac.uk/news/biodegradable-bags-can-hold-a-full-load-of-shopping-three-years-after-being-discarded-in-the-environment

[20] Zumstein, M. T., Narayan, R., Kohler, H. P. E., McNeill, K., & Sander, M. (2019). Dos and do nots when assessing the biodegradation of plastics.

[21] TUV Austria: http://www.tuv-at.be/ok-compost/certifications/ok-biobased/

[22]https://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID,FSP_LANG_ID:874780,25&cs=1D63BAA7EABE56EB230DDAA05D6F2CE70

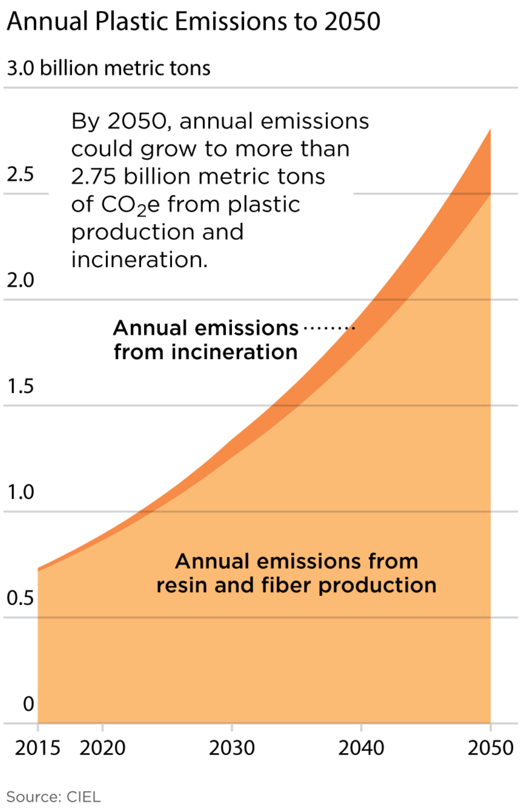
[23] EMF: https://www.ellenmacarthurfoundation.org/resources/apply/circularity-indicators

Qu 2. With regard to their environmental impact, and particularly greenhouse gas emissions, what quantitative evidence is available on the environmental impacts of producing bio-based plastics and managing them at end of life? How does the evidence compare to conventional fossil-based plastics?

The REA's answer to this question is the same as the BBIA's:
'(We will answer the questions related to end of life of bioplastics in Chapter 7 on waste management.)

For all the angst about the role of global air travel in global carbon emissions, at 2%[24] of the global releases they are less than half of global emissions from plastics at ~5% which are measured at 850 million tons in 2019[25].

Figure 2. Annual Estimated Plastic GHG Emissions through to 2050 given by CIEL[26]



BBIA contend that the mitigation of GHG emissions from the production and management of plastics after they are discarded is essential alongside the prevention of environmental damage from accidental release and that bio-based plastics have a significant role to play.
In 2016 work by the Ellen MacArthur Foundation, and McKinsey & Company in the *The New Plastics Economy: Rethinking the future of plastics* a world was envisaged with much higher recycling rates and where the remaining requirement for virgin feedstocks is supplied by renewable resources. Whilst this work appeared somewhat aspirational, encouragingly, quantitative scientific analysis on how the role of bio-based plastics might enable trajectories to a low carbon economy is now beginning to emerge.

[24] Aviation IEA, Lee (2019), Flemming and Ziegler (2016)
[25] https://www.ciel.org/plasticandclimate/
[26] idem

Work by Spierling et al. (2018)[27] reviewed 29 different academic papers to analyse the cradle-to-gate life cycle analysis of 10 different bio-based plastics (including durable and biodegradable materials). This concluded that bio-based plastics generally show lower life-cycle GHG emissions than their fossil-fuel based counterparts. The paper went further to estimate that substituting 66% of the world's conventional plastics with bio-based plastics would avoid 241–316 $MtCO_2$-equivalent (CO_2e) yr–1, approximately 20% of global GHG emissions associated the lifecycle of plastics.

More recently in *Strategies to reduce the global footprint of plastics*[28], for the first time in a published paper that BBIA has reviewed, the impact on GHG emissions from the whole 380 million tonne global plastics supply chain has been modelled in a comprehensive manner. Based on a data set of ten fossil-fuel based and five bio-based plastics the authors have considered future roadmaps for:

- the initial manufacture of plastic polymers from petrochemicals and bio-based inputs
- the energy consumed in the conversion of such polymer to products
- the benefits and dis-benefits in energy and CO_2 release of various end-of-life disposal routes encompassing landfill, recycling, composting and incineration.

Scenarios are considered that envisage decarbonisation of electricity grids to reach 100% by 2050, significant changes in recycling rates, a reduction in the global rate of plastic growth from 4% to 2% and a gradual substitution of fossil-derived plastics by bio-based plastics. The results of this work indicate that if the much needed absolute reduction in life-cycle GHG emissions of plastics by 2050 is to be achieved, it requires not just one action but rather a combination of all in concert including demand management, the decarbonization of energy infrastructure, vast improvement of recycling capability (including both mechanical and chemical recycling) and (importantly in the context of this consultation) large-scale adoption of bio-based plastics.

More data describing individual bio-based polymers is now in the public domain. One notable example is available on bio-based high-density polyethylene (HDPE) by UK firms E4tech and LCAworks and commercially marketed by Braskem[29]. This assessment encompasses two product systems: HDPE from renewable agricultural resources (Brazilian sugarcane derived ethanol) and HDPE from fossil resources (Naptha) and is conducted on a cradle-to-gate basis (the finished polymers are identical in performance). The assessment includes both the production of High Density Polyethylene (HDPE) and co-produced electricity so as to avoid allocation between these co-products as recommended by ISO 14044. The net conclusion is that each kg of bio-based HDPE produced absorbs ~3kg of CO_2e of emissions whilst Naptha -based HDPE production is assessed to release ~2.2kg of CO_2e. Three quarters of the bio-based benefit comes from CO_2 uptake in the growing of sugarcane and one quarter from the bio-based power provided from bagasse burning. Clearly, there will be subsequent emissions from transport, product manufacture and end-of-life disposal but these will be identical to fossil-based materials. This initial sequestration of CO_2 provides a useful insight to the positive role that bio-based plastics might play in the future bio-economy.

[27] Spierling et al. (2018): Bio-based plastics - A review of environmental, social and economic impact assessments

[28] J Zheng and S Suh (2019): Nature Climate Change - Strategies to reduce the global carbon footprint of plastics

[29] http://plasticoverde.braskem.com.br/Portal/Principal/Arquivos/ModuloHTML/Documentos/1191/Life-Cycle-Assessment-v02.pdf

Specific PLA manufacturers have published LCAs such as Corbion[30], and NatureWorks[31], showing lower carbon impacts than conventional oil-based plastics. Corbion has also published a White Paper[32] entitled 'Sustainable sourcing of feedstocks for bioplastics' which highlights feedstock efficiency: 'PLA is one of the most efficient biopolymers: yielding 1kg of PLA polymer for 1.6 kg of fermentable sugar feedstock'.

Whilst still under development, another interesting bio-based plastic is polyethylenefuranoate (PEF) being developed by a number of parties as a potential drop-in replacement for PET (used in fibres and bottles). Even though the emergent PEF production process from fructose is still under development, academic modelling[33] of GHG emission results demonstrate the process is likely to offer reductions between 46% to 54% vs oil-derived PET.

The authors further postulate that based on the global PET bottle market, complete substitution of PET by PEF would result in savings of up to 35 Mt of CO_2e. To put these absolute savings in perspective, they can be compared to the annual GHG emissions of Denmark[34] (entire country covering emissions from all sectors of the economy).

Turning to a UK specific example, Ricardo Energy and Environment[35] conducted a comparison of fossil-based low density polyethylene (LDPE) versus bio-based (and biodegradable) polylactic acid (PLA) based on the latter being (theoretically) manufactured in the UK from local biogenic waste inputs and encompassed cradle-to-grave review considering recycling and composting. This study uses the IPCC 2013 GWP method, developed by the Intergovernmental Panel on Climate Change.

The modelling highlighted the significant dependence on grid decarbonisation (Scottish renewable grid versus UK mixed grid making a significant difference). The report concluded that even when 90% LDPE plastic films are segregated from general waste and recycled (a near impossible ambition given only trace quantities of plastic films are currently recycled in the UK), PLA using the Scottish grid mix is preferable to LDPE in GHG emissions terms. Indeed, based on the current end of life assumptions it is not possible for LDPE to outperform PLA using the Scottish electricity grid mix. To put this into context, the analysis suggests that per tonne of LDPE produced, ~1.5 tonnes would need to be recycled before LDPE has a lower carbon footprint to PLA produced using a Scottish grid mix.

The examples cited above provide supportive evidence that there is good reason to believe that bio-based plastics have a role in the decarbonisation of the global plastic economy. Whilst there is more to understand about the GHG emissions of bio-based plastics for both their biogenic inputs and production processes, it seems difficult to believe that the continued reliance on fossil-based carbon, much of which will inevitably be released to atmosphere despite improved recycling rates, is a model on which humanity can rest.'

[30] https://www.corbion.com/about-corbion/sustainability/life-cycle-assessment and https://www.total-corbion.com/downloads/
[31] https://www.natureworksllc.com/What-is-Ingeo/Why-it-Matters
[32] https://www.total-corbion.com/media/1082/170822_totalcorbionpla_whitepaper_12-web.pdf
[33] A. J. J. E. Eerhart et al (2012) Replacing fossil based PET with biobased PEF; process analysis, energy and GHG balance
https://www.researchgate.net/profile/AJJE_Eerhart/publication/241881454_Replacing_fossil_based_PET_with_biobased_PEF_Process_analysis_energy_and_GHG_balance/links/0f317533bf413ba144000000.pdf
[34] https://www.statista.com/statistics/449517/co2-emissions-denmark/
[35] Ricardo Energy and Environment (2019): Plastics in the Bioeconomy
https://d1v9sz08rbysvx.cloudfront.net/ee/media/downloads/ed12430-bb-net-report-final-issue-2.pdf

Qu 3. If an accurate comparison between the environmental impacts of bio-based and conventional fossil-based plastics cannot be made at present, what barriers exist to making this comparison and what knowledge gaps would need to be addressed to enable us to do so?

The REA's answer is the same as the BBIA's:

'Notwithstanding the evidence presented in our answer to Q2 above, that supports the case for bio-based plastics in the route to material decarbonisation, there are number of barriers to the comparison of the between the environmental impacts of bio-based and conventional fossil-based plastics.

We refer to the attached report commissioned by BBIA of the Bangor University Biocomposite Centre, titled : Factors Affecting the Life Cycle Assessment of Biopolymers.

In principle, there are published standards for life cycle assessments (LCA) that provide guidance on how to compare different polymers fairly with regard to their environmental impacts. However, the rules still leave sufficient room for manoeuvre to specify the methods by which such comparisons are to be carried out in LCA1[36]. Moreover, there are rather fundamental problems that make a fair comparison difficult, and which can only be solved only with difficulty and incompletely, both methodologically and technically.

Let's consider a few of these fundamental matters in turn (drawing on work by the Nova Institute[37]):

Scale - new bio-based polymers that are produced today are usually produced in much smaller plants (typically ~50ktpa) than petrochemical polymers (typically >500ktpa). The bio-based process chains and system integrations are far from being at the elaborated level of petro-chemistry.

Process development – the bio-based polymer industry is in its infancy with small commercial scale facilities only emerging in the last 10 years. In comparison, manufacture of fossil-based plastics has enjoyed some 60 years of process development and operation to bring them to current standards of operating efficiency. Whereas the environmental impact of oil production will increase by 2050 because larger proportions of shale gas and oil sands will be in the petrochemical mix, the environmental impact of biomass production, on the other hand, will be significantly reduced by 2050: digital and precision farming as well as biostimulation will reduce fertiliser use and minimise the use of pesticides as well as increase yields (for local context, in the UK the NFU now has a net zero target for agricultural GHG emissions by 2040[38]).

[36] "Although there are published standards for LCAs (ISO 14040/44, and the International Reference Life Cycle Data System (ILCD) handbook), these do not give fixed rules for calculating GHG reductions: much is left to users to select what they consider the most appropriate method in particular cases. The results often depend strongly on these choices. This is why the LCA guidelines do not offer a consistent or unambiguous way of determining carbon intensities by economic operators or by national authorities." https://ec.europa.eu/clima/sites/clima/files/transport/fuel/docs/novel_transport_fuels_default_values_en.pdf

[37] Nova Institute open letter to JRC (2019): How can the environmental effects of bio-based polymers be compared with those of petrochemical polymers on equal footing?

[38] https://www.nfuonline.com/news/latest-news/nfu-reiterates-its-net-zero-aims-for-agriculture/

Raw materials – whilst individual biomass inputs are suitably investigated and required to provide detailed analysis of both direct and indirect impacts (such as land-use change or impact on biodiversity), when it comes to crude oil there are large gaps in transparency when it comes to analysing all the effects (such as the land/water footprint of crude-oil production, impact on terrestrial and marine diversity, transport accidents). Whilst there are detailed sustainability certifications for biomass, for petroleum there are no certifications to differentiate the impact of the oil industry and to prefer specific origins.

Geographic/age selection - The default values used for petrochemical polymers in LCA modelling favour more modern installations than older ones (simply because operators do not provide data for the latter), so that the values used are not averages that fairly reflect the whole spectrum of petrochemical polymer manufacturing installations. Also, the data covers only the environmental footprint of European manufacturing sides – the majority of polymers used in European industry are produced outside Europe.[39] Additional data sources including country specific data should therefore also be taken into account.

Storage - storage of biogenic carbon is generally not taken into account in life cycle assessment, (although new dynamic models exist to integrate storage into an LCA), all emissions are considered to happen at the same point in time. As our time-horizon to mitigate carbon emissions shortens the impact of storing carbon derived biogenically from the atmosphere in the goods that we use will be important.

Decarbonisation of electricity grids - By 2050, electricity production in the UK and many other countries will be mainly from renewable energy and therefore much cleaner than today with a very low carbon footprint. This alone has a considerable influence on life cycle assessments of facilities that may be built now to last another 20-30 years. Fossil derived plastics are high in calorific value for electricity production through Waste to Energy plants and in many countries, incentives exist for them to be burnt in preference to virgin fuels. From a GHG perspective there is no difference and with a decarbonised grid no such incentives can remain by 2050. Alternatively, burning sustainably sourced bio-based polymers, whilst not optimal (e.g. the compostable ones would better have been composted than combusted), is akin to a bio-mass power station.[40]

The average lifespan of an ethylene facility (feedstock for polyethylene) in Europe/North America is 30 years[41]. By way of illustration, ExxonMobil has recently commissioned a new 650ktpa polyethylene expansion in Texas[42] taking the site production to more than 1.7mtpa (in context, the amount of plastic packaging consumed in the UK is circa 2.7 million tons p.a.)[43] One might expect that this asset to have a similar life to previous facilities and still be producing from shale-gas derived feedstock up until 2050.

The broader point here is that there are decisions being made right now in the global plastics market that will impact the next three decades of emissions. It is not enough just to be evaluating emerging bio-based technologies in the context of now but rather in how they can play a meaningful role in changing this trajectory.

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[39] https://www.euractiv.com/section/energy-environment/news/while-global-plastic-production-is-increasing-worldwide-it-is-slowin-down-in-europe/

[40] See below Question 27

[41] John Pearson (2010): Comparing petrochemical plant ageing https://www.chemengonline.com/comparing-petrochemical-plant-aging/?printmode=1

[42] https://www.nsenergybusiness.com/news/exxonmobil-beaumont-polyethylene/

[43] http://www.wrap.org.uk/sites/files/wrap/PlasFlow%202017%20Report.pdf.

In conclusion we believe that the tools academics, industry and policymakers are using to evaluate the opportunities and risks in the large-scale deployment are rooted in models of the "now" with varying levels of information and transparency. What is also required is the development of plausible future scenarios with which a quasi-standardised life cycle assessment for the year 2050 can be conducted in addition to today's situation. A comparison between bio- and petro-based polymers and their impact on GHG emission through the next 30 years can then be made on an informed basis.

Qu 4. Bio-based plastics currently make up a relatively small proportion of the market, representing around £50m GVA5. What, if any, are the barriers preventing innovative bio-based products from succeeding in the marketplace?

The REA's answer is the same as the BBIA's:

'The bio-based plastics industry is a small but growing section of the plastics industry. Estimates for 2019 suggest biobased plastics represented around one percent of plastic produced annually in the world[44]. Demand is rising and with more sophisticated bio-based polymers, applications, and products emerging. However, there are currently limited comprehensive policy frameworks in place to support biobased plastics (such as mandatory targets, tax incentives, etc.), and, as a result, these products are hindered by low investment security on the global stage.
Below we consider various barriers limiting the success of bio-based plastics in the marketplace both globally and in the UK:

Cost
The challenge for bio-based plastics lies throughout their fast-emerging supply chains:

I. The non-fossilised, living-organisms derived materials in use currently are typically 1st generation crop inputs and provide starting points for cost far higher than the crude-oil comparative materials. Whilst there is much research work being undertaken on 2nd generation materials including non-edible by-product of food production such as wheat straw, the technologies for use of these materials remain prohibitively expensive.[45] It's worth considering the parallel to biofuels here where despite significant research efforts and legislative incentives on fuels, worldwide there are currently only 6 major plants[46] producing second generation biofuels (ethanol). Locally, the UK has had two 2nd generation ethanol plants at demonstrator scale, neither of which are currently operational[47].
II. The manufacture of bio-based building block chemicals (monomers) is then conducted at limited scale (typically <50kt), often in fermentation type processes that are less intensive that their petro-based competitors.[48] Globally, a number of these processes emerged following the 2004 US Department of Energy study on "Top Value Added Chemicals from Biomass"[49] as this was seminal in attracting interest to the sector and steering academic and industrial activities. Recently, the UK has begun is own path

[44] https://www.european-bioplastics.org/market/.
[45] See for example www.resurbis.eu and www.usable-packaging.eu research projects using waste as feedstocks
[46] Journal of Cleaner Production (2018): Business models for commercial scale second-generation bioethanol production
[47] Q Nguyen et al (2017): Global production of second generation biofuels
[48] One of the world's largest plants in Italy will produce 150,000 t/pa biopolymers c.f. https://packagingeurope.com/novamont-boosts-production-capacity-with-new-bio-plastic-plastic-plant/
[49] https://www.nrel.gov/docs/fy04osti/35523.pdf

towards coordinating activities in this area with the publication of the UKBiochem10[50] in 2017.

III. The polymerisation production stage suffers from both the same limited scale and the cost of aggregating monomers from disparate facilities around the world (few countries have yet developed suitable clusters of monomer production at scale).

IV. Where we have seen regulatory stimulus of the market for bio-based plastics as in the USA[51], France[52] and Italy[53],[54] these pull factors have determined growth in the local development of bio-based industries. In the UK no such stimuli exist to date.

This is an industry in its infancy and there is much to do to develop processes and infrastructure of scale.

Regulatory clarity

The real cost of GHG emissions are not priced into petro-chemical based plastics just as the externalities caused by plastic pollution are not accounted for in the price of plastics. Further, stimuli are still given globally to the production of fossil fuels, (including through tax incentives on exploration in the UK) lowering the real price of these sources and making it harder for materials from non-fossil sources to compete with them. The IMF working paper of 2019 judges such subsidies to be circa $5.3 trillion annually or 6.5% of global GDP. [55] 99% of plastics derive from artificially under-priced fossil fuels.

Unless the regulatory regimes change, it is unlikely that bio-based plastics will secure a substantial share of the commodity market. The introduction of a pan-European Emission Trading Scheme from 2020 and a Plastic Tax[56] in the UK from 2021 may help create a more level playing field. The introduction of Carbon Taxes across the globe is also encouraging.[57]

Globally, the regulatory support for bioplastics has been very limited compared to, say, biofuels or renewable energies. And yet both categories of bio-based products aim to fulfil the common goal of decarbonisation and development of a vibrant renewably based bioeconomy. Indeed, there is evidence that bioplastics offer greater job creation and value-added than biofuels[58]. There is no international pattern of support for bio-based plastics. Major policies have been applied to biofuels and without similar for bio-based plastics, the investments needed for large-scale production and market uptake are unlikely.

A perverse incentive against bio-based plastics is in play. Strong policy support exists for biofuels/bioenergy in R&D and pilot plants, but also strong ongoing support during commercial production (quotas, tax incentives, and green electricity regulations). This policy leads to a market distortion regarding feedstock availability and costs. If the energy market is more attractive because of related incentives and support, biorefinery development will be disproportionately focused on energy as the main output rather than building blocks (monomers) for bio-based plastics.

[50] http://ukbiochem10.co.uk/
[51] https://www.usda.gov/media/press-releases/2016/02/18/fact-sheet-overview-usdas-biopreferred-program
[52] https://www.european-bioplastics.org/pr_150723/.
[53] http://www.edizioniambiente.it/libri/923/bioplastics-a-case-study-of-bioeconomy-in-italy/
[54] http://www.kyotoclub.org/docs/bruxelles_060313_bioplastics_bastioli.pdf.
[55] https://www.imf.org/~/media/Files/Publications/WP/2019/WPIEA2019089.ashx
[56] https://www.gov.uk/government/consultations/plastic-packaging-tax.
[57] https://www.worldbank.org/en/programs/pricing-carbon
[58] OECD (2013): Policies for bioplastics in the context of a bioeconomy

In the same manner that there are GHG emissions savings targets along with volumetric mandates for biofuels[59], then environmental targets for bioplastics may be possible. This might have the effect of not only encouraging the development of the most effective bioplastics but would also deter early investment in bioplastics with poorer environmental performance. It would also drive the need for LCA harmonisation.

Yet if we are to decarbonise the economy as Government policy declares, we have to decarbonise the production of those materials that can possibly be converted to biomass. So the importance of biomass use for material production rather than just for energy production, and stimulus to that use in a similar way to that we have seen for energy, are issues which need to be addressed.

Technology development
There is considerable technology development required before the functionality of bio-based plastics and the cost effectiveness of their production processes are optimised.
The investments in recent years in particularly building UK capability in industrial biotechnology puts UK academics and companies in a strong position to begin to tackle these challenges at a research level. However, the infrastructure and support for translational development activity to enable emerging technologies for the production of bio-based monomers and polymers to be prototyped and developed to industrial scale is lacking.

Public resistance to synthetic biology
It is likely that a number of the new technologies for the production of bio-based plastics (particularly monomers) will rely on the use of the use of synthetic biology in the preparation of bacteria, yeasts and enzymes. Although use of such gene edited materials will be undertaken in closed vessels, the commercialisation of such new technologies requires careful management to ensure public acceptance.

Standards
Companies, governments and consumers are confronted with numerous uncertainties. These may limit biobased plastics technologies from growing into full-scale commercial applications. In this context, standards are essential elements in aggregating demand of existing and new bio-based products. Definition and harmonisation of standards related to concepts such as sustainability in order to avoid creating barriers to the international trade of bio-based plastics are required. This is one reason BBIA welcomes this Call for Evidence and supports the unambiguous implementation and enforcement of internationally harmonised standards.

Qu 5. The potential impacts of bio-based plastics on waste processing are covered in Chapter 7. What other potential unintended consequences could arise as a result of a growth in use of bio-based plastics?

The REA's answer is the same as most of the BBIA's answer to this question. The REA's answer on the topic of consumer confusion is differently worded than the BBIA's but the gist of our responses is the same.

'The BBIA has set out below a number of potential consequences that could arise as a result of a growth in the use of bio-based plastics:

[59] https://www.gov.uk/government/news/new-regulations-to-double-the-use-of-sustainable-renewable-fuels-by-2020

Competition for land use

Both petro-based and bio-based plastics are based on carbon chemistry. Accepting that plastics are essential to modern life, there is a choice to make as to whether humanity continues to obtain the required carbon for plastics from underground deposits of oil and gas formed some 200 million years ago or whether a transition towards obtaining this necessary carbon from the atmosphere (captured by plants and other living organisms such as algae and fungi) is not just desirable but essential.

The move to renewable carbon is required because CO_2 will continue to be released from the global plastics ecosystem system in perpetuity. The ambitious global targets for improvements in recycling will not deliver an entirely closed system, unintended losses to the environment will continue to occur, there will remain an imperative for incineration for some applications (e.g. medical waste) and the case for compostable plastics in the collection of food-waste (made elsewhere in this document) is compelling.

Today, bio-based plastics are either produced from agro-based feedstock, i.e. plants that are rich in carbohydrates, such as corn or sugarcane or from farmed sustainable forestry. The former are far more efficient than non-food crops due to highly efficient processes of cultivation, harvesting and transportation. The bioplastics industry is investing in research and development to diversify the availability of non-fossilised, living-organism-derived materials for the production of bio-based plastics. The industry particularly aims to further develop fermentation technologies that enable the utilisation of ligno-cellulosic feedstock sources, for example non-food crops but also agricultural/municipal waste materials
Putting the current usage of non-fossilised, living-organism-derived materials into context of today's global land-use, some 92% of global cultivated land is used for food, 6% for industrial materials, 2% for bio-fuels and 0.016% for bioplastics (latter being anticipated to rise to 0.021% by 2022)[60].

In a local context, recent research by Ricardo Energy and Environment[61] examined the UK's availability of agricultural products including the major cereal and root vegetable crops in the UK and their potential for producing residues that could be used for bio-plastics. The report confirmed that the UK has an abundance of renewable bioresources to supply the biochemicals needed to produce the envisaged growth in markets for bio-based and compostable materials and final products. The report's data highlighted that if the bio-based and compostable materials market grew to [say] 100kt in the next decade (5% of UK plastic packaging), this would require ~1.3% of the UK wheat crop (based on a PLA type material). Similar work by UKBiochem10 suggested ~4% of the UK sugar crop would be required for 100kt of a PET/PEF type material.

Research funded above all by the European Union into sourcing bio-materials from waste feedstocks has reached a critical level. The BBIA is itself involved in two such funded projects[62] whilst at least another ten projects have similar aims.[63] We can predict that with the right policy environment, by 2030 waste feedstocks will have substituted certain crop feedstocks.

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[60] Nova-Institut GmbH: Land use for Bioplastics
https://www.bioplasticsmagazine.com/bioplasticsmagazine-wAssets/docs/article/0904_p46_bioplasticsMAGAZINE.pdf
[61] Ricardo Energy & Environment (2019): Plastics in the Bioeconomy
[62] www.usable-packaging.eu and www.resurbis.eu
[63] https://www.bbi-europe.eu/news/bbi-ju-announces-further-%E2%82%AC-135-million-funding-boost-development-eu%E2%80%99s-bio-based-industries

The BBIA contends that the land use need for bio-based plastics is limited (and certainly modest in the context of bio-fuels) and that it is appropriate to use crop-based inputs for now whilst the industry gains traction and whilst investment in second generation technologies continues.

Increase in price of bio-based plastic products

The relatively high costs of biogenic materials (i.e. from living, non-fossilised organisms), their limited scale of use and the cost of research and development has an impact on bio-based plastics prices. However, prices of existing products have been decreasing over the past decade as more companies and brands are switching to bio-based plastics, as production capacities are rising, and supply chains and processes are becoming more efficient. With rising demand and more efficient production processes, increasing volumes of bio-based plastics on the market and prices will continue to fall.

Nevertheless a large-scale switch to bio-based plastics is likely to increase the cost of materials in the short to medium term. BBIA would argue that this is an intended rather than an unintended consequence and effectively this is the pricing in of the externality of GHG emissions that the petrochemical industry does not take-on at present.

Orphaning of existing petro-based refining and downstream assets

It could be argued that a significant move to bio-based plastics could prematurely orphan or reduce returns on existing assets that support the plastics economy.
Given the continued global growth of plastics, this is unlikely for refining and large-scale petro-chemical assets in the short/medium term.
Bio-based plastic are generally designed to "drop-in" to existing conversion technology resulting in no orphaning of such assets at the product/packaging level of the supply-chain.'

Consumer confusion

There are various bio-based content standards and certification schemes which independently assess and certify conformance to a bio-based content standard but appropriate labelling is not yet universally used and most consumers do not understand it.

Many consumers may think 'bio-based material' means a natural material and be unsure whether they are biodegradable and/or or compostable; uncertainty is likely to be even higher for bio-based materials which, to consumers, look similar to conventional, fossil-derived plastics. Certainly amongst the REA organics recycling industry members we have spoken to they did not already understand that bio-based plastics may or may not be biodegradable and that not all biodegradable plastics are made from bio-based materials. Nor did they understand how to distinguish between these different types of plastic.

Government should explore whether certification of bio-based materials' and finished products' percentage of bio-based content is information that is best kept in the supply chain, amongst all who influence what finished products consumers, businesses, the public sector and NGOs purchases. Would bio-based certification marking of finished products (along with appropriate disposal guidance/instructions on labels) support the right used products going into the right bins?

The REA suggests research into what proportion of consumers are likely to correctly dispose of the following final product types when they are certification marked and their labelling includes appropriate disposal guidance/instructions;

a) bio-based-but-not-compostable finished products, and
b) bio-based-and-compostable finished products.

Call for evidence's section 3 - Biodegradable Plastics

Qu 6. Government has made clear that we want to eliminate all avoidable plastic waste and to move towards a more circular economy. What role, if any, is there for biodegradable plastics to play in achieving the outcomes listed in paragraph 1.7? How could the circularity of these materials be reflected or measured? What is the evidence in support of your view?

Some of our answers below and in section 7 on waste management address how compostable plastics can contribute to clean growth, Circular Economy, environmental protection (in terms of less plastic pollution in the environment) and citizen clarity.

Compostable plastics' contribution to circular economy

The following is a quote from Ricardo Energy & Environment's Plastics in the Bioeconomy report[64]:

'The New Plastics Economy report (Rethinking The Future Of Plastics)[65] presents the need for the exploration of the role of renewable plastic sources, including the use of bio-based sources. The report explains that compostable plastic packaging — if coupled with the appropriate collection and recovery infrastructure — can help return nutrients from the packaged content (e.g. food) to the soil. The report outlines a series of actions and steps needed to drive this systematic change. These steps, and their benefits are as follows:

- Compostable packaging can help return organic nutrients to the soil in applications where currently plastic packaging would be considered 'contaminated' due to food residues.
    - Compostable bags have been proven to increase the amount of food waste returned as nutrient [in compost/composted digestate that is applied] to the soil.
- Compostable and recyclable materials need to be separated and follow different after use pathways.
    - It is generally understood that compostable plastics interfere in today's plastic recycling systems and that vice versa, plastics can contaminate compost within an industrial composting system.
- Appropriate In-vessel (industrial) composting and anaerobic digestion infrastructure needs to be in place.'

[64] https://ee.ricardo.com/news/our-new-report-highlights-potential-tenfold-increase-for-uk-compostable-plastic-packaging-market-by-2025

[65] https://www.ellenmacarthurfoundation.org/assets/downloads/EllenMacArthurFoundation_TheNewPlasticsEconomy_Pages.pdf

A further point, in the compostable packaging standard EN 13432's[66] definition of the term 'ultimate biodegradability' it is recognised that 'new biomass' is one of the results of the breakdown of the compostable item by microorganisms:

3.4 ultimate biodegradability: breakedown of an organic chemical compound by micro-organisms in the presence of oxygen to carbon dioxide, water and mineral salts of any other elements present (mineralization) and new biomass or in the absence of oxygen to carbon dioxide, methane, mineral salts and new biomass'

In other words, some of a compostable packaging item becomes 'new biomass' in compost / composted digestate, which in turn may be utilised by plant roots or contribute to soil function before becoming utilised by plant roots, thus contributing to the sustainable circulation of carbon and nutrients.

<u>Measuring the circularity of compostable plastics</u>

Reform of the UK's Packaging Producer Responsibility System could include that the composting/digestion of compostable plastic and non-plastic packaging items need to be periodically quantified and reported by composters/AD operators who register as reprocessors of packaging (to receive PRN income for the compostable packaging they biodegrade).

Qu 7. With existing technology and materials, what would be the minimum timeframe for complete biodegradation (breaking down to nothing but water, biomass, and gasses, such as carbon dioxide or methane) for plastics designed to biodegrade? We would particularly welcome an assessment in the following environments; deep sea, surface of the sea, freshwater, beach, soil – surface, soil – lightly buried, landfill, industrial composting, and home composting.

The REA's answer is the same as the BBIA's:

'The question is equivocal. It is not clear whether the interest is towards the **intrinsic biodegradability** of plastic materials or the **environmental <u>fate</u>** of any specific consumer or professional product made with a biodegradable plastic material. These two aspects shall not be confused because they must treated using different methodologies.

The **timeframe for biodegradation of a product** depends on the (i) intrinsic biodegradability of the materials it is manufactured from, (ii) dimensions of the products, (iii) the environmental conditions.

(i) **<u>The intrinsic biodegradability</u>** is a specific characteristic of the material and it refers to the ability of the material to be depolymerised and assimilated by microorganisms present in the biosphere and in particular in the environment of interest. The assessment of biodegradation of any chemical/material is carried out under optimised and controlled conditions in order not to limit the microbial development[67]. This type of approach aims at

[66] BS EN 13432:2000, 'Packaging. Requirements for packaging recoverable through composting and biodegradation. Test scheme and evaluation criteria for the final acceptance of packaging', https://shop.bsigroup.com/ProductDetail?pid=000000000030144234
[67] Hemond, H. F., Fechner E.J. (2015) Chemical Fate and Transport in the Environment 3rd Edition; San Diego, CA: Elsevier/Academic Press

finding whether the material under testing is intrinsically biodegradable, i.e. microbes can break it down to carbon dioxide, water, as it is used to grow their own biomass.

Achieving high levels of conversion to CO2, comparable to those achieved by GRAB (Generally Recognized As Biodegradable) substances, is a strong indication that plastic is biodegradable[68].

Relevant standard for biodegradability in soil: EN 17033:2018 Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods.

Relevant standard for biodegradability when assessed by using marine microorganisms: ISO/DIS 22403 Plastics -- Assessment of the inherent aerobic biodegradability and environmental safety of non-floating materials exposed to marine inocula under laboratory and mesophilic conditions -- Test methods and requirements

(ii) **Plastics are solid materials** and thus dimensions make a difference. It is intuitive that the time necessary to degrade a one-meter diameter fully biodegradable redwood block will be extremely long when compared to a leaf or thin straw even if the basic material is the same.

(iii) **Most biodegradable plastics are solid non-water soluble materials**. Biodegradation happens at the surface of solid materials and it can be quantified as (for example) mol C s^{-1} cm^{-2} i.e. amount of Carbon (moles) converted into CO2 per unit time (seconds) per unit surface (cm2). Thus, the complete biodegradation of a product will depend on the mass and on the available surface area.[69]

Environmental conditions will affect the biodegradation rate. Here the main factor is temperature. It has been shown that the biodegradation reaction obeys the Arrhenius curve similarly to most chemical reactions. This enables the development of a methodology to predict field dissipation kinetics taking into account the effects of temperature.[70]

Additionally, the prevalence of microorganisms in a given habitat affects the biodegradation speed. In an environment that is rich in food for microorganisms, there will be more microorganisms at a given temperature and a certified compostable plastic will biodegrade faster in such an environment than in a habitat with no food for microorganisms. Accordingly, the most robust results on questions of marine biodegradability are gained, if biodegradation is compared in marine environments that differ in the prevalence of microorganisms.

If the interest is about ecological risk of littering of products (including the biodegradable ones), then proper tools must be developed. Interesting ongoing projects are:
"the Plastic leak project" by Quantis[71] and the MariLCA project[72],

[68] De Wilde, B. (2012). "Biodegradation Testing Protocols" in Degradable Polymers and Materials: Principles and Practice (2nd Edition), ACS Symposium Series Vol. 1114, ed. K. Khemani, and C.Scholz (Washington, DC: ACS) 33-43. doi:10.1021/bk-2012-1114.ch003

[69] https://www.sciencedirect.com/science/article/pii/S0141391017303816
https://www.sciencedirect.com/science/article/pii/S0141391019301934

[70] Pischedda et al. submitted to Polymer Degradation and Stability.

[71] https://quantis-intl.com/metrics/initiatives/plastic-leak-project/

[72] http://marilca.org/

Qu 8. What evidence is available of direct impacts of biodegradable waste plastics on biodiversity, ecosystems, and the natural environment in the short-term (over the degradation period of the item), and in the long term (including cumulative effects)?

The REA's answer is the same as the BBIA's:

'To answer this question it is important to know what is the specific methodological framework which should be used to measure such impacts. To our knowledge, there is no methodology ready for measuring the impacts of waste (whether biodegradable or not; whether plastic-based or ligno-cellulosic, or whatever).

The above-mentioned studies in the response to Question 7, are the first attempts to determine the environment impact of littering.

It has to be emphasized that application of biodegradable plastics in agriculture ("plasticulture") is not strictly speaking an application on a "natural" environment. Biodegradable mulch films are for professional use. Agricultural fields are not a "natural environment".

Requirements for biodegradable mulch films are present in the European standard: EN 17033:2018[73] Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods.'

Qu 9. To what extent, if at all, can the existing evidence be used to extrapolate the degradation rate of plastics in different environments (e.g. in surface water vs deep sea, etc.)?

The REA's response to this question is in first part the same as the BBIA's:

'The existing evidence shows that (at least some) biodegradable plastics display biodegradation behaviour comparable to cellulose-based products.

Cellulose is used as a benchmark in all the standard specifications to set the level of biodegradation to be reached. Thus biodegradability in EN 13432, EN 17033, ISO 18606, ISO 17088, ISO/DIS 22403 is ascertained by comparing the behaviour the considered material toward cellulose. According to all these standard specifications, intrinsic biodegradability of plastics (and other materials) is shown by showing biodegradation levels analogous to that obtained by cellulose.

<u>All the knowledge available on the biodegradation behaviour of cellulose can then be reasonably applied to predict the behaviour of the materials under study</u>[74][75]. The biodegradation speed will then depend upon the temperature in an environment as well as the prevalence of food for microorganisms which is different from environment to environment.'

[73] https://www.european-bioplastics.org/new-eu-standard-for-biodegradable-mulch-films-in-agriculture-published/.

[74] Bengt V. Hofsten and Nils Edberg Estimating the Rate of Degradation of Cellulose Fibers in Water Oikos Vol. 23, No. 1 (1972), pp. 29-34

[75] Chung Hee ParkYun Kyung KangSeung-Soon Im, Biodegradability of cellulose fabrics 2004 Journal of Applied Polymer Science 94(1):248 – 253

REA comments: With regard to the sentence in the above BBIA paragraph that the REA has underlined, the REA has not reviewed existing evidence for its suitability for <u>extrapolating</u> degradation rates of plastics in different environments. Given our experience in the BSI process for development of the UK testing framework for oxo-biodegradable plastics[76] we are very cautious about this.

In the potential context of assessing a test sample's conformity with minimum biodegradation rate requirements set in a standard, the calculated (extrapolated) results of biodegradation rate under conditions different from those a test sample is subjected to may or may not match with what a different-conditions-test would show. In addition, calculations to predict test sample biodegradation behaviour beyond the period of the test may inaccurately predict test sample biodegradation behaviour shown if the test duration were extended to match the timescale covered using the calculation approach.

Qu 10. What testing regimes/methodologies are you aware of that could verify that biodegradable plastics completely degrade (breaking down to just water, biomass, and gasses, such as carbon dioxide or methane) in the open environment instead of simply fragmenting into microplastics? If not, what are the key challenges to establishing such a test?

The REA's answer is the same as the BBIA's:

'EN 17033:2018 Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods
ISO/DIS 22403 Plastics -- Assessment of the inherent aerobic biodegradability and environmental safety of non-floating materials exposed to marine inocula under laboratory and mesophilic conditions -- Test methods and requirements

The applied test methods show intrinsic biodegradability, i.e. complete transformation into CO2 and biomass using cellulose as the benchmark in specific environments.
Thus the materials satisfying these specifications can be equated with cellulose-based materials in these environments. Behaviour in the open environment will be similar. To illustrate this point, if the open environment is humid, warm and rich in microorganisms, the biodegradable plastic may biodegrade at similar rates as cellulose. In a dry open environment, and in the absence of a rich microorganism community (e.g. concrete in a dry area), slow biodegradation will be observed. BBIA believes that products should be certified according to their intended end of life, not to the specific product's intrinsic level of biodegradability (cf. also answers to Questions 13 and 21).

Microbial lifeforms are present in most locations on Earth so the question about the biodegradation of such materials is more about the environment they are in and therefore the rate of biodegradation. If the surface area of such materials is increased by (say) mechanical action, it is more likely to lead to a higher rate of biodegration.'

[76] BS 8472:2011. Methods for the assessment of the oxo-biodegradation of plastics and of the phyto-toxicity of the residues in controlled laboratory conditions.
https://shop.bsigroup.com/SearchResults/?q=bs%208472

Qu 11. Would such testing regimes/methodologies be applicable to plastics which contain prodegradant agents intended to aid the biodegradation process? We are particularly interested in any evidence established in the last three years.

The REA's understanding of scope statements, biodegradation criteria and tests specified in standards that screen for acceptable biodegradation in well-defined environments is that any sample type can be tested and has potential to comply with biodegradability requirements if it is made of a suitable material and is of a suitable thickness. For example, EN 13432 does not exclude any specific material type and/or thickness.

The REA does not have evidence and is not aware of evidence established in the last 3 years that would support a case for prodegradant-amended polyolefin plastics (also known as oxo-biodegradable plastics) to not be biodegradation tested as per the same methods and criteria as are required for other types of plastic which are intended or claimed to be biodegradable in open environments.

We are concerned about how standards for protecting specific open environments (and any that may singly tackle all open environments in future, if achievable) would ensure that biodegradation tests and their 'pass or fail criteria' take into account micro-sized polyolefins, and any other type of biodegradation-resistant and prodegradant-additive-reliant polymer for that matter.

Here we have quoted part of the BBIA's answer to question 11 because it briefly describes oxo-biodegradable plastics and the role of their prodegradant ingredients:

'Plastics which contain prodegradant are applied to non-biodegradable conventional polyolefins. Normal polyolefins undergo oxidation and degradation with time. This leads to fragmentation. Prodegradants accelerate the oxidation of polyolefins. As a matter of fact, "prodegradants" are catalysts, which decrease the activation energy for oxidation of polyolefin to happen. Energy comes as UV light or heat. We can therefore define prodegradant agents as substances that accelerate the formation of microplastics from polyolefin. [77] [78]'

Qu 12. What evidence, if any, is available to quantify the differing environmental impacts of compostable plastics when they "escape" and then degrade in the open environment?
Tools for quantifying the environmental impact of littering are under development; see answers above and to question 18.

[77] UNI/TR 11605:2015 (Plastics- Additives intended to promote the degradation of polyolefin-based thermoplastic materials)

[78] The technical report provides information on additives intended for promoting the degradation of thermoplastic materials based on polyolefins. It identifies the different original technologies of the products, it characterizes the mechanisms of action, it describes the environmental claims generally used, and it clarifies the differences between the terms "degradation" and "degradability". The technical report deals with technologies based on the use of additives only. It doesn't therefore apply to degradable copolymers such as, for example, copolymers of ethylene and carbon monoxide or copolymers based of ethylene and / or propylene and alkyl vinyl ketones (commonly methylvinyl ketone).

Qu 13. The potential impacts of biodegradable plastics on waste processing are covered in Chapter 7. What other potential unintended consequences could arise as a result of a growth in use of biodegradable plastics?

The REA's answer is the same as the BBIA's, with a number of clarifying words added in square brackets in amongst the text.

BBIA: 'It is essential that the deployment of biodegradable plastics is done at an application level where the systemic impacts are considered. Much noise is currently being made in relation to the impact of alternatives to traditional plastics, most often these complaints come without understanding the final goal – in the case of the UK, and with regard to this consultation, the principle aim is to achieve net zero emissions by 2050.

It is interesting to note that from our understanding, the Government is looking at a future [Extended Producer Responsibility] system [for packaging] which is fixated on [dry-/mechanically/-chemically/-thermally recyclable] material recycling, with little consideration for the wider sustainability or even reality that most plastic material cannot be recycled more than once or twice.

As currently considered in most packaging applications, even bags such as carriers or those used for fruit and vegetable or where associated benefits can be brought through the system via increasing organic waste collection (60% of all bio-based (min 50%) and compostable fruit and vegetable bags sold in Italy are reused for food waste collection despite the collection not being national i.e. where food collections are deployed the reuse rate is significantly higher) the EPR system and fee calculation is not likely to lend itself to a compostable solution, since innovation – essentially anything other than what is widely available today – is not accounted for in a new binary system [of widely-recyclable materials and so called non-recyclable materials because they are not widely recycled].

So, one unintended consequence is that companies placing compostable plastic packaging on the market will potentially be charged at the highest fee rate (non-recyclable) and the composters where the [compostable] packaging is recycled will not receive any credit for the actual recycling.

One often cited concern is that biodegradable plastics do not solve littering, in fact they exasperate it. To the best of our knowledge, biodegradable (compostable) plastics packaging is not flagged as litter concern; no biodegradable (compostable) option has been cited in any of the work the EC has done prior to the implementation of the SUP. In fact the only area where so-called biodegradables were deemed a concern, i.e. oxo-degradables (defined as plastics which contain additives designed to enhance fragmentation) the SUP has moved to ban them whilst at the same time, defining biodegradable plastics as those which meet EU standards for biodegradable packaging i.e. the biodegradation and composting standard, EN13432.

To the best of our knowledge, none of the claims [that biodegradable plastics] will increase litter are backed up with any actual evidence. The much cited UNEP report is a point in case79. The only reference to research cited in that "landmark" report, comes from a small piece of research into youth behaviour undertaken by the municipality of Los Angeles. The link to this work – which is just a presentation at a conference – is no longer available. (see Keep Los Angeles Beautiful (2009) "Littering and the iGeneration: City-wide intercept study of youth litter behaviour in Los Angeles." Session paper at XIII Environmental Psychology Conference Granada, June 23-26, 2015 http://www.congresopsicamb2015.com which is no longer online.

[79] http://wedocs.unep.org/handle/20.500.11822/7468

Having said this, it is clear to BBIA that the branding/labelling/marking of products made from biodegradable materials [and which are independently certified compliant with a standard accepted amongst relevant stakeholders] is key to informing consumers about how to [correctly] dispose of the product once used. Making products which can biodegrade in specific environments defined in standards [and comply with all relevant criteria in a relevant standard] (as we have seen with compostable films) is not an excuse for incorrect disposal or behaviour. This applies for all materials, not just biodegradables.'

Call for evidence's section 4 - Compostable Plastics

Qu 14. What evidence, if any, is available regarding the suitability of the existing industrial and home composting standards? We welcome any suggestions on how these standards could be adapted to current and future needs, if necessary.

Industrially compostable items

Here we have summarised feedback from a number of the REA's industrial composting and AD members. Industrially compostable bags/liners tend not to adequately biodegrade in wet-AD (low solids AD) systems that don't have a following phase where dewatered, digested solids are aerobically composted.

Where users of industrially compostable bags/liners have knotted them (to ensure containment of the waste at least before collection) the knotted parts of those bags are, unsurprisingly, relatively slow to disintegrate and biodegrade. Residues of bag/liner knots get mechanically screened (sieved) out with woody particles when batches composted material complete their actively managed phase/phases of composting.

A few members have reported residues of industrially compostable items but not been specific about which forms/types and in some cases have been unsure whether they were certified items (given our past experiences, we do not trust that all non-certified items are industrially compostable as claimed by the item supplier/marketeer).

Compost screening equipment does not differentiate between industrially compostable plastics and others which are unsuitable in these systems. The REA is not aware of machines that could reliably identify and remove non-compostable plastics at compost screening stage and we are doubtful that NIRS identification and sorting machinery (those types used in MRF's) would perform adequately if trial-used for removing non-compostable plastics during waste preparation for composting, at composting facilities. Space-limitations are a further constraint at a number of industrial composting facilities.

Some industrial composting facilities re-compost the large woody particles that the post-composting screening machinery separates from the compost. However, although any residues of industrially compostable plastics seem likely to become adequately biodegraded during a second pass through the composting system they rarely take this route in reality because so often the woody particles are:

- so contaminated by non-compostable plastics that they are not cost effective to treat any further so are sent to landfill, incineration or an Energy from Waste facility; or
- are less contaminated so undergo steps to remove plastic and other physical contaminants but the machinery removes all plastic types (those pieces large enough to be caught/redirected by the machinery).

Adaptation of industrially compostable standards: disintegration and biodegrdation test temperatures and maximum timescales

Feedback from one of the REA's industrial composting members has been that tests specified in UK-applicable standards for industrially compostable items should match shortest-timescale, lowest temperature industrial composting conditions. The REA would need to research current practices; they may be 6 weeks of composting at temperatures that start out at approximately 50 °C then trend downwards as the composting process advances (excepting temperature spikes that occur after batch turning, in systems which batch-turn).

Any research and development underpinning any changes to UK-applicable standards for industrially compostable items ought to also try to establish which industrially compostable intermediate materials and finished products would cease to comply if sample of them are required to achieve the biodegradation and disintegration criteria within a much shorter timescale and/or when tested under a lower temperature/range of temperatures. If such changes were made to relevant standards, would the reduced range of industrially compostable intermediate materials and finished products result in greater use of non-industrially compostable plastics and an increase in their contamination of biodegradable wastes? We suspect there is a tests-timescales-and-temperatures versus compliant material/final product balance to be struck, should any such R&D go ahead.

Adaptation of industrially compostable standards: sufficient controls on non-volatile solids content?

An REA member has questioned whether EN 13432's controls on non-volatile solids (those which are largely inert materials and not organic matter) are adequate. This standard sets upper limits on concentrations of 11 potentially toxic elements but is that range of elements adequate given that packaging/packaging material/packaging component is allowed to contain up to 50 % non-volatile solid materials and given the types of non-volatile solid materials they may contain? Our brief look into this has shown that at least one of the organisations that assesses and certifies compliance with EN 13432 has drawn up a positive list of allowed 'inorganic fillers and pigments'.

Excerpts from EN 13432 and description of its limits on 'heavy metals and other toxic and hazardous substances':

A.1.1 Volatile solids: 'packaging, packaging materials and packaging components shall contain a minimum of 50 % of volatile solids which exclude largely inert materials'.
3.6 volatile solids: amount of solids obtained by subtracting the residues of a known amount of test material or compost after incineration at about 550 °C from the total dry solids content of the same sample. The volatile solids content is an indication of the amount of organic matter.'

4.1 Control of constituents
'Constituents known to be, or expected to become, harmful to the environment during the biological treatment process (see clause 8), in excess of the limits given in Annex A.1, shall not be deliberately introduced into packaging or packaging materials intended to be designed as suitable for organic recovery.'

3.1 Consituent of a packaging material: 'all pure chemical materials and substances of which a packaging material is composed'.

Table A.1 in Annex A.1 sets upper limits for concentrations of the following elements which may be in 'heavy metals and other toxic and hazardous substances': Zn, Cu, Ni, Cd, Pb, Hg, Cr, Mo, Se, As, and F. A note to this table includes: 'It is assumed that 50 % of the original weight of the packaging or packaging material will remain in compost after biological treatment together with the complete original amount of hazardous substances.'

N.B.: EN 12342 (for compostable packaging) and its mirror standard EN 14995 (for compostable plastics) in some respects are not optimised to UK composting and 'digestion then composting' processes and there has been some composter feedback about residues of some compostable items at the end of some composting processes. Nonetheless, we emphasise that **these standards are valuable for distinguishing between compostable items which biodegrade acceptably well in most UK industrial composting processes** (e.g. those made of corn starch) **and other items which do not** (e.g. those made of oxo-biodegradable plastics). In other words, these standards are essential and we would participate in their review if CEN decides or is mandated to review them.

Standards and independent certification services for home compostable items

In the UK home composting tends to focus on composting garden plant waste materials and suitable food scraps/leftovers from household kitchens (commonly avoiding meat, fish, cheese and other food types that readily attract vermin to composting units which aren't vermin-proof). It can also be used for biodegrading home compostable packaging and non-packaging items such as lightweight carrier bags, magazine wraps and liners for kitchen caddies and food waste bins. Items UK householders home compost in future seem increasingly likely to reflect only the product types within the scope of standards for home compostable items (as product certification, labelling and disposal instructions improve); the 3 standards we have referred to below focus on plastics rather than a broader range of home compostable material types, only TūV Austria's 'OK compost HOME' criteria covering a wider range of materials.

Clients who apply for home compostable item certification from certification body TÜV Rheinland (DIN Certco) can choose between the following standards for compliance assessment:

- French standard NF T51-800 (November 2015), Plastics - Specifications for plastics suitable for home composting
- Australian standard AS 5810-2010, Biodegradable plastics - Biodegradable plastics suitable for home composting

Clients who apply for home compostable item certification from certification body TūV Austria have their item assessed for compliance with this organisation's 'OK compost HOME', Program OK 2, edition D, criteria for assessment and certification of 'home compostability of products'.

UK company Renewable Energy Assurance Limited's (REAL's) certification service for home compostable plastics is provided under a partnership arrangement with DIN Certco; items are assessed for compliance with AS 5810, become certified if they comply and are allowed to bear an appropriate certification mark. (REAL's response to this call for evidence provides more information on their services and certification marks.)

Italy has a national standard for composting at **room/ambient** temperature, UNI 11183:2006, Biodegradable plastic materials at room temperature - Requirements and test methods.
It is summarised as follows: 'The standard defines the biodegradability requirements that must be met by the plastic materials used to prepare products that can be disposed of by aerobic biodegradation at room temperature. The term ambient temperature refers to the temperature

range of temperate regions, excluding the high temperatures typical of industrial composting. The ecotoxicity requirements of plastic materials are also considered in the standard.'
(see http://store.uni.com/catalogo/index.php/uni-11183-2006?josso_back_to=http://store.uni.com/josso-security-check.php&josso_cmd=login_optional&josso_partnerapp_host=store.uni.com)
The REA has not investigated certification body services that assess and certify home compostable item conformance to this standard.

As far as the REA is aware, certified home compostable items can be marketed internationally, to the extent that any particular country recognises/accepts the standard to which the item conforms.

Mandated by the European Commission, the relevant European Committee for Standardisation's (CEN) committee is drawing up a standard with current reference: prEN 17427 Packaging — Requirements and test scheme for carrier bags suitable for treatment in well-managed home composting installations.

We do not have evidence that the home compostability standards referred to above and TUV Austria's OK compost HOME certification scheme criteria are inadequate in the UK context. In our answer to question 15 we have made some comments about scopes of these standards and one being developed at EU level by CEN and made a recommendation.

Qu 15. To what extent, if at all, would a home composting standard that covers all home composting techniques, equipment and environments in the UK be possible? If so, would it be a desirable system to adopt?

Two thirds of UK households have some form of outside space/garden which could be potentially used for installing a home composting unit[80]. We have not checked what recent figures are available on the number of UK households known to be home composting currently nor do we estimate the number of households with a suitable outside space/garden who don't currently home compost but might decide to in future if suitably encouraged/supported to do so.

The BBIA's answer to this question has covered key differences between industrial scale and home composting and described reasons why home composting conditions tend to be more variable and less well controlled than industrial composting.

The REA does not believe it possible to write a home composting standard that covers ALL home composting techniques, equipment and environments in the UK; it would have to assess and set requirements for worst case home composting under within-heap/installation conditions that mirror the spectrum of weather conditions and the most neglected and smallest heaps. In addition, it would seem difficult for tested samples to comply with home composting pass/fail criteria when tests are run under worst case conditions.

We perceive that so far the currently available standards and certification services for home compostable items are positively influencing the development, identification (by certification marking), labelling and home composting of home compostable items. We have not in recent years received negative feedback about such items not home composting but recognise that consumers may not know which organisations to contact.

[80] http://www.prestonbaker.co.uk/explore/property-journal/third-homes-no-back-garden/

Given the standards and TUV Austria's 'OK compost HOME' criteria to which home compostable items (not just carrier bags) are already being certified, placed on markets and home composted after use, and given CEN's current work to develop a standard for lightweight carrier bags which are biodegradable under well-managed home composting, we believe that **a standard that specifies tests and pass/fail criteria that correspond with well-managed home composting in the UK could positively contribute** to the sustainable management of appropriate types of household biodegradable wastes in the UK.

We recommend that government in the UK monitors the progress made by CEN and has **further dialogue with stakeholders on the forms/types of compostable items** that should be included in any home compostable standard which is/intended to be applicable in the UK. Increasing numbers of 'OK compost HOME' certified magazine wraps are in use in the UK and disposal instructions include using them for lining kitchen caddies and outdoor bins that hold food wastes, the subsequent home composting of such wastes being included in disposal options. Certified home compostable liners for kitchen caddies and outdoor bins are in use but would not be within the scope of a standard for lightweight carrier bags.

We agree with the BBIA's assertion that '…the massive treatment of packaging waste through home composting is clearly challenging' but believe the scope of the standard for home compostable lightweight carrier bags that's being developed by CEN is too narrow.

We also recognise that, in the BBIA's words, '…home composting does not allow calculating whether …[waste] recycling targets have been achieved, as the waste is not counted in any waste treatment plant'. Given the challenges in quantifying amounts of household wastes that are home composted it's regarded as a waste prevention rather than recycling measure.

Qu 16. The potential impacts of compostable plastics on waste processing are covered in Chapter 7. What potential unintended consequences could arise as a result of a growth in use of compostable plastics?

There are considerable tasks ahead of us to ensure that all compostable plastics (and non-plastic compostable items) are clearly labelled, their compostability is trustable (i.e. they are certified compliant with a relevant standard and carry a certification mark), labelling includes appropriate disposal instructions, bin users become educated on putting the right items in the right bins (across the spectrum of waste types) and waste collection crews are further educated and adopt as-far-as-practicable-practices that reduce the proportion of contaminated recyclable wastes that are collected for recycling (especially important for composters and digesters of biodegradable wastes).

We acknowledge that mistakes occur during periods of transition and that even afterwards some compostable items will be put in the wrong bins. This will also be true for non-compostable plastics, some of which will still end up in bins for biodegradable wastes even after plastics labelling is improved, e.g. after revised OPRL labelling resources come into widespread use.

Where compostable items (including compostable plastics) are mistakenly put in bins for mechanically- / dry-recyclable multi-materials/plastics, this waste stream would be transported to MRFs for sorting and sale of the recyclable plastics to plastics recyclers. Plastics recyclers have expressed concerns about compostable plastics being sorted into containers for the recyclable kinds of plastics and contaminating them in untolerable concentrations.

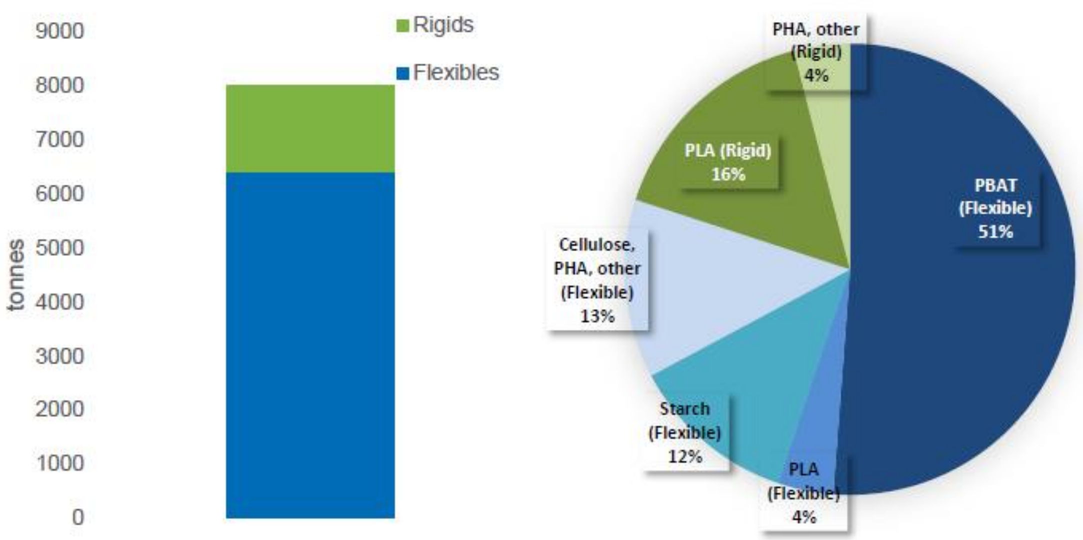
Ricardo Energy and Environment (RE&E) recently carried out a study[81] that considered, amongst other related things, 'the current scale and types of compostable plastics in the market' and 'the potential contribution of compostable plastics to the 2025 targets for plastic packaging as set out by the UK Plastics Pact and a strategy for how this could be achieved'. This study found '..there could be a tenfold increase in the compostable [plastic] packaging market from 10,000 tonnes [currently] to over 100,000 tonnes (range from 90,000 – 138,000) depending on the degree of market uptake'.

The current 10,000 tonnes per annum of compostable plastic packaging represents 0.44 % of the 2,260,000 tonnes of plastic packaging waste arisings in 2017 and 0.96 % of the 1,044,000 tonnes of plastic packaging wastes which were 'recovered / recycled' in that year[82]. Current compostable plastic packaging represents a very low percentage when compared with those recent plastic packaging waste arisings and also a low percentage when compared with how much of those arisings were recovered / recycled (and recovered tonnage was not reported separately from recycled tonnage). We are not aware of any quantitative assessment of the amount and proportion of compostable packaging that's getting into the collection systems for recyclable plastic wastes and to what extent they are being mis-sorted into containers/further streams for particular types of recyclable plastic.

RE&E reported that 'according to information gathered by members of BBNet, the current UK market for biodegradable bio-based plastics is estimated at approximately 8,000 (+/- 1,000 t). The breakdown of this market by biopolymer is illustrated in Figure 5. This shows that a significant proportion of the biodegradable plastic market goes towards producing flexible plastic products'. It also said 'At present, the majority of consumer flexible packaging is sent to landfill or energy recovery' and 'This is due, in part, to the challenging infrastructure for collecting and recycling PE films.'

Figure 5 in RE&E's report

Figure 5 UK biodegradable plastics market 2018



[81] https://ee.ricardo.com/news/our-new-report-highlights-potential-tenfold-increase-for-uk-compostable-plastic-packaging-market-by-2025

[82] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/784263/UK_Statistics_on_Waste_statistical_notice_March_2019_rev_FINAL.pdf

Using this information and if we use 9,000 tonnes as the maximum figure for the current annual biodegradable, bio-based plastics market, the total flexible materials quantity is 7,200 (80 %) and total rigid materials quantity is 1,800 tonnes. Given that the majority of consumer flexible packaging is not recycled, most products made from the 7,200 tonnes of flexible biodegradable, bio-based plastics products (we assume these are compostable) should not be regarded as a risk to the quality of recycled flexible plastic packaging and a significant proportion biodegradable, bio-based plastic products (we assume these are compostable) made from the 1,800 tonnes is likely to be reaching appropriate composting facilities.

We note the BBIA's comments in part answer to question 26: 'On the risk of compostable plastics contaminating conventional plastics, SUEZ UK have informed that in UK MRFs they manage

"PET & HDPE are both positively sorted from the mixed 3D stream by near infrared, whilst the metals are pulled off separately." (quote from Dr. Adam Read to Vegware)
Therefore there is little probability of other polymers going into the PET and HDPE streams. So if a compostable polymer such as PLA went in to the plastics recycling, it would not contaminate those two valuable streams.
As for the possibility of compostable materials contaminating conventional plastics recycling, German and Italian researchers have found there was no reduction to quality, up to these levels:

- Up to 3% PLA in post-consumer PP plastic recyclate (1)
- Up to 10% PLA in PS plastic re-granulates (1)
- Up to 1-2% PLA in recycled PET plastic short-spinning plant (2)
- Up to 10% MaterBi in the recycling of PE plastic shopping bags (2)

Source: (1) the report PLA in the Waste Stream, a report initiated by the German Ministry of Food and Agriculture. And (2) from CONAI, the National Packaging Consortium of Italy: Working Group Biodegradable Packaging Recovery Project report, 2012.'

The REA has also considered whether compostable plastics would be any more or less likely than other non-recyclable plastic types to be mis-sorted into containers for recyclable plastics at MRFs. A contact we spoke to said that typical Near Infra-Red Spectrum (NIRS) detection and sorting machines in use in UK MRFs cost £12,000 per machine. Each machine is capable of and programmed to seek and match the NIRS of one polymer type and transfer items of that type off the waste conveyor belt and into a designated container or onto a designated conveyor belt. They are 95 – 96 % accurate when selecting PET, PP, PVC and PE items (presumably rigid ones). The NIRS machines are worse at successfully identifying items with matching NIRS when the items carry a high level of contamination (e.g. food residue) and/or include much pigment or ink print and/or are joined or stuck together. Perhaps the risk of an NIRS machine mistakenly selecting a compostable plastic type it isn't programmed to seek is low. Perhaps the majority of any mistake transfers of 'clean' compostable plastic to a target polymer's container/conveyor belt would be some of the ones that have become joined or stuck to a target-polymer item earlier in the waste collection, transportation or MRF system.

Compostable plastics are not currently sought by NIRS machines in MRFs because there's too little of these materials to cover the costs of installing the extra machinery that would be needed for identifying and sorting them. Under the current EPR system PRN income available for recycling them – by composting – is very low, £0.70 - £1.00/t).

Considering the prospect of more effective and efficient sorting of materials in MRFs (and Plastics Recycling Facilities) in future, the potential use of fluorescent tracers and digital watermarking is currently being researched[83]. Quoting from Packaging Europe's article '…a key to the success of paper recycling is the fact that everything from corrugated board to newspapers can go into the same stream. Simplicity for the consumer is crucial to a high collection rate. Given the multiplicity of polymers used in packaging, raising recycling rates based on a single collection stream depends on solving the challenge of efficiently identifying and sorting different plastics. Having explored a number of approaches to this challenge, a number of value chain stakeholders are now investing in research around two technologies that could make an important contribution: tracers and digital watermarking.'[84]

Tracer-based sorting uses fluorescent pigments, incorporated into the plastic substrate or in sleeves on the packaging item, which are only visible when using UV light at the sorting plant. 'Watermarks can be printed, for instance on in-mould-labels or on sleeves, or they can be integrated in 2D or 3D moulds. Three-dimensional watermarking technology for plastics such as PET-bottles and trays…provide waste sorters [with] a unique method for selection. Nearly invisible to the human eye, the code can be read by a camera, in infrared, daylight or ultraviolet conditions. Covering the full product, the watermark's readability is not affected by dirt, distortion or orientation. In addition, there is no chemical residue and therefore no impurities entering the recyclate.' At least one of the BBIA and REA's members who produces compostable plastics is participating in current research.

Call for evidence's section 5 - Existing and Potential Biodegradability Standards

Qu 17. A list of currently active biodegradability standards and test methods for all plastic materials in soil, marine and waste water environments is included in the report 'A Review of Standards for Biodegradable Plastics'. Are there other relevant standards or test methods for those circumstances that you are aware of that do not appear on this list?

The BBIA answered as follows:

'ISO 22404:2019, Plastics — Determination of the aerobic biodegradation of non-floating materials exposed to marine sediment — Method by analysis of evolved carbon dioxide
https://www.iso.org/standard/73123.html

ISO/DIS 22403, Plastics — Assessment of the inherent aerobic biodegradability and environmental safety of non-floating materials exposed to marine inocula under laboratory and mesophilic conditions — Test methods and requirements
https://www.iso.org/standard/73121.html

EN 17033:2018, Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods
https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:41401,6230&cs=19E53F436D5E8A6FF49358DA8C195A6E2'

[83] https://global-recycling.info/archives/3142
[84] https://packagingeurope.com/sorting-plastic-recycling-tracers-digital-watermarks-tomra-procter-gamble/

The REA adds the following:

ASTM D5511 – 18, Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions
https://www.astm.org/Standards/D5511.htm
'This test method covers the determination of the degree and rate of anaerobic biodegradation of plastic materials in high-solids anaerobic conditions. The test materials are exposed to a methanogenic inoculum derived from anaerobic digesters operating only on pretreated household waste. The anaerobic decomposition takes place under high-solids (more than 30 % total solids) and static non-mixed conditions.'

REA comment: this standard test method (ASTM D5511) is relevant to dry-AD systems and although it does not set pass/fail criteria for test sample biodegradation in such systems it's could potentially be specified as part of a future standard which aims to set appropriate pass/fail criteria for biodegradability and other relevant characteristics.

Qu 18. What areas, if any, would require improvement in existing standards to strengthen their effectiveness? To what extent, if at all, would the development of new standards for biodegradability constitute a viable alternative? What is the evidence in support of your view?

The REA supports the following part of the BBIA's answer to this question: 'The interest towards the effects of plastic littering on the environment requires the development of tools suitable to be used to assess the risk associated with uncontrolled release of waste. Standards on how to track the environmental fate of plastic waste must be developed. Proper methodologies, where input sources, sinks, pathways, and biodegradation rate are factors to be evaluated need to be developed. In this regard, it is important to mention two important ongoing projects that aim at integrating potential environmental impacts of marine litter, especially plastics, in LCA results: The Plastic Leak Project of Quantis[85] and Marine Impacts in LCA (MariLCA)[86]'

The REA's answer to question 14 included suggestions on aspects of the EN 13432 that should be considered in terms of potential improvements.

Development of digestable bags/liners

EN 13432's criteria for packaging which is biodegraded using anaerobic digestion followed by a composting phase are little used as far as the REA is aware. In other EU countries it's more common for AD to be followed by a phase of composting the dewatered, digested solids, yet much compostable packaging certification focusses on the criteria for compostability in EN 13432. Likely reason: it's simpler to focus on compostability and the compostable certified items which go through AD then a composting phase biodegrade adequately anyway.)

EN 13432's 'AD then composting phase' criteria may not be ideal for UK wet-AD but in this sub-sector of the AD industry items certified compliant with those criteria may represent a better balance between bag/liner function when holding waste and bag/liner biodegradation than items certified compliant with the compostability critieria.

[85] https://quantis-intl.com/metrics/initiatives/plastic-leak-project/
[86] https://www.lifecycleinitiative.org/new-project-marine-impacts-in-lca-marilca/

Digestible plastics: a UK company's progress

One UK company the REA has spoken to has developed a stabilisers-amended polyvinylalcohol (PVA) polymer that has been used for making 'speciality bags' for items used in healthcare which are placed in bags post-use and when machine washed the bags dissolve and the washed item can then be further prepared for re-use. Trials of this PVA-based material in Australia found that the bags were strong enough to hold food waste and that they softened and dissolved when fed into an anaerobic digestion system. The company is now embarking on a full scale trial with a UK wet-AD facility where digestion is carried out at 48 ^{o}C (in the temperature range favoured by mesophilic microorganisms). Up to a particular thickness, this PVA-based material has met biodegradability criteria specified in EN 13432 when tested by a laboratory experienced in running such tests.

If this PVA-based material performs adequately in the full-scale wet-AD trial and complies with EN 13432's other requirements, it could be assessed for suitability for feed into other UK located wet-AD facilities (taking account of factors such as differing hydraulic retention times, organic loading rates, use, positioning and time-temperature regimes used in pasteurisation steps, and types and qualities of digestate outputs).

The company says that as a speciality material, bags/liners made out of it may be more highly priced than polyethylene ones but provided it continues to hold food wastes well at a thinner guage, it has potential to effectively compete with polyethylene on price.

Digestible plastics: how relevant is EN 13432?

EN 13422 includes the following provisions for testing, respectively, a test sample's biodegradation and disintegration under anaerobic digestion conditions:

In clause 7:

NOTE 2 For the purpose of this standard it is sufficient to determine biodegradability under aerobic conditions. If in a special case additional information on biogasification is required, a method with a high-solids test environment such as ISO 15985 should preferably be used. For screening anaerobic biodegradability for example ISO 14853:1999 or ISO 11734 may be used.

In clause 8:

NOTE 1 For the purpose of this standard it is sufficient to determine disintegration under aerobic composting conditions. If in a special case information on anaerobic treatability is required an anaerobic pilot-scale test or a full-scale facility for solid waste treatment should be used.

Its Annex A.2 specifies the following biodegradability (see A.2.3.1) and disintegration (see A.3.2) pass/fail criteria for anaerobic digestion then composting of packaging items:

A.2.3 Anaerobic biodegradation tests

A.2.3.1 Where required, the period of application for the test specified in the test methods shall be a maximum of 2 months.

A.2.3.2 The percentage of biodegradation based on biogas production shall be 50 % or more of the theoretical value for the test material.

NOTE The lower percentage of biodegradation is justified because in all commercially available biogasification plants the process scheme provides a short second aerobic stabilization phase in which the biodegradation can further continue.

A.3.2 Anaerobic biogasification

A.3.2.1 Where required, the test duration shall be a maximum of 5 weeks as a combination of anaerobic digestion and aerobic stabilization.

A.3.2.2 Following submission to the composting process as specified in A.3.2.1, not more than 10 % of the original dry weight of a test material shall fail to pass through a > 2 mm fraction sieve.

NOTE The limit values for disintegration and the test duration are based on present experience. It is anticipated that these may be confirmed or modified as necessary as a result of testing currently being carried out.

Although these test methods may be unsuitable for testing under wet-AD (low solids) conditions and the pass/fail criteria are not appropriate for wet- and dry-AD processes which don't have a following phase of aerobic composting of dewatered, digested solids, they provide useful starting points for development of suitable test methods and pass/fail criteria that could be specified in an appropriate standard in future. (EN 13432's other pass/fail criteria, on ecotoxicity and heavy metals and other toxic and hazardous substances apply in the same manner regardless of whether the test sample is designed intended to be composted or digested then composted.)

Qu 19. When dealing with biodegradation, what are the advantages and disadvantages of producing standards? We would welcome your thoughts in relation to the production of standards at the following levels: national, regional and international?

Standards are needed to characterise the properties of materials and thus the behaviour of different products for purposes of recovery and recycling of waste. This area has been deeply studied in the last 3 decades and a number of standards for testing and evaluating the organic recyclability (mainly industrial and home compostability) of plastic and non-plastic products exist.

Their development and publication in turn supported the development and use of independent organisations' compliance assessment and certification schemes and the certification marks they licence for use on certified products. This has supported the development of markets for certified industrially compostable packaging and non-packaging items (including plastic ones) and certified home compostable packaging and non-packaging items (including plastic ones).

The REA's comments on standards relevant to littering of plastics and other materials into open environments are the same as the BBIA's:

'When littering is concerned, then a specific methodological approach is needed to take into consideration amount of litter, migration among different environmental compartments, environmental sink, exposure, damage, risk assessment. Biodegradability is just one factor relevant to understand the environmental fate of products. The assessment of risk associated with waste leakage cannot be solved with one standard. A broader approach is needed, similar to what has been done for chemicals released into the environment.'

In general standards are not disadvantageous when they have clearly defined and appropriate scopes and their requirements are clear and appropriately reflect that scope. It's important is that publicly available (including on-line) summaries of standards provide a clear and accurate description of their scope. The use of many standards seems to be amongst specialists in the relevant fields. In our experience organisations - independent from materials/product manufacturers - which provide services that assess material/product conformance with a relevant standard, certify compliant materials/products and licence the use of their certification marks in product labelling (on the material/product and/or in documentation about the material/product) play a key role in the appropriate and successful use of those materials/products. The same seems likely to be true of standards and certification schemes relevant in the services sector.

Production of standards at national, regional and international levels

Considering standards for 'biodegradable but not compostable' plastics and standards for 'compostable' plastics, international standards are preferable because a number of manufacturers, retailers and brand owners trade them internationally. However, differences between countries' open and human controlled/influenced biodegradation environments can make it difficult for a single international standard for a specific purpose to meet all relevant stakeholders' needs.

Broadly speaking, the European standards (regional in this question?) for industrially compostable packaging and plastics (respectively EN 13432 and EN 14995) have been, and continue to be, valuable standards, including in the UK.

Our experience of national standards which have been, and continue to be, of value are the British Standards Institution's PAS 100 and PAS 110 (technically these are Publically Available Specifications, not British Standards). In general, national standards can be valuable where international or regional (i.e. at country groups level) standards with appropriate scope have not been developed and/or where different countries cannot agree common criteria to set in the standard.

Qu 20. Are you aware of any past or current work on a national, regional or international level to implement biodegradability standards?

Is this question asking about developing and publishing biodegradability standards rather than about promoting awareness of them and their uptake? In answer to question 14 the REA has written about some of the certification bodies' schemes that assess and certify material/product conformity to relevant standards for home compostable items.

The BBIA answered as follows:

- 'CEN TC 261 Packaging developed between 1994 and 2000 the standards for organic recycling of packaging
- CEN TC 249 Plastics developed standards about bio-based plastics
- ISO TC 61 developed, starting from early 90s several standards on biodegradability
- ISO TC 122 Packaging developed standards on organic recycling of packaging'

Qu 21. To what extent, if at all, could biodegradability standards be beneficial for specific products (such as carrier bags) or product forms (for example those that with current technology are typically too contaminated to be mechanically recycled once disposed of)?

The REA's answer is the same as the BBIA's:
'BBIA believes that the standard should refer to the end of life of a product, not to the specific product's intrinsic level of biodegradability. This is because a product, when collected, will require an end of life treatment option. Products like carrier bags may not be collected separately or may be used for example for collecting food waste; in this case the product must be compatible with food waste treatment protocols for biodegradable packaging and in this case a standard already exists, the EN 13432. So the standard should refer to the final treatment option, not to the specific product [form or it's material type descriptor].'

Call for evidence's section 6 - Certification and Labelling

Qu 22. What standards, labelling, and/or certification schemes are currently in place to determine the level of bio-based content in bio-based plastics?

The REA's response is the same as the BBIA's:
'ISO16620-2015 (equivalent to ASTM D6866) sets out globally recognised methodologies for determining the Biobased content of materials. In the case of a product derived from mixed resources (fossil-fuel-derived and naturally-derived, the test methods allow the ratio of Bio-based to fossil-derived content to be determined).

The general principles are set out in ISO16620 part 1,[87] and the following parts of ISO16620 set out the methodologies that can be employed. BBIA fully endorses this standard.
We would point out that measurement of the Biobased carbon content provides a relatively easy measure of bio-based to fossil-based content, which can be carried out by expert laboratories at a relatively low cost to industry. This is therefore easily quantifiable and represents a viable test-method in practice. Further, the cost of testing is in the range of hundreds of pounds sterling, making it accessible to even SMEs.

However total biomass content is much more difficult to ascertain, with no simple laboratory test methods that we know of and much of the calculation therefore relies on the supply of accurate data on raw material content from the suppliers of each component of a finished article.'

Information about relevant certification schemes and their certification marks is provided in answer to question 23.

Qu 23. To what extent, if at all, should current labelling requirements be changed to produce new suitable standards?

The REA supports the BBIA's answer and makes further points afterwards:

BBIA: 'In the USA there is a formal USDA "Biopreferred" certification programme available based on the ISO16620/ASTM D6866 Biocarbon test method. Products can then carry a formal [certification mark] similar to the following:

We are not aware of a formally 'government-promoted' identification programme yet in Europe, but would very much endorse the creation of a similar scheme in the UK (and indeed in the EU). However there are 2 fully independent and widely recognised certification programmes already in existence that certify based on performance to the same test methods:

87 https://www.en-standard.eu/iso-16620-1-plastics-biobased-content-part-1-general-principles/

"DINCertco Biobased" - which is administered locally in the UK by the Renewable Energy Association Ltd (REAL) – provides a [certification mark that corresponds with the bio-based percentage range in which the tested material falls]. Example:

TUV Austria certifies to the OK Biobased programme: This operate in a similar way to the Dincertco scheme but awards a star rating according to Biobased % achieved. Example:

between 20 and 40% biobased	between 40 and 60% biobased	between 60 and 80% biobased	more than 80% biobased

,

REA's further points:

The relevant DIN Certco certification mark above is used when tests to determine bio-based content are the following ones: ASTM D6866, CEN/TS 16137 and/or ISO 16620 for determining <u>bio-based carbon content;</u> and EN 13039 or DIN 18128 for determining their <u>organic carbon content</u> (aka 'loss on ignition').

TUV Austria's website available information (at http://www.tuv-at.be/green-marks/certifications/ok-biobased/) is not explicit about which methodologies are used for determining bio-based content; information could be requested.

We believe that a consistent approach to testing/determining any item's bio-based content is necessary and if this can't be achieved by international agreements a consistent approach should at least be decided for bio-based items marketed in the UK; it seems likely that government or the British Standards Institution would need to lead on this. Such a consistent approach could be specified in a standard.

It is preferable that a single set of certification marks are used in connection with 'consistent approach tested' bio-based items marketed in the UK in future. One or more certification bodies may choose to provide assessment and certification services aligned to this consistent approach; each relevant certification body should be authorised to licence the use of the single set of certification marks on/in labels for the certified bio-based item (the used certification mark corresponding with its bio-based content level/range).

Please note the REA has suggested in answer to question 5's interest in ways of reducing consumer confusion that government explores whether certification of bio-based materials' and finished products' percentage of bio-based content is information that is best kept in the supply chain. If it is, then certification marking of certified products is relevant in documents that influence product development, specification and purchasing in the supply chain.

Qu 24. To what extent, if at all, should specific labelling rules apply to bio-based plastics to certify their proportion of bio content – either to better inform consumers or for any other reason?

Part of the REA's answer is the same as BBIA's:
'One of the major goals of emerging sustainability programmes for plastic materials (e.g. Ellen MacArthur Foundation 'New Plastics Economy' and the 'UK Plastics Pact') is to decouple the manufacture of plastics from the use of finite resources. From a government, business and consumer point of view, the start-point needs to be to understand the current level of use of finite resources versus bio-derived sources and hence [use of consistently the same test methods] and an equally effective labelling programme [including certification marking] is essential.'

REA's view is that to make and track progress away from use of finite resources we need at least a UK-consistent approach to testing/determining the bio-based content of items plus a system that receives and collates those results.

Qu 25. What evidence, if any, is available on the impacts that biodegradability certification and labelling systems may have on consumers' behaviour towards the disposal of items carrying such labels?

Note: The questions in Section 6 are mixing 'biobased content certification' and 'biodegradability certification' which is potentially confusing because bio-based content is a different from biodegradable content and the tests used are very different.

The subject of certification schemes is covered elsewhere in our answers to this the call for evidence. Consumers are faced with a confusing plethora of green claims, logos and certification marks, and in recent years there have certainly been products on the market which have been claimed to be compostable and/or biodegradable yet it is difficult to identify or track down the product supplier/marketing company to try to verify claims.

Some of the claims we checked in the past (before the Association for Organics Recycling merged with the REA) revealed that the relevant companies had;

a) not had their product tested for compostability,
b) had their product tested for compostability but only some of the required tests had been done,
c) had a sample of material tested for compostability but the sampled material did not match the final product they were marketing [this was quite common and such mistakes are not likely to have ceased],
d) obtained independent certification of conformance to a suitable compostability standard but the certificate had lapsed,
e) claimed that a laboratory test report showing a test sample's conformance to compostability criteria set in EN 13432 was proof of independent certification because the lab report title included 'Certificate of testing' [independent laboratories are not the same as independent certification bodies], or
f) claimed their product to be biodegradable but did not provide evidence that it conformed to a standard that set pass/fail criteria relevant to the end-of-life open and/or human influenced/controlled environments in which the product was intended to biodegrade.

Regarding point f), during our days as the Association for Organics Recycling we received enquiries from industrial composting members about carrier bags (some of which were printed with the word 'biodegradable') which they received at their sites. They were resistant to composting conditions, fragmented into smaller but still readily visible pieces and were **FAR** from being adequately biodegraded by the end of the composting processes. At least some of those carrier bags seemed to be oxo-biodegradable ones and during that period a number of companies were actively marketing oxo-biodegradable plastics and we received enquiries from some organisations in packaging supply chains and packaging specifiers about oxo-biodegradable plastics. This period of enquiries largely preceded August 2011 when Tesco stopped providing oxo-biodegradable bags in its stores[88].

The UK composting industry's experience of receiving unsolicited oxo-biodegradable carrier bags and their lack of adequate biodegradation in those composting process is a good example of consumers not understanding claims on/about products and incorrectly putting them into their bins for separately collected biodegradable wastes.

In connection with this experience we also draw attention to Loughborough University's study supported and published by Defra[89] and quote the following excerpts from its key findings:

- 'The overall conclusion of this review is that incorporation of additives into petroleum based plastics that cause those plastics to undergo accelerated degradation does not improve their environmental impact and potentially gives rise to certain negative effects.'
- 'Oxo-degradable plastics are not compostable, according to established international standards EN13432 and ASTM 6400. Oxo-degradable plastics should not be included in waste going for composting, because the plastic fragments remaining after the composting process might adversely affect the quality and saleability of the compost.'
- 'It is thought that labelling the oxo-degradable plastics as biodegradable can lead to confusion on the part of consumers, who may assume that 'biodegradable plastics' are compostable. This may lead to contamination of the composting waste stream with oxo-degradable plastics.
- 'The fact that the term — biodegradable can be applied to materials with extremely widely differing rates of biodegradation demonstrates that the term is virtually meaningless unless the rates of biodegradation and conditions under which it is measured are specified, preferably with reference to a widely recognised standard.'

Government should put rules in place which require that any intermediate material or finished product (packaging or non-packaging, plastic or non-plastic) - unless it consists only of defined natural material(s) - is **only** allowed to be labelled and marketed as biodegradable if it is independently certified compliant with a standard accepted by the relevant environment protection regulator(s). Such a standard must set pass/fail criteria for its adequate disintegration and biodegradation, no or acceptably low ecotoxicity effects and heavy metal/potentially toxic substances content, and any other criteria necessary for its safe presence in the end-of-life-environment(s) it is intended to enter into. Further, any claim of

[88] See https://www.packagingnews.co.uk/news/tesco-drops-oxo-biodegradable-bags-17-08-2011

[89] EV0422, Assessing the Environmental Impacts of Oxo-degradable Plastics Across Their Life Cycle Loughborough University, A research report completed for the Department for Environment, Food and Rural Affairs, January 2010 (see http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=16263)

biodegradability must include in labelling and in any related documentation reference to the end-of-life environment(s) in which it is intended to 'end its life'.

What we have described in the preceding paragraph is the model that is used for industrially and home compostable items, albeit that environment protection regulator policy on the need for independent certification in the context of composting and 'digestion then composting' which produces waste status compost / composted digestate seems unclear. BS EN13432, BS EN 14995 or ASTM D6400 are the within-UK recognised standards which set pass/fail criteria for industrially (municipally) compostable items and independent organisations assess and certify tested items' conformance with these standards.

The situation regarding environment protection regulator acceptance of standards that set pass/fail criteria for <u>home compostable</u> items is challenging to summarise (so we have not summarised it here) but there are products on the UK market and in use that are independently certified compliant with TūV Austria's 'OK Compost Home' certification scheme criteria and perhaps also others independently certified compliant with TUV Rheinland's (DIN Certco's) home compostable certification schemes aligned to the French standard NF T51-800 and the Australian standard AS 5810.

In addition, as per part of the BBIA's answer to this question:

a) '**A single recognisable certification marking system should be employed** [for compostable items, which appropriately covers home compostable ones and industrially compostable ones]*. This will provide a number of key advantages:
   a. Easy identification and therefore separation and sorting of certified compostable packaging from conventional plastic packaging, by both consumers and waste collection operators.
   b. Facilitate an 'effective' policing of the claims made on pack [and in documents about the certified product]. This can be further enhanced by demanding a certified product reference number be placed by the certification mark. (Indeed this is already standard-practice by the BS EN13432 certifying bodies).
   c. Helps to eliminate companies who and/or products that carry dubious or false green claims.'

* REA's linked point**: each relevant certification body should be authorised to licence the use of the certification marks on/in the label for the certified item**.

BBIA: 'In the early 2000's pilot programmes such as the so-called 'Kassel project' in Germany were used to measure the effectiveness of an identification scheme and to demonstrate how it aided consumers to identify compostable packaging from conventional packaging even if the physical appearance of the packaging was very similar. The Kassel project demonstrated very high levels of consumer awareness, following in-store promotions of the concept. It also highlighted this minimised 'misthrows' by consumers. Moreover it demonstrated that a high proportion of consumers preferred to purchase packs that carried the [certification mark] versus packs that did not.

Given Defra's publicly declared intentions, by end 2023 separate food waste collection will have been rolled-out across England, substantially adding to the amount of food waste separately collected and composted or digested in the UK. It is also possible that separate garden waste collections will increase in England by 2023. This provides the practical vehicle to ensure that suitable compostable packaging can be collected [, biodegraded] and revalorised [e.g. contribute to biomass in compost and composted digestate] via the organic waste recovery schemes in the UK.

Ideally the certification mark on pack should also be licenced for use on the food waste collection 'caddies'[/bins*] to make identification as easy as possible for both consumers and waste collectors/processors accordingly.'

* REA's linked point: Labels on caddies/bins could include something like: 'Items that carry the compostable certification mark shown on this label can be put in this bin/caddie.' Some consideration of how home- and industrially-compostable items would be directed towards industrial scale composting, how home compostable items would be directed towards home composting heaps/installations and what's written in End of Waste rules for waste-derived composts and digestates will be needed.

Call for evidence's section 7 - Impacts on Waste Processing

Qu 26. What, if any, evidence is available to demonstrate the impact that biodegradable (including compostable) plastics have in the current waste management system, including on the quality and safety of composts and digestates? Does the existing evidence allow to estimate the monetary value of this impact?

Clear and specific evidence on the impacts of 'biodegradable but not compostable plastics' and 'biodegradable and compostable plastics' seems scarce. The REA sent specific questions interpreting the call for evidence's questions 26 to 30 to a selection of its composting and AD members. We have used information from one of the few responses to provide the following, anonymised case study.

Case Study

Operator A manages a wet-AD system which digests food wastes which receives liquid and solid biodegradable wastes suitable for low-solids anaerobic digestion. Food waste deliveries total 23,000 tonnes per annum, approximately 30 % from commercial sources and 70 % from local authority sources; packaging that wraps these food wastes is included in that total tonnage figure.

The majority of packaging from LA source food wastes is compostable caddy liners* and where bin users have used something else it tends to be polyethene bags. Packaging from commercial sources includes cartons, cardboard and polyethylene bags. This operator has not quantified how much of the total packaging is compostable plastic and how much is non-compostable plastic but says the 'bulk' of packaging from municipal sources is compostable caddy liners.

* Under the current EPR system liners are not classified as packaging but when organics recyclers communicate about packaging the product forms/formats they have in mind tend to include bin/caddie liners.

All of the food wastes are depackaged by being fed through a machine which shreds and depackages the waste (max 12 mm particle size, £150,000 per annum operating cost). This machine undertakes two necessary functions; shredding the food waste so that it's pumpable and depackaging. The operator believes it would be fair to attribute a half of these costs to the depackaging element; £75,000 per year.

Screened food waste soup is then sent on to the buffer then digester tanks.

Photo 1. Example of municipal food waste received

Photo 2. Example of commercial food waste received

The larger than 12 mm packaging from the shredder is fed through a drum washer (£20,000 per annum operating cost). Washing removes food waste that had stuck to the packaging. Washings are fed into the buffer tank then digester tanks.

The washed packaging is put through a screw press, with the pressed liquid sent to the buffer tank and digester tanks, and the plastics sent to the rejects bay and on to disposal at landfill. The screw press costs the company circa £15,000 per annum to operate.

The operator estimates that the total 1,689 tonnes of washed and screw pressed packaging is approximately 25 % less than it would be if washing was not carried out, i.e. approx 422 tonnes of food waste is washed off the packaging.

Photo 3. Removed packaging before washing

Photo 4. Removed packaging after washing before being pressed

The 1,689 tonnes of washed and screw pressed packaging is obtained from 23,000 delivered tonnes of bagged/liner-contained food waste, representing 7.3 % of those inputs. This removed, processed packaging is sent to landfill at a cost of circa £130 / tonne including haulage (£120/t excluding haulage), so £219,570 for 1,689 tonnes.

Using the figures above, **this facility's total annual cost** for removing (£75,000), washing and pressing (£35,000), and transporting and paying gate fees for landfill disposal (£219,570) of **unsuitable-to-digest packaging is £329,570**! This waste represents just 7.3 % of the 23,000 tonnes of food waste delivered to this facility per annum. Each tonne of unsuitable-to-digest packaging and the organic waste was stuck to it (1,689 + 422 tonnes = 2111) costs £156 to remove, wash, press, transport and pay for its disposal.

Operator A produces whole digestate which is certified by Renewable Energy Assurance Ltd under its Biofertiliser certification scheme. Certified waste-derived digestates are allowed to be supplied to specific end-use markets and stored and used in those markets without being subject to waste regulatory controls.

The operator's comments about compostable bags/liners were as follows: 'The compostable packaging absorbs moisture making it more difficult to separate from the food waste and more weight to dispose of' and it 'does not degrade within the AD process'.

This operator also tried composting the AD facility's shredder-removed packaging material but although the compostable pieces biodegraded, the non-compostable pieces did not and needed to be removed at the compost particle size screening/sieving stage. This operator said '<u>**If 100% compostable packaging was used then this would not be an issue and reduce costs significantly**</u>.'

REA comment: The operator means is that if all the food waste for anaerobic digestion were to arrive in compostable packaging it could be removed and then composted and that would significantly reduce the costs of dealing with the currently unsuitable-to-digest packaging. This is a subject we intend to discuss with more of our AD operator members.

- End of case study –

The REA has not spent time investigating the extent to which separately manageable food waste streams/sources - in which a very high proportion of the packaging and non-packaging items are compostable, including those that would be regarded as compostable plastic - are being composted. However we are aware that Vegware (a supplier of compostable packaging and non-packaging products for containing food and drink products and bags/liners for wrapping/containing food wastes) is trail-blazing on this front.

At the BBIA's event 'The future of compostables in packaging' on 19th June 2019 a presentation by Vegware included the following:

- **'27 UK organics facilities accept Vegware** [compostable packaging]
    - 22 in-vessel composting
    - 3 open windrow composting
    - 2 equipped wet-AD'*
    - **'9 of these 27 process Vegware on a regular basis,** driven by client demand in certain regions'

- **'Products accepted at these facilities**
    - 23 - all Vegware products
    - 3 - drinks waste only**
    - 1 - fibre-based Vegware only (PLA linings fine, but not 100% PLA)
- **Trials**
    - Successful trials at 17 facilities
    - 5 more trials underway (3 IVC, 2 OAW)
    - REA ORG monitored largest trial'

* REA comment: One of the wet-AD facilities separates packaging from food wastes and feeds it into their separate on-site, in-vessel composting process. The other wet-AD facility's process steps include an autoclave (high-pressure, high temperature) machine - apart from pasteurising wastes for animal by-products regulation compliance purposes – helps to hydrolyse and start the break down of the compostable packaging, such that it biodegrades during the digestion phases and contributes to biogas yield.

** This might mean waste packaging formats designed for containing drinks, such as cups for holding hot drinks, cups for holding cold drinks and cup lids (see http://www.organics-recycling.org.uk/page.php?article=3466 for more information about what's allowed to be fed into composting systems that don't have APHA approval for treating animal by-products).

We next quote part of the BBIA's response to question 26:

'REA ORG monitored a composting trial of 1.3 tonnes of used Vegware disposables conducted at Biogen's IVC, with REA's Technical Director Jeremy Jacobs concluding in the trial report[90] that, "this trial provides robust evidence to demonstrate that under normal commercial conditions certified material does degrade successfully".'

<u>Other evidence on contaminant plastic types that wrap/contain separately collected biodegradable wastes and which can be found inside them</u>

The REA has looked for evidence on contaminant plastic types in biodegradable wastes that are separately collected for composting or anaerobic digestion. In our view contaminant plastic types are those which are not biodegradable (e.g. polyethylene) <u>and</u> others which are claimed to be biodegradable but are not compostable (e.g. oxo-biodegradable plastics).

The autumn 2019 edition of the REA's Organics Recycling magazine included an article which highlighted findings from a SEPA funded survey which is due to be published soon. This survey included analysis of household food waste collected in 7 local authority areas; in 6 of these the food waste was 'wholly or predominantly presented in compostable caddy liners' (the liners were either provided by the LA or sourced by householders) and in the 7th area compostable liner use was 'low' (householders were not provided with compostable liners).

Plastic contamination within liners/bags was found to be 1.3 to < 0.1 % w/w on a fresh matter basis. These 'inside bags/liners' plastic contamination concentration figures may or may not be representative of what would be found in other local authorities' food waste collection areas in other countries of the UK.

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[90] REA ORG Biogen IVC composting trial of 1.3 tonnes of Vegware disposables http://www.organics-recycling.org.uk/uploads/article3509/Vegware%20packaging%20trials%20at%20Biogen's%20Tempsford%20IVC-final.pdf

We do not yet know whether the study also quantified and reported the weights of the liners/bags, what percentages they represented in the total* of the collected waste (*food, plastic contamination plus liner/bag) both on a fresh matter and a dry matter basis, and whether separate figures for compostable and non-compostable liners were obtained in each local authority area studied. The study also quantified plastic contamination in food wastes from commercial sources but the figures weren't included in the magazine article.

In this call for evidence the REA wanted to provide an updated version of our May 2019 calculations on '*Costs of dealing with plastics that arrive at organics recycling facilities*' (see below). However, the SEPA funded survey's figures included in our magazine article don't also include the percentage in fresh matter figures for the areas where compostable liners were wholly or predominantly used' nor for the area where most liners used where non-compostable. The operator who provided information for the case study above did not separately quantify and report the amounts of a) compostable bag/liners, b) non-compostable bags/liners and c) types and quantity of plastics within each of the types of bags/liners. Our May 2019 calculation was as follows:

'Costs of dealing with plastics that arrive at organics recycling facilities

Based on information the REA has gained from members and from surveys of the UK organics recycling industry, the concentration of <u>non-compostable plastics</u> in biodegradable wastes delivered for organic recycling / recovery is, conservatively, 1 % weight for weight [on a fresh matter basis].

Input tonnages to composting facilities totalled 5.92 million tonnes in the year 2014 and 'waste-fed' AD facilities reported treating 3.84 million tonnes that same year (see http://www.wrap.org.uk/sites/files/wrap/asori%202015.pdf). Assuming 80 % of those 9.76 million tonnes of waste contained, on average, 1 % w/w plastic, the UK organics recycling sector incurs an annual cost of **£7.26 million** (excl VAT) for removing approx. **78,080 tonnes of plastic** and sending it for recovery at Energy from Waste facilities. This is a very conservative estimate which does not include all costs incurred by the organics recycling sector for dealing with non-compostable plastics.

Assumptions made in the calculation and exclusions;

a) extraction of 1 tonne of plastic waste costs approximately £10 / tonne of waste received at the organics treatment facility,
b) the cost of washing organic waste off the extracted plastic and managing the used wash water is excluded, or alternatively the extracted plastic is not washed and the value of the organic waste that sticks to it is lost at the organics treatment facility, [or the extracted plastic is dried before sending to other treatment/disposal and the cost of drying is excluded] and the extracted plastic waste is sent to Energy from Waste facilities that charge a median gate fee of £83 / tonne excluding VAT {in reality an unknown percentage of the extracted plastic waste goes to landfill (median gate fee of £107 / tonne incl landfill tax) instead of EfW; REA's perception is that the proportion of extracted plastic waste that goes to landfill is lower than the proportion that goes to EfW facilities}.

Excluded from the calculation;

a) the costs of transporting the extracted plastic waste from the organics treatment facility to the EfW facility, and
b) the costs of managing plastics at concentrations above 1 % w/w in wastes delivered to those AD facilities that accept at least some of their organic waste - usually separately collected food waste - bagged in non-compostable plastic (some of them have estimated that plastic is approx. 10 % w/w in waste delivered for treatment).'

We made an assumption that 80 % of those 9.76 million tonnes of waste contained, on average, 1 % w/w plastic on a fresh matter basis; 80 % may have been too high but it seems likely that the 1 % non-compostable plastic is much too low a figure for sources where users of caddies/bins for biodegradable wastes use non-compostable bags/liners.

The REA supports the following part of the BBIA's response to question 26:
'Given the exclusions quoted [above] it would not be an exaggeration to say that **the organics system managing food/garden waste is bearing a cost of circa *£10 million annually* from having to handle plastic contamination**. No compensation or even recognition is given to the organic recycling plants for having to handle and dispose of what is effectively the equivalent to 20% of all the plastic packaging sent to recovery in the UK. See figure 3.

As food waste collections in particular are destined to grow considerably (two or three times current levels) we could assume that in a future time, if the contamination levels remain unvaried, the cost to food waste treatment facilities of handling plastic contamination could rise to £20 or £30 million annually.

Figure 3: Plastic Packaging Waste Treatment in the UK 2016 – 2018

THE UK PLASTICS PACKAGING TREATMENT DATA	(1000 Metric Tonnes)		
	2016	**2017**	**2018 - From UK HMRC Govt Data**
Plastic Packaging Waste Arisings	2,260	2,350	2,444
Net Plastic Waste Exported Outside of EU (Net of Imports)	647	520	437
Plastic Waste Reprocessed in UK	331	358	343 (14%)
Total %: Exported & Reprocessed ("Recycled")	**43.3%**	**37.4%**	**31.9%**
Net Plastic Waste Dispatched to EU	59	55	89
Total %: Exported, Dispatched & Reprocessed ("Recycled")	**45.9%**	**39.7%**	**35.6%**
Plastic Waste Not Recovered	1,223	1,417	1,575
% Plastic Waste Not Recovered	**54.1%**	**60.3%**	**64.4%**

'

About effects of compostable and non-compostable plastics on compost and digestate quality

Here the REA quotes part of the BBIA's response to question 26:
'We also do have data from Italy where food waste collections have been established in the central and northern regions for 15 years and more and since 2010 there has been a national obligation to use compostable bags for food waste collection. In April 2018 a compost

association conference including Italians, Austrians, Swiss and Germans[91] presented data on the contamination of food waste collections by plastics.

Whereas the Italian system on average has reduced overall contamination to 3.1% from non compostable plastics, the data from the other associations (where compostable plastics are not used for collections) showed that some 26.7% of final compost samples and 50% of final digestate samples in Switzerland did not reach the standard for elimination of plastics; whilst in Germany the figures were 8.7% and 10.8% respectively. (The data are not fully comparable due to different standards being applied). The lesson learnt is that where compostable plastics are used for collections, contamination of food waste and its outputs (compost and digestate) falls.'

REA's further comments:

Compost test methods for quantifying and reporting physical contaminants include plastics as a specific sub-category but they do not differentiate between compostable and non-compostable plastics. To the best of our knowledge this is the case with test methods used by other countries as well as the UK. In Germany a test method is used which also quantifies and reports the total surface area of flexible plastics found within the tested sample but it does not differentiate between compostable and non-compostable plastics.

The REA has responded to some social media account users' posts where they have been dissatisfied with the quality of compost they have received due to physical contaminants in it, particularly plastics. We have encouraged users to provide feedback to the compost supplier and if it was a compost certified by the Renewable Energy Assurance Ltd (REAL) that they can complain about it if they wish to do so. We do not have a compilation of those posts and one we have sought to include in this response is no longer published by the relevant account user.

REAL publishes summaries of investigated complaints about composts made by composting processes it has certified (see http://www.qualitycompost.org.uk/product-complaints/guidance). The relevant composting processes and composts are anonymised and product investigation reports can be downloaded from this webpage. Some of the complaints were about plastics in the composts; we have not checked and summarised for this response which of the relevant complaints were upheld.

REAL's Biofertiliser Certification Scheme assesses and certifies digestates. Investigations carried out by the 'REAL BCS Certification Bodies' have investigated 'complaints made against BCS producers/products', anonymised summaries and investigation reports are not available at http://www.biofertiliser.org.uk/product-complaints/guidance

The Environment Agency and Scottish Environment Protection Agency have also spoken in general to the REA and some other stakeholders about complaints they have received about compost and digestate quality; some of them have been about plastics in the compost/digestate and it hasn't been clear how many of the complaints were about composts/digestates that weren't from a REAL certified sources.

[91] https://www.polimerica.it/articolo.asp?id=19763

Qu 27. What, if any, evidence is available on the behaviour of bio-based plastics compared to conventional fossil-based plastics in the current waste management system?

The REA's answer is the same as the BBIA's, with a few amendments shown in blue coloured font:

'There are three types of bio-based plastics used for packaging but we will focus upon two categories for simplicity: bio-based but not compostable, and bio-based and compostable. The first type acts in a similar way to traditional fossil-fuel based plastics and is known as a "drop-in". The most well-known article sold using a bio-based non compostable plastic for packaging is the Coca Cola Green PET bottle produced predominantly from raw materials derived from sugar cane in Brazil and whose properties are (for waste management purposes) identical to other PET products. These can be recycled through mechanical or in the future when available, chemical recycling but not through organic recycling. Their loss into the environment has exactly the same consequences of any fossil fuel plastic without biodegradation qualities.

Here is an image from the Coca Cola bottle with its plant-based logo.

The second type of bio-based plastic used for packaging is compostable. These materials are certified (as above, answers in Chapter 6) to the standard in the UK known as the ENBSI13432:2000 and have the characteristic of compostability in industrial composting plants where they decompose in a timeframe up to 180 days. Most films will decompose in a time frame of 20 to 40 days whilst thicker materials take longer.

Materials certified "Home Compostable" (as above Chapter 6) will also compost in industrial facilities but are designed to compost in a well-managed home composting unit. The decomposition time can vary anywhere between several months and a year.

From this we can understand that to ensure the correct treatment path for compostable plastics these need to be delivered to composting facilities or excluded from the waste management system upstream by being composted at home.

It is evident that in the current waste management system available in England sorting of materials (of various nature) is difficult and there are high levels of contamination between streams and falling levels of recycling. This applies to compostable materials too.

However there are clear signals that the commercial waste management sector is waking up to the opportunity offered by compostable plastics, organising collection where these are available in sufficient volumes in closed environments. The companies Vegware, Keenan's, Forge Recycling, Paper Round and First Mile[92] have all introduced the separate collection of

[92] https://thefirstmile.co.uk/service/compostables-recycling

compostables where these are available in volumes, such as in offices, cafes, sites, events, buildings, where the stream can be controlled. The Parliamentary Estate[93] has adopted the use of compostable tableware and cups; during the transition from two to three waste streams, the compostables bin was contaminated and the first load was not of sufficient quality to be composted. Behaviour change activities proved successful and the second load has been sent to an industrial composting facility.

According to Vegware,[94] today some 40% of UK post codes have access to a trade collection of Vegware compostables where these derive from closed environments using them for catering.

Where [specific forms/formats of] compostables are used for drinks only, and only contain milk or cream residues, they may be composted in open windrow composting plants under conditions published in August 2018[95] and approved by the Animal and Plant Health Agency (APHA), Environment Agency and Scottish Environment Protection Agency.

- hot and cold drinks cups*,
- lids for hot and cold drinks cups*,
- drinks cup clutches / holders / sleeves*,
- drinks stirrers that consist of only untreated wood without any additives,
- drinks stirrers made of other compostable materials and/or include an additive*,
- straws*,
- coffee pods / capsules*,
- used coffee grounds,
- used loose leaf tea, and
- used tea in tea bags*,

Where identified with an asterisk the products must show a certification of compostability, as described in Chapter 6.

Other compostable products used for food packaging and potentially contaminated with foodstuffs fall under the Animal By-Products Regulation and require composting in a facility that is approved for treating ABP materials. There are 53 industrial composting facilities in the UK with such a license.[96]

Currently these collection programmes regard the recovery of materials used for catering in business environments. Household collections of compostable packaging and materials are virtually inexistent throughout the UK. Consumers are likely to encounter and purchase compostable materials used as food packaging - primarily films but also yoghurt pots and other rigid products such as trays made from PLA, coffee pods, tea bags, candy bar wrappers etc. Whilst these may be home compostable in certain cases, the more rigid, thicker materials require industrial composting to break them down. (In the same way a tree trunk is biodegradable, it requires years to effectively decompose, whilst a leaf, identical in biological terms, will decompose in weeks or days. So thicker, more rigid compostables require industrial processes to decompose.)

[93] https://www.parliament.uk/mps-lords-and-offices/offices/commons/media-relations-group/news/uk-parliament-to-dramatically-reduce-plastic-use-through-new-compostable-products-/
[94] https://www.vegware.com/news/2019/04/10/uk-regions-with-tradecompostingcollections-for-vegwareclients/
[95] https://www.letsrecycle.com/news/latest-news/compostable-cups-green-light-composting/
[96] https://www.gov.uk/government/publications/animal-by-product-operating-plants-approved-premises

It is unlikely at present that many of these are separately collected and sent to industrial composting but, like 65% of conventional plastics, are disposed of in landfills or incinerators (see Figure 2) in the UK.

One exception to this is the collection of food and garden waste with compostable bags or liners. These are widely accepted and used to bring organic material to composting plants throughout the UK and used to bring some organic material to some AD plants. Further, where retailers sell or supply compostable carrier bags with the purpose of using them also as bin liners for food waste collection, these bags are widely accepted as carriers for food waste in treatment facilities (but we believe many of the wet-AD facilities that receive such wastes remove the carrier bags rather than digest them and do not know how many of them do or could send them for composting in facilities that have approval for treating Animal By-Products). The COOP Food Group has been especially progressive in this sense, supplying compostable carrier bags as a dual use bag in more than 1,000 stores[97], mainly located in areas where the food waste is sent for composting.

The well-known case of Oldham in Lancashire demonstrates how the use of compostable carrier bags for food waste collections drives up participation rates among the public and reduces costs for the Council. A Council with a population of circa 230,000 people was able to demonstrate savings to the Council budget of £282,029 in avoided disposal costs and an increase in participation in food waste collections from 19% of the population to 96% (year of reference 2014/2015).[98]

Retailers are slowly introducing compostable bags for the collection of fruit and vegetables, such as Waitrose and Aldi and we are expecting others to follow shortly. These may also be used to collect food waste and deliver that to [waste] treatment facilities.

One footnote regarding disposal of compostable plastics that are not recovered in organic recycling but conversely are incinerated. In terms of end of life, PLA manufacturer NatureWorks conducted incineration testing at the optimum incineration temperature of approximately 1100°C (2000°F). The heat content of NatureWorks' PLA was determined to be 8,368 Btu/lb, which is higher than newspaper, wood, corrugated boxes, average MSW, garden waste or food waste). Further analysis showed no volatile gases and low residue, representing a significant advantage over oil-based plastics in incineration[99].'

Qu 28. How, if at all, would waste collection systems need to be adapted to accommodate the *niche* introduction of biodegradable plastics?

Plastics biodegradable in soil

Agricultural/horticultural mulch films are designed to biodegrade in soil after use (and comply with European standard EN 17033); these products after they have been used should not be entering waste collection systems. We expect that other plastic products designed to be used on or in soils should stay in that environment so not be put into waste collection systems.

[97] https://www.co-operative.coop/media/news-releases/shoppers-can-bag-compostable-carriers-at-co-op-as-retailer-ditches-single

[98] http://www.wrap.org.uk/sites/files/wrap/Oldham_Council_carrier_bag_case_study_Dec_2014.pdf.

[99] See page 765 for a table of results for VOCs from incinerating various plastic wastes: https://www.researchgate.net/publication/264141843_Analysis_of_VOCs_Produced_from_Incineration_of_Plastic_Wastes_Using_a_Small-_Electric_Furnace

Plastics which aren't compostable but claimed to be biodegradable

The REA does not support the production, marketing and use of biodegradable plastics which do not conform to a standard which sets pass/fail criteria appropriate to the end-of-life open and/or human influenced/controlled environment(s) in which that plastic is intended to biodegrade.

In addition we do not support the littering of any kind of plastic in any open and/or human influenced/controlled environment(s). The majority of any specific type of plastic in use should reach the end-of-life environment it was designed for and along its pathway to this environment it should not contaminate other resource streams, waste streams or environments.

Compostable plastics

Compostable plastic bags (including reused carrier bags) and liners used for wrapping/containing food wastes are in use where this waste stream is collected for composting. Such collections by or on behalf of local authorities tend to be area-specific but food wastes in compostable bags/liners are collected from a variety of business sources and locations by companies who provide food waste collection services and then find suitable composting and/or AD facilities to take them to. Commercial/business sector food wastes are managed seem to be managed in a much less area-specific manner.

Some local authority collections of garden waste are in compostable plastic sacks/bags but we not know what proportion of the bags/sacks are compostable plastics and which are compostable paper/processed wood fibre based bags/sacks.

Compostable plastics in formats which aren't bags/liners/sacks are also accepted with food waste by some composters. Acceptance is subject to that waste stream being from sources where education of bin users and collection arrangements results negligible non-compostable material. For example, Vegware has made notable progress with it's closed-loop arrangements for the in-vessel composting of (mainly) business source food wastes which contain compostable packaging and non-packaging items, including compostable plastics such as cup lids (see our answer to question 26 for more details).

Other in-use applications in the UK include compostable magazine wrappers (their second use is containing/wrapping food waste), cups for cold drinks, lining material for cups for hot drinks, cup lids, windows on paper/board based sandwich skillets, sweet wrappers, coffee pods and tea bags.

Considering the **collection and composting of compostable plastics which are formats other than bags/liners/sacks/magazine wrap**, this is already happening as a niche activity in connection with food wastes from business sources (example being Vegware and there are other companies doing similar). They are mainly being collected with food waste but some, subject to fulfilling rules published at http://www.organics-recycling.org.uk/page.php?article=3466, are collected without food waste and sent to composting facilities which do not have approval for treating animal by-products, e.g. open air, turned windrow composting facilities.

Given these already occurring activities and substantial efforts in the packaging design, manufacture and supply chain to make changes such that increase percentages of packaging are recycled – through solutions which separately work for mechanical recycling, chemical recycling and organic recycling (e.g. through composting and suitable AD facilities) – the REA suggests the following changes which would support the organic recycling of compostable plastic (and non-plastic) packaging (and non-packaging) items:

1. inclusion of certified compostable plastic and non-plastic packaging and non-packaging items as minimum service standard core materials to be collected with food wastes or food plus garden waste <u>where</u> those wastes are contracted to be, or under local authority management are, biodegraded in a facility suitable for managing those wastes*' **;

2. easy and trustable identification of compostable plastics (by bearing an independent certification body's certification mark;

3. where the product form is a bag, liner or magazine wrap intended for (further) use to wrap/contain biodegradable waste it has a <u>***readily-visible-at-distance***</u> appearance [e.g. a unique colour and/or pattern] so that waste collection crews and biowaste facility operators can quickly and easily identify non-compostable bags/liners that wrap wastes and either reject them and the wastes they contain [sometimes they're black bin bags full of non-biodegradable wastes] or reject a section of or all of a delivered load if many non-compostable bags/liners are present);

4. clear labelling of compostable plastics which include instruction to;
   a. check local acceptance in the food / food and garden / garden waste bin (reference to clear local authority instructions would be key*) and if accepted, place them in;
      i. the food waste bin (where such a collection is provided), or
      ii. the food and garden waste bin (where those wastes are collected co-mingled), or
      iii. the garden waste bin (where the compostable plastic product type and type of food/drink it contained is suitable {see http://www.organics-recycling.org.uk/page.php?article=3466} and a brief version of the specific provisions of this position could be included in LA info for householders);

5. clear and up to date local authority guidance and instructions for householders which covers how to identify compostable plastics and, reflecting their biowaste treatment service contractor's policy / contractors' polices on which bin they should be put in;

6. substantial education of householders, waste collection crews, waste transfer station staff and biowaste treatment facility staff such that;
   a. compostable plastics are recognised, put in the correct bin ('food only' bin, 'food+garden' bin or 'garden only' bin), fed through the waste collection supply chain and accepted at biowaste treatment facilities (rather than being rejected because contamination by non-compostable plastics is too high),
   b. dry-recyclable, non-compostable plastics are recognised and put in bins for dry-recyclable plastics,
   c. plastics which are not dry-recyclable and not compostable are recognised and put in general/residual waste bins; and

7. waste collection contracts and practices amongst waste collection crew that result in the lifting of biodegradable waste bin lids to check for visible-from-the-top contamination (incl non-compostable bags/liners used), add-to-bin labels to inform householders when their biodegradable waste bin/bins include visible contaminants at a level which renders it fit only for emptying into the general/residual waste collection,

and stickers on food waste bins that show compostable certification marks (so householders can easily visually match them with one or more certification marks on certified compostable products).

* Suitable facilities are those with appropriate permits in place and with approval for treating animal by-products which carry out:

a) non ABPR-approved composting where the compostable packaging/non-packaging waste complies with the rules published at http://www.organics-recycling.org.uk/page.php?article=3466, and
b) ABPR-approved
    i. enclosed / in-vessel composting,
    ii. 'dry' (high solids) anaerobic digestion with a following composting phase,
    iii. 'wet' (low solids' anaerobic digestion with a following composting phase for the dewatered, digested solids,
    iv. dry- or wet-AD integrated with a composting process that has the necessary authorisations to mix 'fresh', solid biodegradable waste in with dewatered, digested solids at the beginning of their composting phase(s), and
    v. dry- or wet-AD where the treatment process includes one or more steps that ensure biodegradation of certified compostable items (e.g. use an autoclave prior to digestion).

** This would give the appropriate local authorities access to funding for collecting certified compostable plastic and non-plastic items with suitable biodegradable wastes and for the compostables' tonnage to be included, with the tonnages of suitable biodegradable wastes in the national waste data reporting systems).

Benefits of making the above suggested changes include:

a) reduction of biodegradable waste contamination by non-compostable plastics,
b) lower costs of removing, treating (where cost-beneficial) and sending non-compostable plastics to EfW or landfill,
c) lower risk that some batches compost/digestate output fail to achieve sufficient quality due to plastics content, and
d) the majority of compostable plastic and non-plastic packaging and non-packaging items continuing to go into suitable biodegradable waste treatment facilities instead of into the parts of waste collection and treatment systems that collect, transport and sort dry-/mechanically-/chemically-recyclable plastics and other non-plastics (e.g. cans, metal, glass, paper, cardboard).

Step-wise phase in of compostable items

Having talked with a large waste management company involved in multiple aspects of wastes management, they believe that the householder (and wider bin user) education job ahead of us is so large that compostable plastics applications should first focus on compostable liners, sacks, carrier bags and magazine wrap (re-)used specifically for containing/wrapping food waste / food+garden / garden waste and compostable tea bags (which aren't put into the dry recyclables stream). (To the best of the REA's knowledge the majority of compostable bags, liners and sacks are being fed into composting processes. We do know from REA composting members' feedback that contamination by non-compostable bags, liners, sacks and other discarded plastic product forms is problematic and very expensive to manage – see our answer to question 26 for more info.)

After bin users have become good at using compostable liners, sacks and re-used carrier bags and magazine wraps to wrap/contain their food waste/food+garden waste/garden waste (taking account of their biowaste treatment contractor's policy), compostable plastics applications could then - subject to agreement between stakeholders which include the composting and AD industries - be broadened in a step-wise manner to include others on the following list which was first proposed by the BBIA and on which the REA commented in its response to Defra's consultation on reforming the UK packaging producer responsibility system:

'1. Applications which always accompany a material whose only recycling route is organics recycling (composting), and frequently cause contamination and cannot be recycled if made from plastic:

a) tea bags and coffee pads [not currently packaging]
b) sticky labels on fruit/vegetables
c) food preparation disposable gloves [not currently packaging]
d) plastic coffee pods

2. Applications where inevitable bio contamination and/or mixed-material construction renders conventional packaging unsuitable for mechanical recycling:

a) foodservice disposables (plates, bowls, food containers, trays/dishes, napkins/serviettes [not currently packaging], sandwich boxes, bread and cake window bags, hot and cold drinks cups and lids)
b) condiment sauce sachets and pouches

3. Applications where the item is too small or otherwise impractical for mechanical recycling:

a) candy and sweet wrappers and others that are commonly littered

4. Applications which can be used or reused as a liner for a kitchen food waste caddy or a kerbside food waste bin:

a) lightweight carrier bags (not 'bags for life')
b) bin/caddie liners for food waste collections
c) very lightweight fruit and vegetable bags
d) lightweight fresh produce packaging (e.g. the Waitrose banana bag, bags containing salads, spinach, broccoli, etc.)

5. Magazine wraps – may be reused to collect householder food waste, to take from kitchen to the food waste bin.'

Note that already in use are a variety of compostable products (including those describable as plastics) that match with the formats and applications listed above.

We note the following part of the BBIA's answer to question 28 to which we make a few clarifications and alterations as shown in blue text below:

'The report published in May 2019 by Ricardo E&E on the scope of compostable packaging in the UK market[100] illustrates the potential for introduction of compostable packaging- some 138,000 [tonnes] in 2025 if certain conditions prevail. Given that overall plastic packaging represents some 2.5 million [tonnes] it is clear that the amount of [plastic] compostable [packaging] foreseen represent a niche in the market place, around 5 % of current [plastic]

[100] https://ee.ricardo.com/news/our-new-report-highlights-potential-tenfold-increase-for-uk-compostable-plastic-packaging-market-by-2025

packaging. However, given the predominance of the use of compostables as films they could represent some 20 to 25 % of plastic films used as primary consumer packaging.

Currently little or no plastic films are recycled. Data published by WRAP illustrate consumer films recycling to be around 4 % of the annual volumes put onto the market[101]. There is an evident potential for compostable films to substitute the more difficult to recycle plastic films especially where food is packaged. By sending the film with waste food to composting [and other suitable facilities as proposed by the REA above] both the waste food and the packaging can be recovered, raising recycling levels and reducing plastic waste.

In order to achieve this potential which (as the Ricardo E&E report illustrates) is around 138,000 [tonnes], compostable [plastic] packaging should be collected with food waste where it is destined for a composting or AD facility as described in the paragraph above or collected with food and garden/green waste where it is destined for a composting or dry-AD-with-following-composting-phase facility. (We think that although that some specific forms/formats of compostable plastic packaging with milk and/or cream residues are allowed to be fed into composting processes that do not have ABP regulation approval[102] it is unlikely that their co-mingled collection with garden wastes from household sources would be encouraged as many householders could find the associated 'right bin, right waste' challenge too complicated.)

For this to happen Councils and/or their licensed operators need to be authorised to collect compostable packaging with food and/or garden waste and operators need to treat them whilst householders need to be directed to do that where they do not have home composting for thin films such as bags.

To enable this the Government should specifically define "biowaste" with a wider definition allowed under EU law in the 2018 Waste Framework Directive[103] as per Articles 3 point 4 and 22 and which should be transcribed into UK law under the Environment Act in 2020 and notably:

"bio-waste" means biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, wholesale, canteens, caterers and retail premises and comparable waste from food processing plants;
Member States may allow waste with similar biodegradability and compostability properties which complies with relevant European standards or any equivalent national standards for packaging recoverable through composting and biodegradation, to be collected together with bio-waste.

By clearly allowing the collection of materials that are compostable (including compostable plastics) with food waste and other appropriate separately collected biodegradable waste streams, the UK Government gives a clear mandate that these materials may be collected and destined to organic recycling.'

Digestible plastics

In the REA's answer to question 18 we have written about a UK company's development of a so-far-promising anaerobically digestable stabiliser amended, PVA-based polymer, trials of it as a bag/liner for containing food waste and its behaviour in AD, price issues and standards for digestibility.

[101] http://www.wrap.org.uk/content/plasticflow-2025-plastic-packaging-flow-data-report
[102] http://www.organics-recycling.org.uk/page.php?article=3466
[103] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018L0851

If certified compliant with all relevant parts of EN 13432 (or a digestibility standard that may be developed in future), correctly labelled digestible bags/liners become available* and we achieve sufficient education of contract procurers and selectors, bin users, waste collection crews and waste management facility staff, this could result in the majority of such bags/liners being used in areas/at sources where food wastes are wrapped in bags/liners then sent to AD facilities.

* Perhaps including a 'check local acceptance' instruction on whether it they can be used/put in the food waste bin.

With a readily-visible-at-distance appearance that is unique to digestible bags/liners AD facility operators have improved prospect of rejecting any whole or part load that contains significant numbers of non-digestible bags/liners.

We have written about compostable plastics in MRFs in response to question 16 and the issues would be the same for digestible plastics.

Qu 29. How, if at all, would waste collection systems need to be adapted to accommodate the *mass* introduction of biodegradable plastics?

Widespread acceptance of compostable plastics amongst enclosed / in-vessel composting facilities with approval to treat animal by-products could result in the majority of compostable plastics that may come into use in the UK in future being composted (approx 138,000 tonnes, just 5 % of current plastic packaging) being composted. Acceptance of suitable compostable plastics (see http://www.organics-recycling.org.uk/page.php?article=3466) amongst more outdoor composting facilities (without approval to treat ABPS) would contribute to that majority.

Further increase in that majority could be achieved through acceptance of compostable plastics at AD facilities which have a following composting phase (the compostable plastics being fed through AD then into the composting phase) or an ABP regulation approved composting phase (the compostable plastics being largely separated from the digestible wastes then being fed into the composting phase and co-composted with dewatered, digested fibre and/or other biodegradable waste inputs to that composting phase). Other suitably equipped AD facilities would also be relevant (see our answer to question 28).

In terms of compostable plastic bags/liners their potential mass/widespread use for containing separately collected biodegradable wastes would enable AD facilities with no suitable composting phase to send machine-removed bags/liners to composting facilities or AD+composting facilities to be biodegraded.

Some of those AD-with-no-composting-phase facilities are likely to 'front-end' remove the compostable plastic bags/liners; we don't know to what extent removed bag/liner drying is currently prevalent before they're sent to landfill/EFW and whether that would change if this waste stream were sent to suitable composting facilities (in terms of biodegradation it would be preferable not to but this may not be cheaper than sending the waste after drying).

Mass/widespread use of compostable plastic bags/liners would make messaging and instructions to bin users (in domestic and non-domestic sectors) simpler and it's likely that biodegradable waste contamination by non-compostable plastics would go down. Our

Organics Recycling magazine's article on the soon to be published SEPA funded study[104] has found that 'although the number of samples analysed in the project was limited, the results suggest that provision of compostable caddy liners by LAs resulted in cleaner food waste in terms of the amount of plastic within the liners on a weight by weight basis'. (It goes on to say that 'No obvious correlation could be found between the quantity of food waste presented for recycling and the type of caddy liner used' and 'Overall, the results show high variability of food waste weight both between and within domestic food waste sources, irrespective of the type of caddy liner used'.)

One multi-facilities wet-AD operator the REA has spoken to has said that their past switch from a compostable liner which had stretchy properties to another compostable liner which tears much more readily means they would consider shredding the compostable liner-wrapped household food waste, feeding it through their wet-AD processes then removing the liner residues during digestate screening and sending them for appropriate biodegradation (recycling or recovery depending on whether the receiving facility is producing End of Waste status compost), other recovery (e.g. EfW) or disposal. However, any such change would require at least a very high proportion of the household food waste to arrive in compostable liners AND that changeover/transition would HAVE to be planned and managed such that when individual AD operators bid for contracts on the basis of receiving household food wastes in compostable liners they don't fail to win them because competitors have offered to receive those wastes in non-compostable liners (which are currently cheaper).

We have written in this answer about AD waste treatment sector issues because this is such a major influence on whether and how compostable plastics could, on a mass/widespread basis, be collected with bioegradable wastes in future.

Qu 30. How do anaerobic digestion, composting, and energy-from-waste operators currently manage compostable plastics in areas where food waste is collected in bags/liners?

Management of compostable plastics where bag/liner-contained food waste is composted

At many composting facilities that accept food wastes each tipped load of waste is visually assessed for obvious contaminant/non-target material. A tipped load may be rejected entirely if it shows widespread/heavy contamination, e.g. by non-compostable plastics, but more commonly loads are 'manageably contaminated' and methods are employed to transfer as much as is practical (given time, space and health and safety constraints) of the contaminant wastes to the containers for rejected wastes.

Machinery for breaking open or splitting bags does not differentiate between compostable and non-compostable ones. At most composting sites, the bag/liner-contained food waste which has not been rejected at the 'tipped waste inspection stage' is fed through a shredding machine which breaks open the majority of bags. Such machinery is also used for shredding plant materials, so it's cost- and space-effective to use the same machinery and it doesn't need to remove the bags from the food waste.

The shredded bags/liners undergo composting with the food and other biodegradable wastes. Composting process durations are typically between 8 and 12 weeks but a few compost wastes for just 6 weeks. Taking account of composting members' feedback, **the majority of compostable plastics adequately biodegrade** (become at least no longer

[104] Compost quality: A closer look, Organics Recycling magazine, REA, Autumn 2019, Issue 42, pp 17 – 18.

visible) **within these typical 8 to 12 week composting timescales.** Compostable plastics biodegradation rates in industrial composting are influenced by the material type they consist of, that material's thickness, how much of its surface area has biodegradable waste stuck to it, its moisture content and humidity level within the composting matrix, temperatures within the composting matrix, the compostable plastic material's positions within the composting matrix and other factors which influence the range of microbes in the composting matrix and their activity rates.

Post-composting machines used at or soon after the stage of compost particle size screening/sieving include those which remove a significant proportion of plastic residues. (Other physical contaminant types and stones are also largely removed using the same or other machinery, depending on machinery design and configuration.) The machinery does not differentiate between compostable and non-compostable plastics. The smaller the piece/particle of plastic, the less likely it is that the machinery separates it from the compost particles. In addition, some of the visible plastic pieces adhere to compost particles, are not separated from the compost by the machinery and so accompany the compost to its destinations of use, which include soils.

Physical contaminant test methods for composts quantify and report plastic pieces/particles that are 2 mm or larger in the tested compost sample and do not differentiate between compostable and non-compostable plastics. The upper limit set for plastic > 2 mm (in any dimension) in BSI's Publicly Available Specification 100 and the upper limits set in SEPA's relevant regulatory position statement apply to all types of plastic (again, no differentiation between compostable and non-compostable plastics).

Large woody particles separated from smaller compost particles at the particle size screening/sieving stage, and termed oversize material, often include visible pieces of plastic (of varying sizes). Plastic contaminated oversize material is sent to EfW or landfill facilities.

<u>Management of compostable plastics where bag/liner-contained food waste is dry-digested then composted</u>

A UK operator of a dry-AD process with a following phase that composts the digestate receives biodegradable wastes that include compostable packaging (e.g. cups, films, carrier bags) and non-packaging wastes (e.g. caddie / food bin liners, table ware). Householders choose what to use for wrapping/containing their food waste; some use compostable bags/liners and others use non-compostable (they report receiving 'a lot' of single use plastic bags). We have not investigated exactly how these compostable packaging and non-packaging wastes are managed at this facility. Its digested, composted output is classed as a compost and is certified under REAL's Compost Certification Scheme, so can be supplied to suitable markets for storage and use without being subject to waste regulatory controls.

<u>Management of compostable plastics where bag/liner-contained food waste is wet-digested</u>

To the best of our knowledge, the majority of food waste from sources where food waste arises unpackaged is collected in polyethylene (non-compostable) bags/liners. Unpackaged food wastes from some local authority and business sources are collected in compostable liners but we do not know what proportions of this type of waste stream arrive at the relevant wet-AD facilities.

Most wet-AD facilities in the UK that digest waste inputs that include or consist of food waste do not have a post-digestion composting phase. Those who have tried feeding compostable bags/liners into their digesters have found the stickiness of the bags/liners they have tried translates to more machinery down-time for maintenance. They tend to prefer the food waste arrives in polyethylene (non-compostable) bags/liners because they are less stretchy and more moisture resistant so don't become sticky. Having said this, one of the multiple-wet AD facility operators we have spoken to said their changeover from receiving local authority food waste in compostable bags/liners to polyethylene ones was driven entirely by the local authority's desire to reduce the cost of its food waste collection service (polyethylene bags/liners being cheaper than compostable ones).

The wet-AD operator case study included in our answer to question 26 describes how the facility manages food wastes it receives wrapped/contained in compostable and non-compostable bags/liners. Other UK wet-AD facilities that receive similarly wrapped/contained food wastes manage the bags/liners in similar ways; in summary by removing them, to some or no extent washing and/or reducing their moisture content (some operators dry this waste) then sending it to EfW or landfill facilities.

Physical contaminant test methods for digestates quantify and report plastic pieces/particles that are 2 mm or larger in the tested digestate sample and do not differentiate between compostable and non-compostable plastics. The upper limit set for plastic > 2 mm (in any dimension) in BSI's Publicly Available Specification 110 and the upper limits set in SEPA's relevant regulatory position statement apply to all types of plastic (again, no differentiation between compostable and non-compostable plastics).

<u>Energy-from-waste operators' management of compostable plastics in areas where food waste is collected in bags/liners</u>

Our dialogue with industry on this point has been limited. Feedback is that only concrete or niche plants 'really care about 'hot fuels'' (fuels and wastes with high calorific value). Most EfW facilities process at least some lower-calorific-value wastes, such as plastic and other physical contaminant rejects from composting and AD facilities. If the plastic fraction of those rejects consists of a higher proportion of compostable plastics, the moisture content of the rejects waste stream will be higher and so it will have a lower calorific value. That's unless the composting or AD facility dries, or partially dries, its rejects waste stream before sending it to EfW. We have not investigated the influence of waste calorific value on waste throughput rates at EfW facilities although we have heard it can influence the gate fees they charge.

Qu 31. Is there any other information or evidence related to this topic that government should be aware of?

The REA has discussed some of the issues below with some of its members. We have quoted the BBIA here because the issues merit consideration:

'Assuming that biowaste is collected with compostable packaging in it, what happens next? Currently the UK has a mixed final treatment system with composting on the one hand and

anaerobic digestion plants on the other. Rarely do the two plants operate in the same site or in a connected way as they do, for example, in Italy.[105]
The consequence of this is that packaging waste of any nature sent to AD plants is stripped out and discarded, either in landfills or incinerators. We do not know the volume of food waste discarded with that packaging. Anecdotal evidence from Italy suggests it can be as high as 10% of the food waste delivered but technologies are improving and we believe this figure can in reality be lower.

In any case an AD plant in the UK will strip out all packaging and dispose of it, with a certain loss of food waste associated and costs which we have seen above under answer 26 could be in the range of tens of millions of pounds annually.
A composting plant will be able to accept compostable packaging and therefore has the cost of stripping out non compostable packaging, such as plastics, aluminium, glass and other undesirable materials.

Logic would therefore beg the question: why not compost the packaging that comes from the AD plant where this is compostable? This is precisely what happens in Italy and many other European countries where either AD plants are "dry" i.e. take not just food waste but compostable packaging and garden waste; or where the stripped packaging is sent to aerobic treatment with a part of the digestate that is an output from the AD process to produce nutrient rich compost.

Robin Szmidt of Target Renewables Ltd has made an analysis of the comparative efficiency of wet versus dry AD systems. He has written that:

"Elsewhere, particularly in mainland Europe, Anaerobic Digestion technologies that can receive and manage packaging within the digestion process are more widely employed. In particular so-called Dry-AD systems typically are capable of receiving packaging material in the feedstock, together with a higher level of physical contaminants than tolerated by wet-AD systems.
Dry-AD systems that can do this are generally referred-to as plugflow or batch systems. They normally operate in the thermophilic (high temperature) range which is relatively high compared to the mesophilic (low temperature) range commonly seen in the UK. Examples of such installations can be seen at:
https://www.thoeni.com/en/energy-engineering/
http://www.hz-inova.com/cms/en/home?page_id=543

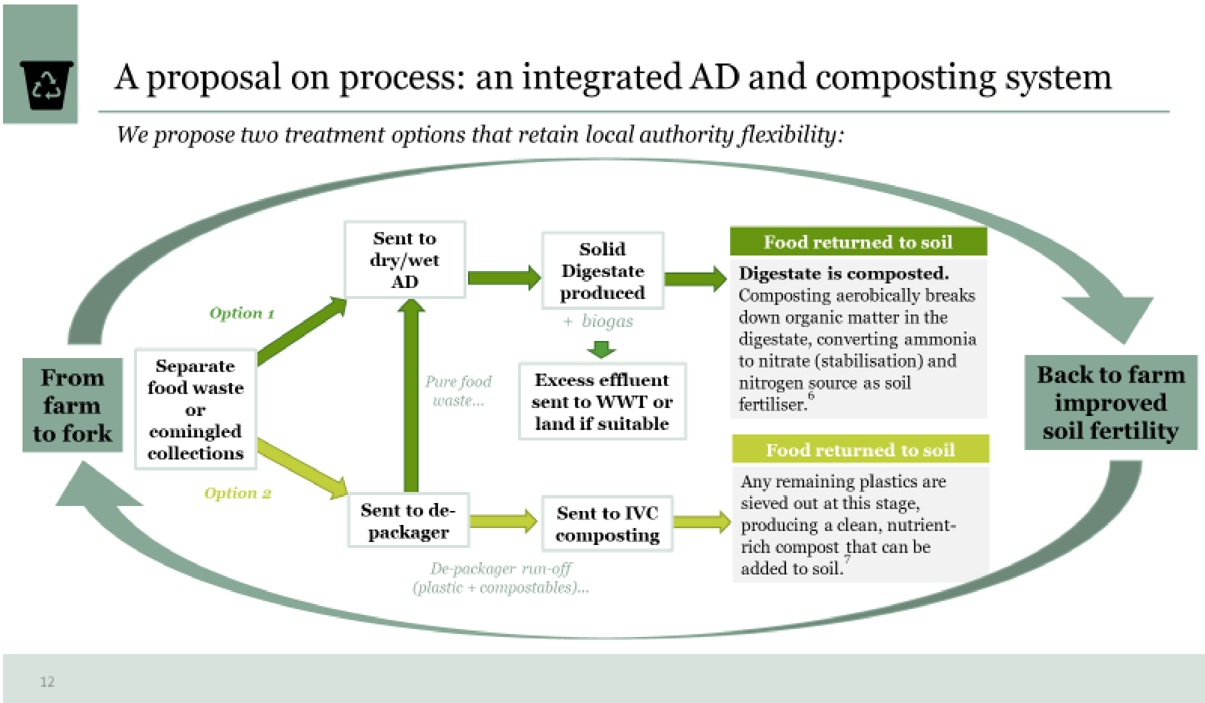
Systems that can be designed to include a proportion of non-biodegradable materials, whether naturally occurring or waste tend to result in a higher level of recovery of that material if biodried, post-AD. There is little reliable data in this regard but as an example, the Thoeni-built Dry-AD facility at Gavle, Sweden, was specifically designed on this basis. At that site, post-AD separation allows a higher degree of product quality (lower product contamination) that might be expected under UK conditions. A similar approach is being adopted at a number of, particularly, Scandinavian sites. Such sites are generally designed to a level of $\geq$ 90% biological efficiency and to a level of contaminant removal that exceeds that required under PAS110 or PAS100."[106]

Dry AD or combined wet AD and composting systems may have extra costs compared to the current UK model where wet AD dominates, but they also offer notable savings in disposal costs from the current model. The benefits are manifold, including reducing plastic waste, sending

[105] https://www.compost.it/en/
[106] Paper available upon request

less food waste to landfill/incineration, storage space for waste plastics on site, and the production of compost rather than wet digestate with consequent benefits to farming, soil quality, ammonia emissions and nitrate run-off.

This combined model could look something like this:



Of course, there are many variants possible. What is important in terms of compostable packaging is that the packaging is sent to recovery with the food waste attached to it rather than to disposal.

For this to happen the packaging being received by both AD and composting plants needs to be largely free of contamination. This is another reason why mandating collection of food and garden waste with compostable materials is the right way of approaching a resource efficient circular economy model.

Compostable plastic films compatible with the short cycle of an AD plant (less than 30 days) are recently available on the market place.[107,108,109,110] Where collection schemes can use these materials and there is a low level of contamination, AD operators would not need even to extract them from the food waste, but can digest them together. Fortunately for the UK the number and size of AD plants treating food waste is relatively small, around 75[111,112] and they are not yet individually of a scale comparable to similar EU countries. Therefore we have the opportunity now of getting the system corrected before we start to collect and treat greater volumes of food waste. Individual plants in Denmark[113] and Italy[114] are now treating over

[107] http://www.futamuragroup.com/sustainability/certifications/
[108] https://www.aquapakpolymers.com/biodegredation/
[109] https://www.novamont.com/eng/leggi_press.php?id_press=42
[110] https://products.basf.com/de/ecovio.html
[111] https://anaerobic-digestion.com/anaerobic-digestion-plants/anaerobic-digestion-plants-uk/
[112] http://adbioresources.org/map
[113] https://www.renewableenergymagazine.com/biogas/eastern-denmark-s-largest-biogas-plant-ready-20180622

500,000 tons p.a. of food and garden waste together, extracting energy and producing compost. Two of these plants combined treat more food waste than England - the opportunity for change in England is now, rather than maintaining a system that has evident loss of materials and energy and consequences in terms of air[115] and soil quality[116].

55% of English land is classified as a Nitrate Vulnerable Zone[117] where the seasonal opportunity for spreading of wet digestate is short – by combining anaerobic digestion and composting to produce a dry, solid material, organic carbon as well as nutrients can be returned to soil with lower risks of nitrate leaching and for a longer season. As the increase in food waste to AD will be significant over the next years, it is vital we get the use of outputs right now.'

Lastly, when considering future policy drivers for investment in composting, wet-AD, dry-AD and integrated AD and composting processes please also take into account the biogas potential of the waste mixtures appropriate for wet- and dry-AD systems and their respective efficiencies, i.e. biogas yields likely to obtained from the digested wastes. One on-line article[118] provides the following information:

- wet-AD of material with a biogas potential of 160 Nm^3 per tonne, operating at 60 % efficiency will harvest 96 Nm^3 of biogas per tonne; and

- dry-AD of material with a biogas potential of 110Nm^3 per tonne, operating at 90 % efficiency will harvest 99 Nm^3 of biogas per tonne.

~ End of document ~

[114] http://www.montello-spa.it/anaerobic-digestion-with-biogas-production/?lang=en.
[115] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf
[116] https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/656/65607.htm
[117] https://www.gov.uk/government/collections/nitrate-vulnerable-zones
[118] https://www.isonomia.co.uk/do-or-dry-the-future-of-uk-anaerobic-digestion/