UK Waste Strategy: Bioeconomy Opportunities Aplenty

If human development is to continue in a sustainable manner, it is becoming increasingly clear that the economy of the future is going to be circular: an economic model where products, at the end of their lives, are fed back into the system in order to continue their use and extend their value. In order for this kind of economic model to work, waste needs to be minimised. This is the central tenet of the UK government's recently published Resource & Waste Strategy. Given that the concept of circular economy is one that frequently goes hand-in-hand with the bioeconomy, what opportunities does this Strategy hold for the UK's bioeconomy?

The Impact of Waste

In any economy, waste is something to avoid: it represents inefficient use of resources, and thus the benefits of those resources being lost. Natural resources are not infinite, and although the bioeconomy promotes the use of biomass as a resource because it is renewable, inefficient exploitation of even renewable resources can have disastrous consequences (look to deforestation and associated loss of biodiversity as an example of how this applies to biomass).

That is not to mention the waste itself: an argument based solely on resource efficiency assumes that the waste itself does not have a negative impact. However, it is well-known that in many cases, waste can cause huge damage to the environment. Waste that biodegrades in landfill will result in emissions of methane, a potent greenhouse gas, as the waste is broken down anaerobically by microbes. Waste that finds its way into the environment can provide a serious hazard to wildlife, as no shortage of horror stories of animals that have mistaken waste for food will testify, and it is only recently that we have become aware of the scale of the damage. It is now estimated that almost every water course on the planet has been contaminated with plastic, particularly microplastics, which result from the fragmentation (but not degradation) of waste plastic.

Thus, the case is clear for better waste management: the twofold benefits of increased resource efficiency and reduced environmental damage should be reason enough, but coupled with the economic benefits of implementing a circular economy, it is no surprise that waste has become an area of interest for lawmakers.

The Waste Hierarchy

When dealing with waste, traditionally stakeholders have adhered to the idea of the waste hierarchy. This system indicates which methods of dealing with waste should be prioritised in industry and wider society. As is to be expected, the theoretically best way to deal with waste is to prevent it occurring at all, but the Strategy acknowledges that this is not always feasible. Perhaps in the future the economy will be geared towards waste-prevention (the Strategy loosely posits a post-2030 timeline for this ambition), but for now the UK's Waste Strategy will be geared towards the second stage of the hierarchy: reuse and recycling. This is not to say that prevention is not on the cards: in all areas of the strategy, prevention policies have been implemented when feasible, such as through banning of plastic items where alternatives exist, and wider commercial safeguards for food producers to minimise unused surpluses.

Plastic: A Sustainability Challenge

Simply put, the modern economy would not function without plastic: as a lightweight, durable material, it has established itself in countless applications. However, the obvious downside of plastic stems from the self-same durability that makes it such an important material: plastic does not degrade in the environment except on unacceptably long timescales. It is little surprise then, that plastic has been under the microscope with regard to waste policy for some time. Likewise, it will come as a shock to nobody that plastic is the target of many of the policies proposed in the Waste Strategy.

However, such is the variety of plastics and their applications that blanket policies are not feasible. Thusly, the Strategy focuses in on plastics that are known to be the most significant issue for the waste disposal industry: single-use plastics, including packaging. It goes without saying that these plastics present the most immediate issue: as their name suggests, they are manufactured with disposal as their intention. It is, however, well-known that due to their durability, these single-use plastics are prime candidates for recycling, and facilities for recycling them have been available in the UK for many years. So why, then, do these single-use plastics continue to be an issue?

One explanation lies with where the responsibility for recycling lies: currently, it is largely the responsibility of the consumer to recycle their used plastics. This duly reduces the incentive for single-use plastic producers to make their plastics more conducive to recycling, thus creating a vicious cycle wherein poorly-informed consumers do not recycle plastics that could otherwise be recycled.

The Strategy seeks to change that, by introducing a "polluter pays principle" built around an "extended producer responsibility framework", wherein policy will aim to make the producers of disposable plastics responsible for the entirety of the plastic's life-cycle. According to a loose timeline outlined in the Strategy document, this will be facilitated early this year by ensuring that recycling collections are consistent across the entirety of the UK, meaning that it will become easier for producers to label packaging in a way that promotes recycling.

This incentive, however, is not enough: there is no point increasing collection of plastic waste if it is not to be used down the line. The Strategy reveals that the government will impose an additional tax on all plastic packaging that does not contain over 30% recycled plastic. This is subject to an ongoing consultation, and will not be implemented until 2022 if supported by said consultation. The aim here is obvious: to provide a financial justification for plastic producers to make the switch to recycled plastic. Many big-name companies are starting to make this transition already, meaning that, hopefully, recycled plastic packaging could become the norm in the future.

As far as the bioeconomy is concerned, the major players here are biobased plastics, for which this proposed legislation presents both an opportunity and a quandary. Much of the Waste Strategy is concerned with reducing the environmental impact of waste, and as far as plastic is concerned, its environmental impact stems from its very existence. All of the greenhouse emissions associated with plastic stem from its disposal through incineration, or indirectly from energy use during its production, and a case can be made that its use results in reduced emissions due to its light weight allowing for more efficient transportation. The majority of biobased plastics are, in terms of their material properties, identical to their fossil-based counterparts, and thus their environmental impact, at least in the terms laid out in the Strategy, is identical. What case, then, do biobased plastics have for consideration in the wake of this Strategy? The answer relates to environmental impacts elsewhere: greenhouse emissions.

Since biobased plastics are manufactured from biomass, as opposed to fossil fuels, they act as a carbon sink, since the biomass will have absorbed carbon dioxide during life. The manufacturing process does not result in any direct emissions, thus maintaining this sink status. This is championed as the chief property that biobased plastics offer for the bioeconomy going forwards: as a mitigating factor for emissions elsewhere. This effect is compounded at the end of the plastic's life: eventually, mechanical recycling ceases to be feasible, as the plastic gradually breaks down. Currently, the only way of disposing of plastic that does not involve landfill (and releasing the plastic into the environment) is through incineration. This results in carbon emissions, but in the same manner as with biomass fuel, these emissions are mitigated by biomass' status as a carbon sink, meaning biobased plastics perform significantly better environmentally than fossil-based plastics if the end-of-life treatment is incineration.

This, however, may turn out to be a hard sell for Defra, who make it clear in the Strategy that the desired approach with plastics is to reduce their presence in the environment through recycling, and producing more plastic – whether biobased or otherwise – is counterproductive to this end. There is hope that, in the future, chemical recycling techniques will be able to reduce the need for incineration, but this technology is very much in its infancy, and thus unable to play a serious part in any short-term waste strategy. It seems that the best bet for biobased plastics in terms of responding to this Strategy would be to highlight the novel properties they can bring to the table that fossil-based plastics cannot, but the essential property they will all need in order to see usage in packaging will be recyclability or compostability.

Packaging, however, is not the only plastic application that comes under fire during the Strategy: single-use plastic items have been under the spotlight recently, not just in terms of policy, but in the wider public awareness too. As the general public become increasingly aware of the damage done to marine ecosystems by discarded single-use plastic items such as straws, stirrers, and cotton buds, there have been ever-louder calls for these plastics to be banned. This has already resulted in bans in various places, with plastic cutlery banned in parts of France, and Italy set to ban cotton buds. The Waste Strategy looks set for the UK to follow suit, with a ban proposed on all single-use plastic items "where alternatives exist". It is in this latter point that the bioeconomy shines.

As far as "alternatives" go, in general the public will seek to find something as close to the original as possible, due to familiarity. Here, the bioeconomy offers the option of compostable plastics. These are already starting to see use as a material for food waste bags, and coffee pods, but wider applications are becoming available. The clue is in the name: these plastics will completely degrade in industrial composting units in a matter of months, as opposed to centuries, which is the estimated degradation time for conventional plastics. The need for industrial composting is worth noting, and must be emphasised by labelling, as these items must still be collected at the point of use. Since frequently they are products associated with food (such as cutlery, stirrers, straws, etc) they can be collected (and composted) alongside food waste, but this must be made clear to consumers, lest well-meaning members of the public attempt home composting and end up releasing the plastic into the environment. However, it is not just food-related applications where compostable plastics shine. In applications where contamination with biological material is likely, recycling of plastics can be very difficult. This is obviously the case where disposable plastics are used in agriculture, most commonly as films to protect growing crops. Unfortunately, soil contamination makes these films highly difficult to recycle, a trait that is solved by using compostable plastic films, as the composting process is not affected by soil contamination.

It is also worth noting that although they compost like biomass, compostable plastics are not necessarily biobased themselves (although they frequently are, and manufacturers do tend to pursue both properties where possible). If, however, they are, then they also offer the same aforementioned environmental benefits of biobased plastics in addition to being compostable, which is the ideal situation.

Overall, plastic waste is rightly seen as a highly important issue. Since compostable plastics offer a solution, this concern will likely provide a boost to their development, but as far as non-compostable biobased plastics are concerned, producers will have to ascribe additional focus to ensuring their plastics are both recyclable, and able to incorporate recycled plastic, and with this being such a young sector, it may slow the development of novel biobased plastics in the UK. By what degree remains to be seen, and will no doubt depend on the outcome of the proposed consultation into biobased plastic standards, due later in 2019.

Food Waste: A Boon for Bioenergy

The other principle focus of the Strategy is the handling of food waste. This is unsurprising, given that the food and drink industry is a significant source of emissions in the UK – accounting for one fifth of the UK's total carbon footprint. There has been progress on this front in recent years: UK food waste levels are down by 14% over the past 10 years, and the target is for a further reduction of 20% over the next decade. This will be the equivalent of a per-capita reduction of 31kg of food waste per-annum.

The key message of the Strategy's approach to food waste is prevention. Even though the bases are well-covered when it comes to dealing with food waste when it arises, the fact that it does arise demonstrates an inefficiency in the production, excepting of course unavoidable food waste from the inedible parts of produce. Duly, much of the Strategy's focus is on reduction of food waste, both inside and outside of the farm gate. Funding is being made available for projects to focus on the redistribution of edible food that would otherwise go to waste, and legislation is being pursued that enables food producers to ensure their produce is not wasted, if they end up with unsold surpluses due to commercial issues such as unfulfilled contracts, and last-minute cancellations or changes to specifications. These approaches have the twofold benefit of reducing both food production and food waste. The latter aspect of this represents an opportunity for the bioeconomy: if food production is to be made more efficient in this way, then it may result in a reduced need for agricultural land for food production. This may allow for an easing of the pressure on industrial crop production, opening up increased opportunities for crops to be utilised as feedstocks. To what degree is unclear, alas, as no indication is given as to how much – if any – cropland will become available as a result of food production efficiency increasing, as the Strategy itself does not consider this option.

However, when it does arise, food waste is good business for the bioeconomy. It is a readily-available source of easily-digestible biomass that can be utilised as feedstock for anaerobic digestion, producing biogas for energy generation. This sector benefits where food waste is collected separately in the UK, and is championed in the Strategy as the ideal way of dealing with food waste, not only preventing food waste from ending up in landfill, but also generating renewable energy in the process, and reducing the UK's reliance on fossil-fuels. This is a symbiotic relationship between two sectors that works well: since local authorities are responsible for food waste collection, and anaerobic digestion favours small-scale generation, the two synergise well, stimulating local economies. It is unsurprising, then, that the AD sector continues to grow in the UK, despite dwindling availability of

financial support. If greater financial incentives were available, AD could become more economically viable, and continue to provide the twofold benefits in terms of waste management and energy generation.

This latter point only makes more sense when seen in the light of the policy proposals outlined in the Strategy for dealing with food waste. Alongside the proposals for a consistent set of materials to be collected for recycling, there is also a proposal of mandatory separate food waste collection. This is already the case among the devolved powers, and has been a success in Scotland, Wales, and Northern Ireland. Of course, the purpose of this policy is to reduce the volume of food waste destined for landfill – eliminating food waste should always be the long-term goal – but in the short term, wider collection of food waste means an (albeit temporary) increase in available feedstock for AD. This is significant, because other AD feedstocks include energy crops, which remain a controversial issue across the bioenergy sector, due to concerns that their cultivation prevents the use of cropland for the production of food, seen to be a more significant issue by some, despite evidence suggesting that sustainable energy crop production is possible. By increasing the amount of food waste made available as AD feedstock, it reduces the need for perennial energy crops, which can be used as feedstocks in biorefineries to produce advanced biofuels and a wide range of industrial chemicals. Methane from anaerobic digestion of food waste can also be utilised directly as a biofuel as replacement for fossil diesel in LGVs and HGVs. Compressed Biomethane used in transport is eligible to be "double-counted", by the Renewable Transport Fuel Obligation (RTFO), making it more valuable to fuel blenders. This competition between processes is healthy for the development of both sectors, and can only be seen as an incentive for wider food waste collection, such is its versatility as a feedstock. This will have longer-term benefits for the involved sectors too, as food waste is rarely a homogenous source of biomass, and so this may accelerate the development of biorefinery technologies that do not rely on specific feedstocks, which will allow for more sustainable sourcing, when a greater variety of available sources can be utilised.

Even this is not the limit for the possibilities: biofuels produced from food waste, or from freed-up energy crops, are not the only options. Biogas produced from anaerobic digestion can also be utilised as a transport fuel, and is particularly suitable for large vehicles, such as the vehicles used to collect waste. This is the kind of scheme that captures the imagination of the public, and raises awareness of the issues surrounding waste. This kind of system has already been seen in the UK, with success. It of course makes no difference as far as AD is concerned, how the generated biogas is utilised, this merely demonstrates the options available, and the potential which still remains untapped.

Waste at End-of-Life: Opportunities for Biorefining

Unfortunately, it is not, at least in the current state of play, possible for no waste to be produced at all. Despite the best efforts to maximise recycling and prevention, there will always be some that slips through the net. The question is what is done with it.

Waste that contains organic material has the potential to be a valuable feedstock for biorefining. In these processes, organic material is industrially treated via either gasification or pyrolysis. The latter process produces pyrolysis oil, which can be burned as a fuel, substituting petroleum fuels, but of greater interest is gasification. Gasification produces syngas: a mixture of carbon monoxide, carbon dioxide, and hydrogen, that can be simply burned as an energy source, but that can also be utilised to industrially synthesise chemicals, polymers, or fuels. In this way, waste biomass is converted into useful products, epitomising the circular economy ethos. The variety of applications entirely depends on

what stakeholders wish to synthesise, and in a similar manner to the use of food waste as a bioeconomy feedstock, in the short term this can offer great benefits to the bioeconomy through the development of novel, more robust processes. Over time this will become less important, as overall waste production is reduced, but that is not to say that technologies like this needn't proliferate: they provide an effective and under-utilised alternative to landfill for organic waste.

Of renewed interest to biofuel developers is the gasification or pyrolysis of refuse derived fuel (RDF). The RTFO has recently been extended to include a new category of fuels termed Developmental Biofuels. Biomethane produced via a thermochemical process like gasification or pyrolysis is eligible to receive developmental certificates that have a price roughly three times greater than biomethane from AD. Hydrogen from electrolysis and chemically identical diesel and jet fuels are also eligible if produced from compliant wastes streams. Going forward, this will be the UK's model for development of sustainable transport fuel for HGVs and aviation, as on the same timescale sustainable transportation technologies, such as electric- or hydrogen-powered vehicles, will have been developed for domestic transport and even autonomous vehicles could become more widespread.

It may seem like celebrating the use of waste as a feedstock is somewhat paradoxical: that it may encourage greater production of waste in order to be of greater industrial benefit, but this is not the case. It is simply a case of maximising the short-term benefits of the UK's waste situation, as these options are all more sustainable than landfill, both in terms of resource efficiency and environmental impact.

Looking ahead

With a sector as massive as waste management, it is unsurprising that any change is going to be slow, but there is an impressive urgency present throughout the Strategy, as is necessary as the environmental crisis continues to steepen. The Strategy provides several timelines for when we can expect policy to be determined and/or enacted.

2019 is set to be a significant year for this Strategy, and will be the initial acid test of how much of a success the Strategy will be. Promised for this year are consultations on both standards for biobased plastics, and on how food waste is reported. The former is a significant milestone for the wider bioeconomy, and manufacturers of biobased plastics will be hoping that the results of the consultation are implemented quickly, in order to assist biobased plastics with gaining a foothold in the UK market. The latter will explore to what extent the government can demand that companies report how much they have reduced their food waste output, and impose targets therein. The outcome of this consultation, particularly the latter part, will enable those who utilise food waste as a feedstock to appraise the degree to which they can expect to lose input thanks to increased food efficiency, allowing sectors such as anaerobic digestion to amply prepare for the promised changes. 2019 is also slated as the year in which it will be agreed what "consistent set of materials" will be collected for recycling across the UK. As the bioeconomy becomes ever more intrinsically linked with the packaging sector, there will no doubt be many in the bioeconomy who await this announcement with interest. It is also worth noting that, even though the UK is set to exit the European Union in 2019, Brexit is unlikely to affect waste policy in the short term, as the Strategy commits to retaining equivalents of all EU laws regarding waste management.

Looking further ahead, single-use plastics are set to be abolished from the government estate by 2020. Although this in itself will make a tiny difference in terms of direct impact, this will hopefully

educate those with the power to set waste policy on the benefits of alternatives offered by the bioeconomy, and galvanise the government into greater support of these materials, products, and technologies in the future.

Lastly comes the first major target in the Strategy: for 75% of packaging to be recycled by 2030. This is very achievable, particularly if the sister target – for all plastic packaging to be recyclable, reusable, or compostable by 2025 – is achieved. It will be by this measure (and others) that the success of this Strategy is judged, as it will determine whether the flagship policy reforms have worked. The Strategy will be revisited by 2025, in the meantime, the bioeconomy's task is to continue to demonstrate its value in a waste management context, and to continue to highlight that sustainable development is achievable, and worth pursuing. The bioeconomy may not take centre stage in this Strategy, but its ethos is the same: resource efficiency underpins a circular economy, and a circular economy benefits us all.

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