



Environment and Climate Change Committee

Uncorrected oral evidence: Methane

Wednesday 27 March 2024

10 am

Watch the meeting

Members present: Baroness Sheehan (The Chair); Baroness Bakewell; Lord Duncan of Springbank; Lord Grantchester; The Earl of Leicester; Lord Ravensdale; Earl Russell; Lord Trees; The Duke of Wellington; Baroness Whitaker.

Evidence Session No. 3

Heard in Public

Questions 44 - 62

Witnesses

[I](#): Sandra Esteves, Professor in Bioprocess Technology for Resource Recovery: Energy and Materials at the Sustainable Environment Research Centre, University of South Wales; William Maxwell, Waste Projects Manager, South Oxfordshire District Council; Paul Thompson, Head of Renewable Transport Fuels & Landfill Gas, The Association for Renewable Energy and Clean Technology; Jacob Hayler, Executive Director, Environmental Service Association; Claire Shrewsbury, Director Insights & Innovation, WRAP.

Examination of witnesses

Sandra Esteves, William Maxwell, Paul Thompson, Jacob Hayler and Claire Shrewsbury.

Q44 **The Chair:** Good morning, everyone, and welcome to the Lords Environment and Climate Change Select Committee. This morning we will take evidence for session 3 of our inquiry into methane, looking at waste and waste management. I extend a very warm welcome to our panel of expert witnesses and thank them for making time to be with us today. I remind all attendees that the session is webcast live and subsequently made available to view via the parliamentary website and that a transcript will be taken and made public. Witnesses will have the chance to review the transcript and make necessary amendments with the agreement of the clerk. I remind members that when they speak for the first time they should declare any relevant interests. I will ask each of the panellists to briefly introduce themselves, starting with Paul Thompson.

Paul Thompson: Good morning. I am from the Association for Renewable Energy and Clean Technology, the REA, which is a trade association covering a wide range of renewable energy technologies. I am primarily here to talk about landfill gas and biogas from an energy policy point of view.

Claire Shrewsbury: I am from WRAP. I am the director of Insights and Innovation. WRAP is an NGO that has been working with Defra on food waste prevention and collections. I am here to share some of our knowledge about that.

William Maxwell: I work for two district councils that have the honour of being the highest recycling-rate councils in England, so I am representing the views of people from local authorities who collect recyclable material.

Jacob Hayler: I am the executive director at the Environmental Services Association, which is the trade body that represents the recycling and waste treatment industry in the UK. We cover the full range of waste activities, from collections, sorting materials, processing those materials, energy from waste and landfill disposal as well.

The Chair: Excellent, thank you. Can I come to Professor Esteves online now?

Sandra Esteves: I am a professor in bioprocess technology for resource recovery and I work in energy and materials at the University of South Wales. I also direct the Wales Centre of Excellence for Anaerobic Digestion. I have been involved in R&D for anaerobic digestion for over 20 years and I have supported the implementation of the technology since 2006 in the UK and elsewhere. I am happy to share my views as well.

Q45 **The Chair:** Excellent, thank you. Before asking the first question, I will refer to my register of interests as per the parliamentary website and also mention that I am a director of Peers for the Planet, which is a non-remunerated role.

Could you outline the main sources of methane emissions across the waste management and wastewater sectors in the UK? I will start with Professor Esteves.

Sandra Esteves: I will start with a little bit of background. As everyone knows, methane was generated many years ago as a gaseous fossil fuel and is thought to be produced by biogenic and thermogenic conversions within the Earth's crust and even deeper. Apologies, there is some background noise. In biogenic conversion—

The Chair: We can hear you. While Professor Esteves is brought back online—

Sandra Esteves: Apologies.

The Chair: Do carry on.

Sandra Esteves: Biogenic and thermogenic conversions have been related to waste management over thousands of years. As a result of that, geothermal sites, volcanoes and glaciers can be a powerful methane source, as well as practices around the oil and gas extraction industries.

Other sources of methane are obviously the agriculture and the farming sectors, rice production and ruminants. We have looked at a small farm slurry store in Wales and we have measured emissions, for example, over a year. Those emissions, extrapolated over the 12,000 dairy farms in Wales, could result in approximately 1 million tonnes of CO₂ equivalent of storage of slurry alone. Within the UK context, there are approximately 70 million tonnes of slurry currently not being treated. There are a lot of potential emissions around the slurry side that could be captured.

Taking us to more current waste management practices, ones implemented probably around the last 50 years, they have been reliant on industrialisation of what could be mimicking what we find in nature. We have biogenic generation, and we will talk a little bit about the biological routes to methane, but also gasification and pyrolysis almost mimicking the thermal conversions that we see in nature.

Bioprocesses include landfill, composting and other aerobic processes and anaerobic digestion. All of these rely on microbial conversions for degradation of organic wastes and methanogens can play a significant role in all of these processes. Methanogens are micro-organisms from the Archaea domain, so very old microbes. They work in anaerobic conditions, so they do not require air to operate; in fact, they are inhibited by air. Therefore, as feedstocks for methane, we have things like acetic acid, hydrogen, CO and CO₂ and alcohols—for example, ethanol, propanol, butanol and methanol.

While the UK has reduced the amount of organic waste that goes into landfill, many other countries still rely on these processes for much of their waste management. Some methane can be collected from engineered landfills. However, these typically have losses of over 50% due to their building filling nature, the inefficient covers and the collection systems. Therefore, around the world there are landfills that can potentially produce 10% to 15% of global methane emissions, so landfills are definitely a significant source of methane.

When we look at composting processes, although one may expect that they should not produce methane because they are aerobic processes, in reality that is not the case. Methanogen although are strict anaerobes, they live in compost heaps and form co-operations with other aerobic and facultative microbes, which consume the residual oxygen available and provide the necessary conditions for methanogens to also work in those matrices. It is not uncommon to find 30% or so of carbon passing through a composting site ending up as a methane as an output. Composting processes are therefore potential significant sources of methane. Recovering that is particularly difficult because you have systems that rely on very high volumes of sparged air through the matrices. The methane content in air is fairly dilute but a significant source, and difficult to recover.

When we come to anaerobic digestion, it obviously aims to produce methane but we aim to capture that methane, whether it is for fuel usage or chemical feedstock. There was a study conducted in the UK in 2021 that determined that on average we probably see a loss of below 4% from AD plants of the methane captured at the plants. We have some room for improvement and I will illustrate some areas that can be improved.

The Chair: Professor Esteves, we should move on to other witnesses. I am sure you will have an opportunity later to fill us in on the rest. Mr Thompson, I will come to you.

Paul Thompson: Very briefly, to highlight the significance of the landfill point in the UK, I am taking the most recent CCC figures from last year's progress report. Waste is about—this is all emissions, not just the methane—25 megatonnes CO₂ equivalent. That is 6% of total UK emissions, but within that 75% of those emissions are from landfill. We are talking about by far the biggest part of the issue, even in this country, where we are relatively sophisticated in how we manage it.

The Chair: Please do lean into your microphones because I think some of us are having difficulty hearing everything that you are saying.

Jacob Hayler: We have done a lot of work at ESA looking at emissions across the sector from the various different sources. I should emphasise that we do not look at agricultural wastes or wastewater treatment. We just look at the emissions associated with the management of household, commercial and industrial wastes, which is the core part of our sector. Today we think landfill emits about 10 million tonnes of CO₂ equivalent.

That is a massive decline in the last 30 years, around a 75% reduction in methane emissions from the landfill sector in that period of time.

We did a piece of work with slightly different figures to the ones quoted from the CCC. If you look across all of our emissions, we think it is more like 35 million tonnes. Quite often what happens is parts of our sector are not included in the statistics, so recycling gets included in the industrial statistics and energy from waste gets put in the energy statistics, but when you bring it all together it is about 35 million tonnes, of which about 10 million tonnes comes from landfill. That is CO₂ equivalent. If you are looking at methane specifically, then landfill is the overwhelming source of emissions on methane. Others are pretty trivial.

There are probably 130,000-odd tonnes from anaerobic digestion, very small amounts from composting, for example. It is overwhelmingly landfill. In terms of the gas capture rates at those sites, historically about 75% of gas is captured at those sites, but we think with modern sites and modern management techniques we can get those figures higher. It is more like 80% to 90% today. We have an internal sector target to capture, on average, 85% of all the landfill gas by 2030 across all our sites in the UK.

Claire Shrewsbury: To build on Jacob's point, the biggest source of methane within landfill is food waste, so it is the importance of getting food waste down. Paper and card are also significant sources. While less of that is disposed in landfill, every tonne of paper and card produces twice as much methane as food. Obviously the other significant sources are garden waste, wood and other organic materials, from nappies and pet waste, but much less so. Food waste is the one to get.

The Chair: Would you like to add anything, Mr Maxwell?

William Maxwell: I think my colleagues have been pretty comprehensive.

Q46 **Lord Duncan of Springbank:** I am intrigued by the question of food waste and paper waste. If you look at the significant contribution that represents, how can we reduce the waste itself? Not in a sense capturing the gas once it has been landfilled, but rather how do we reduce food waste? I am curious here about the techniques that could be used to try to reduce that, things like a landfill tax or supermarket taxes, methods that could be deployed to reduce food waste or recycling of that. That is my first question.

My second question for Jacob is: if you can capture such a significant quantity of the gas from these landfill sites, what does it cost to capture the gas? I cannot imagine that it is cheap. The question that would follow is can that therefore be—not just in the UK—spread more widely? Broadly, there are three questions tucked inside that. I direct that to anyone. Perhaps Claire might want to start off.

Claire Shrewsbury: At WRAP we have been working to try to prevent food waste since about 2007. Within the UK, the amount of food waste

went down between 2007 and 2018. Unfortunately, it then rose again into 2021. That is probably a reflection of Covid and everybody being at home. I will touch on some of the questions further in, but within England only about 46% of local authorities collect food waste. With the simpler recycling reforms that have been announced and the new burdens funding that was announced on Monday to support those local authorities that do not have food waste collection, in theory they should be in place by 2026.

We have done some research on this. Once you give a household food waste collection, they do reduce food waste because they can see the waste. Once you can see it, then you can do something about it. We do need some more research into some of those numbers but there is definite correlation. What is key for households is that they have the system, so they have a food waste caddy to put it into. We know that if you provide free liners to people then that increases their participation—that is not universal throughout the UK—and they need the motivation. They need to know why they need to do it.

We have been running campaigns. In particular, we have just run a campaign in Wales where we link reducing food waste, but then recycling food waste and that going on to being processed through anaerobic digestion to become energy again and leaning into the cost of living crisis and the fact that energy prices have gone up. That makes people understand why it is that they need to engage in that. That is what we need to do.

Lord Duncan of Springbank: Perhaps Jacob would like to touch on the other part about the cost of capturing that.

Jacob Hayler: Before I do, I will build on some of the points around the drivers. Historically, the landfill tax has been a very effective instrument at driving not just food waste or organic waste, but all waste out of landfill. Today, if you look across all of our household and commercial waste, probably about 10% of it goes to landfill. Thirty years ago, when the landfill tax first came in—it has probably flipped the other way around—it was probably about 90% of our waste went into landfill. That has been a huge driver and it has led to a massive investment programme in alternative treatment technologies. For example, every tonne of waste that is diverted from landfill to energy from waste saves about 200 kilograms of CO₂, so it has helped from that perspective.

Going forward, the two big things from us are, first, the mandatory separate food waste collections, as mentioned by Claire. There might be a question mark around the level of funding and whether that is sufficient. I think £295 million was originally announced back in the 2021 Government net-zero plan. We have had about 20% inflation since then, so that should be about £345 million in today's money. That is probably an issue for councils to look at.

The other big one for us in the future is a potential ban. We would like to see a landfill ban come in, a comprehensive ban on organic waste, but

also any form of combustible wastes. One of the things we are concerned about is that from 2028, the alternative to landfill for non-recyclable waste, which is energy from waste facilities, will be in the UK Emissions Trading Scheme. That is the right thing to do, to have those facilities paying for their CO₂ emissions, but that will raise the cost of the alternative, which does create the risk that some of that material could then go back into landfill in the future. We would like to see—and we think it is important—a comprehensive landfill ban in 2028 to complement the Emissions Trading Scheme and to make sure we do not see an inadvertent and perverse increase in emissions at that point in the future.

In terms of the costs element, it is probably surprisingly not as expensive as you would think. All these modern landfill sites in the UK are very heavily regulated. There are mandatory requirements on these sites to install gas capture equipment and there is a regulatory obligation upon them to make sure that they are maximizing the gas capture as much as they can. Those costs are recovered through the gate fee that they charge for waste when it is deposited.

The additional element to that is around power generation. When we capture the gas, what do we do with it? We have had a very good record. Landfill gas has provided a lot of generation historically. It has been supported through the renewables obligation as a support mechanism at levels that have tended to be below some of the other renewable technologies, but it has been very effective. One of the things we are worried about is that when that scheme expires, I think from 2027, there will be less of an incentive for some of the more marginal and difficult to access gas on different parts of the site. At the margin, that could reduce the incentive to generate power from the gas and do something useful with it. We could end up with more flaring than necessary.

William Maxwell: To build on the comments made about collection from Claire, it is certainly the case that to get half of the local authorities to be collecting food waste within two years is quite an ask, regardless of the money. There are specialist vehicles. We have to buy hundreds of thousands of caddies. Logistically, there is a bottleneck in getting all of this in place. That is quite a challenge.

To build on Jacob's point about the costs, I just point out that it is not just from a local authority point of view the cost of the vehicles and caddies. There is a whole logistical arrangement that needs to be put in place. When I was working for Liverpool, you had to design a scheme that will match the environment you are collecting in. If you have lots of multi-occupation properties, if you have a high student turnover, if you have all these factors, that staggers the expectations and the time required for food waste collection.

Certainly it is the case in Lancashire. Trying to co-ordinate 12 districts as a disposal authority and the county council having to manage the waste that comes back requires that collective partnership arrangement. However, it does remain welcome.

Can I just make a very quick point, Lord Duncan? You talked about upstream interventions. Your first question was on how to reduce waste in the first place. There are some interesting opportunities perhaps to build on the extended producer responsibility or EPR, where people who produce packaging also have a duty to think about the way that they are presenting food, which may not mean it gets fully consumed because you are offering two-for-one offers and people are buying more than they need because they think it is a saving. I think there is an area still to explore upstream, as you point out, so that the food that people bring into their homes does not end up as waste in the first place.

Paul Thompson: On a very narrow point around costs and particularly the electricity generation side of it, we engaged external consultants to work through a bunch of industry numbers and make sure we were pulling them together in a sensible way. The very clear message that came out of that—a brief summary of which I have shared with your researcher—was that almost none of the current generation would be able to continue generating electricity from landfill gas if it were dependent on power sales income alone—in other words, once the renewables obligation support falls away.

I will share some more detail on that, but basically that came out very strongly. Over 85% of current generation is due to lose that support in April 2027, with the remainder by April 2031. This is a very pressing concern for us. The difficulty is once you have decided to decommission that equipment and disband the teams, you have lost a lot of equipment and expertise that would be very hard to recapture if a few years later you say, “Actually, I do want to find a way of having this carry on”.

One more point on the scale of that: in 2021 that electricity generation was nearly 3 terawatt hours, which is the equivalent of about 370 megawatts of capacity. It is not as large as certain other renewable technologies, but it is certainly quite a material amount that would have to be replaced by some other means if it was not there.

Q47 **The Earl of Leicester:** A supplementary for William Maxwell. I understand that when food waste was first taken to anaerobic digestion plants, the producers of food waste had to pay about £40 a tonne to get rid of it. Is it true to say that there is now some value in food waste—£25 pounds a tonne, I have been told—and therefore that may provide some incentive to get the other 50% of councils who are not collecting food waste?

William Maxwell: In principle, you are absolutely right. The logistics are a little bit more complicated because of the split between the people who collect it and the people who dispose of it. The county council often has a disposal role and it has to work in combination with the local authorities to pass back those savings. The gate fees are volatile, but you are absolutely right that it can be virtually no cost to take it to an anaerobic digestion plant. If you are looking to send it to an incinerator, you are looking at over £100 a tonne. That difference, when you are collecting tens of thousands of tonnes, is significant.

Jacob Hayler: If I could add to that, the question would be whether zero gate fees are sustainable for the anaerobic digestion industry. I think what has happened is a lot of those facilities have been struggling to get hold of sufficient quantities of food waste. The competition has driven those gate fees down to very low and perhaps unsustainable levels. The introduction of mandatory food waste—what that should do is create a greater supply of the feedstock to enable more of these facilities to come on stream and be sustainable. William made the point about gate fees for alternatives. If you send it to energy from waste, it will be £100 a tonne. Landfill tax is over £100 a tonne, going up to £126 in a year or so. It is still the much cheaper and better option, from the council's perspective, to send it to AD.

Q48 **Lord Duncan of Springbank:** Two very quick points. I note in the briefing prepared by our clerks that in Scotland organic waste is still around 30% going into landfill. Is that an outlier, where Scotland is unusual, and it is considerably less across the rest of the UK?

Secondly, the statutory instrument that would bring in the weekly organic waste collection has not been laid, it has been delayed. Is that primarily because it would simply cost too much for councils to be able to implement it in this period of restricted funds for councils?

William Maxwell: I will excuse myself from the first question about the Scottish figures, if you do not mind, Lord Duncan. In terms of the delays, I think there have been a series of delays to the Environment Act and to the timetable to implement the measures in there. We welcome a date now, but it does not give us much time to deliver against that date.

The Chair: Would anyone like to take the Scotland question? Then we must move on, unless Earl Russell has a very pressing question.

Jacob Hayler: Very quickly, on the other issue around introducing the separate food waste collections, it is part of a much broader package around recycling reforms that are all coming together. There is a lot of complexity around that. There is a change in the funding streams from councils to packaging producers to help fund a lot of the changes. It is part of a much broader programme, which I think is part of the source of the delays.

I have not seen the briefing and the Scottish figure to which you are referring. I am very happy to have a look at that. I would be very surprised if 30% of organic waste was going to landfill in Scotland, but we can certainly double-check and come back to you.

Claire Shrewsbury: I—

The Chair: Unless it is on the Scotland question, we should move on.

Claire Shrewsbury: It was to say that 63% of Scottish local authorities collected food waste separately in 2022 and 2023. That is what we can add to that.

The Chair: Earl Russell, is your question very pressing or can it wait?

Earl Russell: If you are short of time, I will pick it up later.

Q49 **The Earl of Leicester:** I should refer to my entry in the register of interests. I am a landowner and farmer and have grown energy crops for AD plants. Indeed, I have an AD plant on my land in a landlord/tenant relationship with a company called Future Biogas.

You have outlined the fact that most of the leakage is coming from waste from landfill plants, so I think we can move on from that, which was my first question. How are methane emissions in the waste sector regulated and to what extent is there coherent regulation across the different sources within the waste sector and sectors outside of waste?

Jacob Hayler: As I mentioned earlier, landfills are very heavily regulated and have been subject to multiple directives originally originating from the EU: the landfill directive from 1999, the waste framework directive and also the integrated pollution prevention and control directive. All of these place obligations on sites to put in monitoring requirements and gas capture and collection. It is regulated by the Environment Agency in England, Natural Resources Wales, SEPA in Scotland and so on. You need to put in place the appropriate measures to control both the accumulation and also the movement of gas. There are obligations placed on you in terms of the gas collection infrastructure and making sure that that minimises the broader impacts. It is monitored through perimeter monitoring, surface monitoring, with most parameters monitored on a weekly basis, as well as taking boreholes and making sure that the equipment that has been put in place is measuring or is doing its job.

The Earl of Leicester: Do you think there are any cowboy operators out there who are escaping such monitoring?

Jacob Hayler: There are a lot of cowboy operators out there. I think that there is waste crime and lack of enforcement across the landfill sector. More broadly, it is one of the most pressing issues that we face as an industry. There are two elements to that. The Environment Agency has identified several hundred high-risk and illegal sites around the country. We think that it is an order of magnitude higher.

The Earl of Leicester: This is per year?

Jacob Hayler: This is at any given time. We think it is an order of magnitude higher. The agency does a waste crime survey, which thinks that 25% of all waste is handled illegally. There was the recent case in Kent, in Hoad's Wood, where a site had probably about 7,000 tonnes of waste dumped in an area of natural beauty. That was allowed to continue for an extended period for months. There are many, many shocking cases like that. That is one aspect.

The other aspect is the regulated landfills themselves. HMRC estimate that there is a tax gap on landfill tax of about £150 million a year. If you work out what that means, over a fifth of all the standard rate material

going into landfill is being misclassified. The Exchequer is effectively being defrauded by people claiming that this is inert material, but it is going in and contains organic material. That is not being effectively controlled.

Paul Thompson: Very briefly, on the regulator point: there is a resourcing issue here, particularly in terms of the very obvious crime. The other thing that goes along with that is resources for providing the services for people who are trying to do the right thing. A permit variation to add a new piece of equipment that would improve your operations can take quite a long time. Quite typically you could be waiting 18 months for something that seems quite trivial. It is quite a consistent refrain that you probably hear, that they are not as resourced as they should be to catch the people doing the wrong thing and they also do not have the resources to assist and check up on—but also support—the people trying to do the right thing.

The Chair: Professor Esteves, would you like to add to that?

Sandra Esteves: Yes. I do agree that—

The Chair: Would you mind leaning into your microphone? We are having difficulty hearing you.

Sandra Esteves: I hope you can hear now. Within the landfill there are frameworks for monitoring available, but there is obviously a challenge to capture the methane that is produced. On composting sites, from my understanding, there are no regulations or monitoring requirements for fugitive emissions. That is an element that potentially could help.

Within AD plants, what we see basically is that methane is a product and operators have sensors to measure the gas that they are producing at various qualities and so on. Within the permitting side of things, you have measurements around the combined heat and power emissions, for example, but related to fugitive emissions, these are not covered yet in the permitting regulations. Under the updated 2022 regulations for England, there is a little bit of an indication that emissions should be agreed with the Environment Agency, but there is not a stipulated amount as yet.

I would like to raise that, within anaerobic digestion and the quality protocol and the PAS 110, which is the publicly available specification of quality for digestate, there are elements of stability that come into play and are measured within digestates. The levels currently are quite generous, in my view. There would be potential for reducing that level of residual methane that those digestates produce, which would enable a reduction of the methane lost from the digestate store. I will probably leave it there.

Q50 **The Duke of Wellington:** As always, I declare my agricultural interests as detailed in the register. It has been an incredibly interesting discussion this morning. By the way, in the Kent example referred to by Mr Hayler, I

heard that what was particularly shocking about that incident was that the wood in question was classified as an SSI. It was very shocking and I do understand the lack of resource to detect this infringement, but it is clearly a big problem. Anybody living in the countryside knows the amount of waste that is deposited all over the countryside. That is a problem for all of us.

The set question that I have is that we need to understand how methane emissions from waste have changed over time. I think we have covered that in a number of ways, but I would like to ask about the measurement. We have been told in previous sessions and in the briefing note for this session that there has been a dramatic reduction in the last 25 to 30 years in the amount of methane emissions from landfill and from other places. How confident can we be in the measurement techniques that existed 30 years ago? We heard in another session that there was a difference between top down and bottom up and I wonder how confident we can be on that. I do not know who could comment.

The other thing that I thought I would question a bit is the very high capital cost of installing anaerobic digesters, which require quite complicated technology, and also prevention of leaks is very important. So there are two questions.

Paul Thompson: I can start off and if Jacob has anything he can add. In terms of the measurement from landfill, there are two sides here. First is what the total emissions are, and second is what happens at a particular site. I think it is fair to say that the total amount is obviously an estimate. People cannot figure out what exactly that is. It is based on a calculation methodology that is in line with international approaches for essentially understanding how much material goes into landfill and then working through, based on estimates of the composition of that landfill, how much methane will arise. How much methane is produced from landfill in the first place is, by its nature, an estimate. There have been differences of opinion on that and there is a Defra project under way at the moment, I understand, to try to refine that methodology.

When that leads into a capture rate, we measure the electricity generated, which is a number that we have a very high degree of confidence on. Also we estimate the amount of methane that was combusted via a flare, on which we have less reliable data and to some extent are reliant on surveys and then extrapolating from that to generate an average number. I think you are right to ask when we are talking about a national picture. The overall trend is clear, but there could be a significant error bar when we report those particular numbers.

In terms of site by site, we already have a lot of monitoring that is required for our permits. Some other technologies have come on very quickly in both their quality and cost reductions over the last few years. There is increasing use of satellite images; there are options on using drones. We want to get to a place where we can understand on an individual site basis: are you managing your site appropriately; are the things that we required you to do in the expectation that they would have

an impact on methane, fugitive emissions, having that impact? It is important whether we are using a regulatory regime or a financial incentive system to make sure people do the right thing.

We need to understand from a public, government and operator point of view what the link is between their actions and what the real world outcomes are. That is moving on very fast. There is clear scope for improvement over the next three to five years, which I think would help everyone.

Jacob Hayler: I think Mr Thompson has covered most of the stuff around the monitoring accuracy. The point for me to emphasise would be that, as he said, the trend is absolutely clear. We have had massive reductions in the tonnages of waste going to landfill in this country and that will correspondingly lead to massive reductions in the amount of emissions coming from that.

In terms of the capital costs for anaerobic digestion plants, I do not think that that has been the key barrier for AD projects. Certainly when thinking about using food waste as the input, the real barrier has been around lack of feedstock and feedstock availability, which is something that will hopefully be corrected once the new requirements come in for mandatory separate food waste collections.

Q51 **The Duke of Wellington:** Can I come back on that narrow point about the capital cost? I am obviously pleased to hear that it is not thought that the capital cost is a barrier to entry, but I believe it is the case that, for example, for municipal organic waste going into plants, one of the great problems has been finding sufficient nearby land on which to distribute the digestate. Is that correct?

Jacob Hayler: That has been flagged. I have definitely seen that flagged as an issue. Those AD plants have two outputs, one related to the power in most cases, or it could go to fuel or into the grid potentially. Yes, in terms of the digestate—the actual soil enhancer—you do need an available land bank in order to make use of that digestate. Yes, that has in some cases been a constraint.

Sandra Esteves: Just to add around the ability to accurately measure methane emissions—

The Chair: Can I remind you to speak up and lean in?

Sandra Esteves: We are seeing a major development around monitoring within the academic arena attached to drones and satellites specifically. There is even potential to attribute methane emissions that may be down to fossil fuel or more biogenic and recently produced methane. I think we will see in the next five years or so significantly more ability to attribute the actual methane sources and how much as well.

I would like to add that digestates are very valuable from a nutrient perspective. Of course they have to be utilised sensibly and when required, but I believe digestates can also be a re for many other

opportunities. Digestates can be utilised in microbial fermentations to produce all sorts of products. We can turn digestate into single cell protein, for example. There are opportunities around digestate use for a variety of other applications, not just the land bank, the usual outlet for digestates. The processing of digestates may help to balance nitrogen loads because a cake or fibre product may be richer in phosphate, with more liquor fraction that is richer in potassium and nitrogen. The processing can help that balance as well.

Q52 **Earl Russell:** Coming back to Hoad's Wood, that site was a SSSI. A huge amount of damage was reported over a considerable period of time by local residents and nothing was done about that. In your minds, why is that system broken to the extent it is? Is illegal dumping a big cause? What percentage is that of our methane emissions? Is it a missing bit that we should look at more?

Paul Thompson: I will give a brief answer and then Jacob can take it. The brief answer to that is we have had 10-plus years of austerity. Regulatory bodies are consistently asked to do more with fewer resources, which tends to impact morale and retention. Certainly I know lots of good people at the EA struggle with everything they are asked to do.

Jacob Hayler: Three elements of the system are broken, from our perspective. First, it is far too easy for criminals to enter the sector. The Government promised in 2018 that they would tighten the regulations on waste carriers. In 2017, a consultant registered their dead dog as a waste carrier. Journalists have registered their pets as waste carriers to illustrate the system's weakness. Anyone can pay a fee, put in a registration and be registered to carry waste. First, that needs to be tightened. The Government have said they will do something about it. Here we are, six years after they first promised that, and nothing has happened.

Secondly, we need to stop those criminals getting their hands on waste material. Waste producers have a duty of care to ensure that their waste is handled properly. It is not enforced properly. That requirement is given lip service and it is never regulated. Properly obliging the big tier 1 developers to manage their waste properly throughout their supply chains would lead to stronger self-regulation and we would not be reliant on the Environment Agency, which has a tough job running around afterwards and trying to act.

Thirdly, we need quicker enforcement action. Yes, the Environment Agency is under-resourced. Its annual budget for fighting waste crime is about £20 million, which is a fraction of what is required. It cannot tackle thousands of illegal waste sites and a fifth of all material being misclassified when it has such a small budget and such a small number of people trying to go out to tackle that. As an industry, we support using some of that permit income, which is an order of magnitude higher than the enforcement budget, to go after the criminals rather than focusing your regulatory effort on the lowest risks.

Q53 **Lord Trees:** I am interested in how you made such dramatic improvements in methane emissions from the waste sector. You alluded to it a bit and I am sure it is quite complex, but putting it rather crudely, has it been achieved mainly because you have improved separation before stuff goes to landfill and have taken more food waste out of that system and diverted it to anaerobic digestion, diverted paper and whatever, or is it due to better capture at landfill? This would tend to indicate where we should concentrate in the future on the methodology to reduce methane emissions even further.

Paul Thompson: Truthfully, it is a range of those things, but the growth in electricity generation has essentially been from 2002. In the report that I referred to earlier, we asked them to correlate the line of increasing electricity generating capacity with improvements in the reported capture rate. Again, whatever the question marks over that, the methodology is at least approved. The fit between the two lines was strong. A number of things could drive that, including tightening permits and changing expectations of how to do things, but that has played a strong role in getting people to capture it. However, fundamentally we do not want this material to go to landfill in the first place.

Q54 **Baroness Bakewell:** How interesting, what you say about the successes. In some situations we are going backwards if we cannot track or control situations that have already been improved and on which people are suddenly defaulting. Is that right?

Paul Thompson: We risk going backwards. As ever, the more you increase any penalty or tax, the greater incentive you give people to try to get around it. Anything involving tightening regulation needs to be combined with better enforcement of people who try to evade it. We also risk going backwards on the electricity generation because for the vast majority of people it will not be economically viable in a few years' time. There are opportunities to go further forward and certainly risks of going backwards.

If I can give one statistic to give the scale, we had our consultants model what would happen if there was a 1% change in the methane capture rate over a 10-year period. To do that, among other things, you have to estimate how much landfill gas will be produced. The answer that came out was that over a 10-year period, say from 2027, it would amount to 1.1 million tonnes of CO₂ equivalent, not annually.¹ When we used the government methodology for putting a financial value on that, using the green book² approach and so on, over the 10 years it came out at £321 million. That is the value plus or minus 1% change in capture rates over a 10-year period.

For people who are interested in this kind of thing, that is an undiscounted value over the 10-year period expressed in 2022 numbers.

¹ In other words, the 1.1 million tonnes of CO₂ equivalent is a total value of the 10-year period, not an annual figure

² i.e., Treasury Green Book guidance

I have shared those numbers with your researcher. Any change to this—a few percentage points better or worse—is substantial, because it is such a key part of the problem. Most things we could do to imagine how we could do this better will pay for themselves—we do not want to waste money—but it will be easy to build the case for doing this because that amount of methane is so significant.

Finally, we totally support all the attempts to get this material out of landfill, but once it is in landfill, it will continue generating methane for decades to come. Even if all the policies work as we hope they will, we still have a major legacy issue for several decades.

Baroness Bakewell: Who do we influence to change that?

Paul Thompson: We talked about resourcing. We talk a lot with Defra, which is keen to try to help because this is its headache from a climate change point of view. When we deal with the energy department, it is engaged but it is focused on a model of pounds per megawatt hour of electricity generation, which fails to account for this bigger picture. Lots of people are working on things that would make a difference, but they need to be given a greater sense of urgency and more support in the energy department, Defra and indeed the Environment Agency on these other areas.

Baroness Bakewell: Is it up to Defra to bring them together?

Paul Thompson: Defra does not have a large budget for running these sorts of things. We need a strategic grip that brings all these things together and says, "This is important".

The Chair: Excellent. Mr Hayler, you wanted to add to that. Briefly, if you might.

Jacob Hayler: From our perspective, the overwhelming driver of the reductions historically has been diversion. It has been about getting it out of landfill in the first place. One of the two big risks to that going forward—or potentially going backwards—would be around the lack of enforcement, which we have already touched upon. Another would be that the alternative energy from waste goes into the Emissions Trading Scheme and massively increases the cost of the alternative. We are worried about some of that material then going back into landfill. We strongly argue for a landfill ban and we are pressing that with Defra.

Q55 **Earl Russell:** My question is about international best practice. In what ways has the UK shared best practice internationally for capturing methane emissions in the waste sector? What more could the UK do to go further to share that? I will put that into context. Somebody said earlier that the UK is moving from a 75% to a 95% capture rate. Is there also scope to share best practice on that?

Jacob Hayler: A lot of those improvements in the capture rate are quite simple things. A lot of fugitive emissions tend to come off when the site is operational, when you work on the open face before you cap the top and

get all the emissions contained inside. Working in smaller, tighter areas is one simple way to reduce the level of fugitive emissions coming off and get those gas capture rates up. That is implementing best practice. The leaders in the landfill sector will be achieving that, but it is probably not achieved across the whole sector. There is definitely scope for raising standards across the UK sector. Some of those operators will also be multinationals and so will adopt that best practice in other parts of the world. I am not specifically aware of any particular initiatives around us sharing best practice internationally.

Claire Shrewsbury: From our point of view, rather than the reduction of methane emissions themselves, WRAP works to take the whole story of food waste reduction internationally. The amount of land required to grow the amount of food that is wasted in the world is the size of Russia, with all those associated emissions: growing the food, transporting the food and then wasting the food. Tackling food waste at a global level will help. WRAP is involved in that internationally.

Earl Russell: Do you get proper funding from the Government to spread that message?

Claire Shrewsbury: We are supported obviously in the UK to do food waste and then now, as a charity, we seek funding to do that. We recently received a large grant from the Bulmer Foundation to work in five countries around the world.

Earl Russell: But do the UK Government fund you to do that abroad in any way?

Claire Shrewsbury: Not specifically internationally, no.

Paul Thompson: I have a couple of other international things. The regulatory regime that a lot of people are working through via the permits incorporates and is based on European legislation, the industrial emissions directive, much of which we and our members were involved in developing 10 years ago. We and a number of other members are part of in particular European and other international efforts. We are a member of the European Biogas Association. The EU's Biomethane Industrial Partnership is focused on driving best practice in outcomes, cost reduction and maximising wider benefits. There is a certain amount of co-operation and learning in there. It is not being driven by UK central government.

William Maxwell: Quickly, the United Nations sustainable development goal 12.3 looks to halve food waste by 2030. It provides best practice examples of how different parts of the world are developing towards that outcome.

The Chair: Thank you. I will ask a question on behalf of Lord Grantchester, who would like to ask a supplementary. Before that, I will go to Professor Esteves.

Sandra Esteves: To conclude on the point, Wales achieving food waste segregation, AD deployment and so on played a significant role in the mandated food waste separation we see spreading around Europe and possibly even within the UK. The digestate is much better quality once it is separated at source. Also, it enables dry recyclates to find a better market with better quality. Demonstrating that it is possible to go from source-separated food waste all the way to good-quality products has been important for other countries. Countries like Australia are asking what Europe, Wales and the UK are doing. That learning is passing across the world.

We have a strong UK industry for AD and ancillary processes, which could export products and services elsewhere. That link between knowledge dissemination and knowledge transfer is done through the International Energy Agency and the trade associations, the REA and the ADBA and the universities, but a lot more can be done. More availability of funding would certainly help.

Q56 **The Chair:** Excellent, thank you. I will ask Lord Grantchester's supplementary because his microphone is not working. The supplementary is addressed to Mr Maxwell. You have worked for Liverpool City Council, which has low recycling of organic waste, and now Oxford, which has high recycling. What main differences drive that and what lessons can be learned?

William Maxwell: I point out that they are different areas geographically and demographically. Looking at recycling rates, having a settled rather than a transient community makes a huge difference. Levels of deprivation make a huge difference in the time, knowhow and understanding that people have to invest in the scheme. A large transient student population does not help because there is no consistent scheme. Liverpool has several universities and so a high turnover of people come for a short time.

Multi-occupational housing stock makes a big difference. I do not know if anybody has tried to descend a six-storey building to the basement to stand in a darkened room and pull out all their recycling into various large containers, but it is not a fun experience. The way the city is built, the way the people come and go and the level of time investment they have to put into it all matter enormously. That happens wherever you are.

At the same time, having the right scheme in place and having the right support mechanism to support residents to do the right thing also matters. Manchester, the urban neighbour, has a recycling rate of 40%, close to the national average, which is a success, as opposed to Liverpool, which I am afraid is still in the low 20s. The gap is significant.

Q57 **Baroness Whitaker:** To continue on the theme of worst practice and to move to the national scene, to what extent do organic waste collections currently run in the UK? I shall give, if I may, some personal instances of variation. I want to know what are the main barriers to national

consistency. In one rural area we are promised little bins for compostable waste in July 2024. They first came into the UK a decade ago. In one urban area where I live, the flat inhabitants put their compostable waste into a great big bin and their recycling into another great big bin. When I talked to the bin operatives—what we used to call dustmen—they told me it all goes into the same grinder fixture on their lorry. Those are two not very satisfactory procedures.

I think Claire Shrewsbury said only 46% of local authorities collect food waste. This sounds like a bit of a disaster. Can you illuminate? What is actually happening? What are the reasons why it is not better?

Claire Shrewsbury: Yes, I can take that. Waste is a devolved policy area. Each of the individual nations has its own individual policies and drivers. We work in Wales, which has 100% coverage of separate food waste capture, collections—

Baroness Whitaker: Not just capture. What do they do with it once it gets into the lorry?

Claire Shrewsbury: It is collected separately and then goes into an anaerobic digester in the main. There might be a little bit of composting, but it certainly is not all put back in together. In Northern Ireland, everywhere you can collect your garden waste, you can put food in, which is not ideal. Separate food waste collection in Northern Ireland is quite low. It is in the 30s, but a consultation is going on to address that and see if that is separate. That material does not go through to anaerobic digestion, it goes through to closed composting.

It is different across the nations, but simpler recycling coming in gives the opportunity to capture that material. It is true that even in high-performing areas about 60% of what could go into the separate food waste collection is put out for that. We need to work harder on that. As I was saying earlier, we need to make sure people are motivated to put their scraps—hopefully non-edible food because we do not want them to have edible food to throw away because we want to prevent that—into those food caddies to be collected separately.

Baroness Whitaker: What sort of motivation would you suggest: sanction, financial incentive?

Claire Shrewsbury: The clearest evidence suggests that we should restrict residual collection. Reducing the frequency of collections is the cheapest option. If you have fortnightly, three-weekly or even four-weekly collections, nothing left in that bin is smelly and attracts rats, as in the newspaper headlines. Everything should be out. It should be pretty inert material. That gives councils the opportunity to operate less frequent collections. That is the cheapest option. Giving a restricted bin, a much smaller vessel, is a key motivator to moving people to do the right thing not just with their food waste but with all their other recyclables.

Baroness Whitaker: I will not pursue that, but I am not sure how popular it would be with—

Claire Shrewsbury: It is not popular at all.

Jacob Hayler: I—

The Chair: If you can keep your comments short, I would appreciate it.

Jacob Hayler: Yes, sorry. I will challenge the notion that once organic waste and dry recycling is separated by the householder it would then be mixed together. That does not happen. First, it is not allowed. Second, it might go on the same vehicle but there might be separate containers on the same vehicle. It would make no sense whatsoever because it would contaminate the recyclate and completely undermine the economics of it. It would make no sense whatsoever and so that does not happen.

William Maxwell: It makes no sense but it does happen. It is a PR disaster and we try to avoid it at all costs. I will tell you why it happens. Sometimes the food waste has been contaminated so badly that we cannot pass it on to the anaerobic digester. If people are not choosing to use the separate containers and are mixing them up, we cannot sell on the material, either the dry mixed recyclate or the food waste. Secondly, occasionally the bins fill up and the truck breaks down and we have to empty it or we will have a problem with overspilling, but we try to minimise those occurrences because of how it appears to the public.

Jacob Hayler: That is not standard practice.

William Maxwell: It is not, no.

Baroness Whitaker: It is a big central metropolitan block of flats where I have seen it going, but perhaps it is very unusual.

Q58 **Lord Trees:** To some extent my set question about the barriers to achieve higher organic waste and recycling has been answered, but one specific issue within that and within our notes is the SI, which has not yet been laid in Parliament. You are not the right people to make an analysis, but what is the delay, as far as you are concerned, in putting a statutory instrument in place to require these frequent food waste collections?

Paul Thompson: The perception certainly is that this whole process has taken a lot longer to go from the Government saying what they had in mind, to saying what they wanted to do, to doing it. I do not want to speculate about the motivation of the people behind it, but it makes it harder for the people who want to take prompt actions to make these investments. We must do this because this is definitely happening. Of course those people who wish to play for time, thinking it will never happen or the Government will delay it, are encouraged by it. Things taking a while sends the wrong message and we are perilously close to the deadline for when all these things are meant to be implemented.

Jacob Hayler: Part of the challenge is that it is not just separate food waste collections but it is this wider package of complicated reforms, which have all sorts of different interests. One reform is around packaging producers having to pay significant sums of money for the

collection and recycling of packaging. They have a certain interest. Local authorities and local government will have different interests. That creates complexity around the policy. The Government announced their resources and waste strategy in 2018. Almost six years later, they have not worked out precisely what they are meant to be doing. Okay, they can blame Covid for some of the delays and political turnover in the department is also unhelpful, but here we are almost six years later and they still have not done it.

Lord Trees: One for the Minister when we get him, maybe.

Q59 **The Chair:** Excellent. Shall we move on? I have a question here. Where can further reductions in methane emissions from the waste sector be found? Ms Shrewsbury, you mentioned large amounts of food waste that maybe needlessly arise. Are we in danger of using food for fuel unless we tackle sources at source? Could you touch on the amount of food waste at the farm gate, from the retail sector as well as the domestic sector? Professor Esteves, you mentioned slurry as a source of large emissions of methane. Could you touch on that? Going back to Ms Shrewsbury, you mentioned packaging. Paper and cardboard generate large amounts of methane. Can we do anything to tackle that source?

Claire Shrewsbury: To put food waste into perspective, I do not have the absolute figures for food waste from farm, but we have it and we can forward that on to you. In general, 70% of all food waste arises in the home. The perception is that it is in a supply chain. At WRAP, we work on a voluntary agreement with businesses to tackle supply chain food waste and redistribute food when it does arise. In the food waste hierarchy, food should be used to fuel humans before it then maybe goes to pets, but the uncomfortable truth is that 70% of it occurs in the home and that is where we need to tackle it.

The Chair: Briefly on packaging, while we are with you?

Claire Shrewsbury: With packaging, it is about getting the paper and the card away from landfill. The collection rates are pretty high now for that sort of material.

The Chair: Excellent. Can we move to Professor Esteves and then open it up to the other panellists if they want to add anything?

Sandra Esteves: One of the largest challenges with animal slurries is adopting energy generation at distributed farms. The size of farms may not be conducive or economically viable to deploy AD technology with biogas capture, but there are concepts around deploying centralised AD facilities between farms. A method can take the more slurry cake part is collected and treated centrally. We also study other concepts, where you take volatile fatty acids out of that slurry and leave behind the fibres to produce biochar on farms and then centrally treat that volatile fatty acid element. While you do that, you can reduce nutrient levels and produce more bespoke fertilisers. You can also reduce the risk of moving bacteria from farm to farm, which is another possibility. Innovation is occurring

related with animal slurries storage that will allow better management from those as well.

Other things can be adopted. While nature has given us methanogens, nature has also given us methanotrophs. These microbes can reduce methane levels in atmospheres or in residual amounts in exhaust gases and so on. There should be more push to use these technologies to treat that residual methane, whether it is from slurry stores, digestate stores or upgrading of biogas systems. There is potential to degrade it, but we have to do more R&D and then follow with the deployment of those technologies.

There are a considerable monitoring and control strategies that can be implemented for AD plants, where we can reduce the time of digestion and also recover a lot more methane. We have delivered improved recoveries of up to 50% more gas in some plants. Technologies and know how can be deployed and dissemination of that is important.

Q60 The Chair: Thank you. Before I open this up to the other panellists, can I add another question about how our methane emissions are monitored? Who carries out the leak detection and what do they do with that data?

Jacob Hayler: The site operator is under an obligation to take usually weekly readings, which will include methane, carbon dioxide and some other parameters. Those will all have to be reported as part of their permit to the regulator, being the Environment Agency in England and the corresponding bodies in the other devolved Administrations.

The Chair: Is that a statutory requirement only for the permitted ones?

Jacob Hayler: That is for permitted landfill sites, yes.

The Chair: How many are not permitted?

Jacob Hayler: That would be going back to closed historic sites. All open operational sites today will be permitted unless they are completely illegal sites, like the ones we were talking about before. In landfill terms, some closed sites would not be subject to the landfill directive requirements, but those would be old sites going back decades.

The Chair: Thank you. Would anyone else like to add anything on detection?

Paul Thompson: I wanted to add an opportunity for improvement, not so much in innovation but in best practice. That is driven in the biogas sector through professionalism. The whole thing started with lots of people trying out things on a small scale—small-scale farm things as adjuncts to individual businesses, which has produced quite a lot of learning. People who are used to measuring and tracking and asking questions about this kind of stuff now manage these plants as part of wider portfolios. The trend towards professionalisation in the sector is broadly good. Combining that with increasing improvements in the regulatory system—both the expectations but also the monitoring

techniques we use, so that we are not just saying, “Do more of this” but, “Do better targeted, more accurate things”—it is the more we can make use of that. Those two should reinforce each other.

The Chair: Thank you. Before we move on to Lord Ravensdale, I have a quick question. It would be useful to know how much residual meat is wasted.

Claire Shrewsbury: I do not have those figures but I can certainly get that for you.

The Chair: If you would not mind, it would help our inquiry going forward. Lord Ravensdale.

Q61 **Lord Ravensdale:** Thank you, Chair. I will first declare my interest. I am a chief engineer working for an engineering consultancy at AtkinsRéalis. I have a few things to pick up there. The theme of the end of the renewables obligation scheme has come out quite strongly, which is not that far away. 2027 was mentioned. Would any panellist like to mention the schemes being considered to replace the renewables obligation scheme? What should be considered to replace that and keep energy from waste plants going?

Also to pick up on the points made around innovation and novel technologies, some have been mentioned already, but could there be a bit more on some of the future technologies? Methane-eating bacteria has already been mentioned, so maybe provide a bit more on the readiness level of some of these technologies. Also, what plans are there for carbon capture and storage in the sector? Maybe you could wrap up on some of these novel technologies, Paul?

Paul Thompson: If I can take the energy questions, I will defer to others on the other innovation engineering questions. I am happy to say a little bit on the CCS as well. The simplest alternative is to extend the renewables obligation for a while, which is politically difficult because it is a closed scheme. We have engaged closely with the energy department on policy around the contracts for difference scheme, which is the live electricity scheme. It did consult earlier this year and we responded. This was around repowering things, taking an existing thing and allowing it to continue for a period. The difficulty is that they have been told to develop this policy in a narrow silo. When you look at it purely as pounds per megawatt hour, landfill gas or electricity is pretty good value, but it is more expensive than solar or onshore wind.

One criteria they set was that you must be sure that the total capacity must not decline over the period. The landfill generation will decline because closed landfills produce less gas over time. The answer they came to was that it should not be included in that policy, which is okay within those rather narrow confines but is not sensible in the bigger picture.

The other option is to upgrade this gas and inject it into the gas grid, which is technically possible but is not currently supported under the

existing biomethane policy. It might be in future but the Government are at the early stages of developing a future framework. The difficulty is that this technology has not been deployed in the UK yet. It has been deployed only quite a small amount elsewhere in the world. It is difficult to get any idea of real cost details of it. However, it is likely to be viable only on large-scale sites. Our initial run through that is 10 to 12 maybe, at best. It may be an opportunity for some, but not for the majority.

The long-term answer is to have a policy, probably managed and owned by Defra, on paying you to do things that you would not otherwise do that involve methane results. It would take a little bit of time to set up. It would almost certainly need primary legislation. We need to reach the end point of all the various searches that are on at the moment so that we can be sure that whatever is done is robust.

The solution we propose is to use the tools we have for interim support so that the teams we have are not disbanded and can continue for a while, then whatever long-term policy we put in place will be able to make use of a going concern. I do not particularly want to get drawn into large-scale biomass power, but the Government have proposed a similar flexibility for interim payments for solid biomass power hoping to do CCS, essentially aimed at Drax and one or two others. When they are convinced of the need to do it, they are prepared to be much more flexible on an interim arrangement. Particularly on this methane side, it is a similar case for enabling us to hold on to what we have, not go backwards over the next few years, buy ourselves some time and then put in place the long-term policy that will be based well on evidence, that we can have confidence in and that is value for money.

Lord Ravensdale: Briefly, you mentioned the pound per megawatt hour comparison with wind and solar. Do you have the approximate figures for the levelised costs of electricity and where energy from waste sits compared to others?

Paul Thompson: Yes. Most of the landfill is getting 1 ROC—renewable obligation certificate—per megawatt hour. Translated into CfD administrative strike prices, if that makes any sense to you, that came out in 2022 prices at £80 per megawatt hour. That is the total income we would need both from power sales and from an additional top-up. The number required as a mean point from the research we commissioned was £93.09 per megawatt hour. When the REA started, it was one of the cheapest renewable technologies you could have. It is not so much that it is become massively expensive but that wind and solar have dropped in price considerably. Some of our analysis shows that this is still good value for money for electricity, but you will always be able to point to something else that is cheaper.

Of course, the approach we have tends to treat all megawatt hours as equivalent. We do not measure the value you get from baseload electricity as opposed to those periods when wind and solar are not available. That is not an anti-point on them at all, but the current system

does not value the avoided system management costs that that electricity gives you as opposed to some other things.

AD and CCS have a huge amount of opportunity. There is a lot of investment in trying to make CCS work at a large scale as a key part of the Government's decarbonisation strategy. Assuming all that infrastructure is put in place, a biomethane plant connecting to the gas grid has the advantage that it started off with biogas, roughly half methane and half CO₂, and has already taken out a relatively clean supply of CO₂. It has done the expensive and hard bit. Assuming the infrastructure is in place not too far away to drive it there and inject it, we can see the ability to do that as viable.

Indeed, the AD company on your property is a leader in proposing that. That gives you the prospect of negative emissions because that is biogenic CO₂ and so the net effect of that, if you manage it properly, is that less CO₂ is in the atmosphere than there was previously. It is definitely an opportunity. If you can make that work, the economic case for doing these plants gets turned on its head because suddenly the amount of needed ongoing subsidy is small, if any, once you have captured the real value of those emissions within our economic model.

The Chair: We are up against the clock, so please keep your comments brief. I will pass on to the Earl of Leicester when Lord Ravensdale has finished his line of questioning.

Jacob Hayler: I will focus more on the landfill site levels. You can do novel things. People think about biofiltration, which oxidises some of the methane and will reduce its global warming potential. At that sort of level though, I query whether it is necessary. The big things are, as we have already talked about: first, stop sending stuff to landfill in the first place and reduce the inputs, and secondly, manage sites more tightly to get the capture rates up to 90%, potentially.

Carbon capture and storage is capital intensive. It will never happen on a landfill site, but energy from waste facilities, the alternative to landfill, are among the first track of projects currently negotiating government support. They are at scale with 1 million tonnes of CO₂, for example, per annum captured. To me, that reinforces the notion that we should divert this material out of landfill and into that alternative.

Lord Ravensdale: Thank you. Professor Esteves, briefly, what is the technology readiness level of the methane-eating bacteria and other innovations you have mentioned?

Sandra Esteves: We worked on solubilising methane. Although it is okay to solubilise methane, say in comparison with hydrogen, doing that has challenges. We have been working on reactors that do that effectively because we want to reduce parasitic energy consumption with those processes. The developments are getting there, but yes, we need R&D and innovation funding to bring up the TRL of those processes.

CO₂ has been mentioned. There is a lot of interest within the biogas industry. It is a good feedstock. The CO₂ is available, especially in upgraded biogas plants. What do you do with that CO₂? You normally need to excite it with hydrogen in order to produce exciting molecules, but some microbes—for example, phototrophs—can do that without the need for an electrolyser and producing that hydrogen in the first place. A lot of developments are in course, but further R&D and dissemination and knowledge transfer will be required for those.

Q62 **The Chair:** Excellent. We are a minute over time, but I want to give the panellists an opportunity to make any remarks that are important that have not yet been made.

Paul Thompson: I have one, briefly, that we nearly talked about but we did not. When capturing the food waste, quality of food waste is essential. It is best to avoid particularly plastics being in there in the first place, which is about education and management at every stage of the chain, starting with householders.

The Chair: We will go a little bit over time with Claire Shrewsbury and then Earl Russell. That is not a question, I hope. Ms Shrewsbury.

Claire Shrewsbury: We have talked a lot about collection of food waste from households, but we have the opportunity to collect food waste from businesses as well. If we take it out of all the households, we still need to take it out of the businesses, especially in the hospitality sector. That is a good opportunity.

Jacob Hayler: That is due to come into effect next year, but as an industry we have a fear around enforcement. We have already talked about how stretched the Environment Agency is. Will it have the resources to police the introduction of separate food waste collection from businesses? When it was introduced in Scotland, relatively low levels of participation were not particularly helpful for people who had invested.

The Chair: I am conscious, as you have raised it, Ms Shrewsbury, that we have not discussed behaviour and how the Government or bodies like yours can influence that. Maybe you can write to us with any thoughts on that after this meeting. With that, given it is 11.33 am, it remains for me to say a huge thank you to our panellists for sharing their expertise with us. It has been much appreciated, thank you. With that, I formally end the public session of the meeting.