HOUSE OF LORDS

Environment and Climate Change Committee

Uncorrected oral evidence: Methane

Wednesday 20 March 2024

10 am

Watch the meeting

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

Evidence Session No. 2 | Heard in Public | Questions 23 - 43

Witnesses

I: Professor Matt Rigby, Atmospheric Chemistry Research Group, University of Bristol; Professor Grant Allen, Earth and Environmental Sciences, University of Manchester; Dan Wicks, Managing Director UK, GHGSat; Glen Thistlethwaite, Technical Director, Air Pollutant and Greenhouse Gas Emissions Inventories, Tools and Projections, Ricardo.

Examination of witnesses

Professor Matt Rigby, Professor Grant Allen, Dan Wicks and Glen Thistlethwaite.

Q23 **The Chair:** Good morning and welcome to the House of Lords Environment and Climate Change Committee. This morning we will take evidence for the second session of our inquiry into methane, looking at the measurement and monitoring of methane emissions.

I extend a special welcome to our panel of expert witnesses and thank them for making time in their busy schedules to be with us. I remind all attendees that the session is being broadcast live and subsequently will be available to view via the Parliament website. 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 also remind members that they should declare any relevant interests the first time that they speak.

Before asking the first question, could each of our panellists briefly introduce themselves?

Dan Wicks: Good morning and thank you for having me. I am the managing director of GHGSat, which is a private company headquartered in Montreal. We own and operate a constellation of satellites purposefully built for the detection of methane. We use them to work with businesses globally in the detection and mitigation of their methane emissions.

Professor Matthew Rigby: Good morning. It is a pleasure to be here. I am from the University of Bristol, in the school of chemistry. My research is about trying to understand sources of sinks of greenhouse gases. I am part of the UK's greenhouse gas monitoring network, which is known as the DECC network.

Glen Thistlethwaite: I am a technical director at Ricardo. I have been working on UK greenhouse gas and air quality inventories for over 20 years on both greenhouse gas and air quality pollutants, mainly for DESNZ and Defra.

I am a UNFCCC[1] Lead Reviewer, which means that I lead expert teams reviewing submissions of other Parties to the Convention and under the Kyoto Protocol and, in the future, under the Paris Agreement. I was a contributor to the design of the IPCC Refinement[2] in 2019, so I had a role in developing methodologies for greenhouse gas reporting, which typically flows down to the kind of monitoring reporting systems that are prevalent in the UK and elsewhere.

Professor Grant Allen: Thank you for the invitation. I am the chair of atmospheric physics at the University of Manchester. My research is into

[1] United Nations Framework Convention on Climate Change

[2] Intergovernmental Panel on Climate Change (IPCC) "*2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*" Ref: https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

greenhouse gas budgeting, from the global scale right down to the site-specific scale. Along with Professor Rigby, I work with the UK's measurement network and develop different technologies for accounting for methane at different scales.

Q24 **The Chair:** Before asking the first question, I refer to my registered interests as per the Parliament website. I would like to mention that I am a director of Peers for the Planet, which is a non-remunerated position.

My first question to the panel is: how are the UK's methane emissions tracked and who is responsible for data collection and reporting?

Professor Grant Allen: At the moment, our emissions are reportable to the UNFCCC. Glen Thistlethwaite will be able to say a lot more about that in a moment. Our methane emissions are tracked by both what we call a bottom-up method and a top-down method. Bottom-up methods refer to a modelling-based estimate—a best guess based on emission factors and activity data for different sectors that contribute to our emissions in the UK. Top down refers to an attempt to validate those emissions through direct measurements, which Professor Rigby is very much involved with. I think that Glen and Professor Rigby will be able to say a lot more about that.

As well as the formal UNFCCC reporting, there is also a lot of activity in academia through work funded by the Natural Environment Research Council or United Nations Environment Programme, which is academic in nature. They are typically focused studies—we have many examples that we have worked on over the past 10 years—to target specific sectors, such as oil and gas or landfill waste. That data is typically in the academic realm, but we would like to make better use of it in the inventory. That is something we are keen to work on.

Professor Matthew Rigby: As Grant said, one of the things we are involved in at the University of Bristol is evaluating the national inventory, which Glen can talk a bit more about. We do that primarily through a system called the DECC network. This is a network of measurement stations around the country. The sites are mostly on telecommunications towers, where we draw air down from a couple of hundred metres up in the atmosphere and measure the concentrations of greenhouse gases in a lab at the bottom of those towers.

We can then use atmospheric models to simulate where the air came from before it was measured at these sites. That is a process we refer to as inverse modelling and that is how we get top-down emissions estimates. These measurements are sensitive to scales of maybe tens or hundreds of kilometres around the measurement sites. With this network, we can learn about UK-wide emissions, or possibly on slightly smaller scales than that.

It is fair to say that the UK system is pretty unique and very mature globally. We are one of only three countries—possibly four now—which are reporting this kind of top-down emissions evaluation along with our inventory every year. We have been doing that since 2004. It is something that we are regarded as world-leading at, which is positive.

I will leave it there and maybe Glen can say more about the inventory side of things.

Glen Thistlethwaite: The inventory is the primary mechanism by which the UK reports its progress towards international and national targets. It is the dataset that pulls together all the bottom-up information and the best evidence from across the UK from every anthropogenic source to inform our progress to the UNFCCC and for carbon budgets. It is also used for things like subnational tracking—for example, the Scottish and Welsh government targets.

It is based on methodologies that are all consistent with the Intergovernmental Panel on Climate Change methodologies. It is reviewed annually by expert teams from the UNFCCC. In that regard, it is similar to many of the other developed countries' submissions to the UN. It has had many years of development, improvement and QA associated with it.

It is different to the measurement techniques that Grant and Matt have spoken about, as it is bottom up and source specific. This is important for the resolution of data and to understand policy relevance and the opportunities for mitigation. We have to be able to get the source resolution best estimates for agriculture, the energy sector and waste management, for example, so that we can understand what levers we need to pull as we move towards net zero.

Crucially, the inventory stands on the shoulders of all those data reporting mechanisms. That is an important point to make: the inventory cannot manufacture data; we stand on the shoulders of all the regulatory and reporting systems underneath, which are implemented through regulations or through financial or voluntary mechanisms. This gives us the evidence that we need for each source. We put that together, consistent with the IPCC guidance, and it is used for carbon budgeting.

Q25 **The Chair:** We have heard a couple of mentions of top-down and bottom-up measurements. To what extent do the two measurements correlate? We have heard some concerns that estimates are relied on too heavily and that maybe more direct measurements are necessary.

Professor Matthew Rigby: First, the bottom up and top down are completely complementary, and we need both for the reasons that Glen gave about sector-level attribution. The top down, at the moment, provides a large-scale constraint on the total emissions from the country.

You asked about the level of agreement. In the last decade, there has been very good agreement at the national scale between the top down and bottom up. That is encouraging.

The problem comes as we look further back in time. If we go back to the 1990s, there is a large discrepancy between the estimates. The top-down estimate is about half of the bottom-up estimate at the time. That is obviously concerning but it is really important for understanding the trend of how much we have reduced our methane emissions. There is a discrepancy between the two.

As we are looking at historical data, it will be very difficult to go back to try to figure out what was going wrong with one system or both. We are working on it and the inventory teams are working on it, but there is still some uncertainty. It is important to say that we need both systems in place as we continue towards net zero so that, if similar discrepancies arise, we can start to pick them apart.

Dan Wicks: There are a number of studies that suggest disagreement between bottom-up estimate approaches and direct measurements. There is clearly work to be done to better characterise direct measurements, particularly as we want to transition that understanding of emissions through to attribution to a particular process or facility. That is where measurement is particularly important.

Q26 **Lord Giddens:** I add my welcome to that of the chair; it is really good to have you all here. How are methane emissions from different sectors measured and reported in the UK? Perhaps you would like to comment on the areas in which there are greatest difficulties in generating adequate data. Would you like to begin, Mr Wicks, or are you too orientated towards Canada?

Dan Wicks: I would defer perhaps to Matt or Glen on this.

Professor Matthew Rigby: I can say something very briefly on the national-scale top-down side of things but I know that Glen and Grant will have interesting things to say on that.

From the DECC network perspective, we think we can say something about the large-scale attribution of methane to agriculture, waste and fossil fuels. At the moment, that is mostly based on how those sources tend to be in different places around the country. We think the network has some selectivity for the different sources. However, the system needs work, and it is part of ongoing research projects.

We are investigating things such as using trace gasses that are co-emitted with methane from gas leaks, for example, as a way of teasing apart that source from other sources. We can talk about that more later. Glen can certainly talk more about how sector-level attribution is done in the inventory.

Glen Thistlethwaite: The bottom-up estimates—the inventory estimates—are not often based on measurements. Methane is a more difficult gas to obtain measurements for regarding a lot of the diffuse sources that are concerning areas for the inventory or that are difficult to estimate. We follow IPCC methods, but there is very little in the way of bottom-up measurement for diffuse sources across large areas—for example, across a landfill site or an installation where there might be lots of small leaks from infrastructure. Those are very difficult to monitor in situ.

As a comparator, we have a very good dataset for carbon dioxide. For a lot of combustion and process sources, it is a relatively straightforward process to gather the relevant activity data, understand the carbon content, assume an oxidation factor and come up with an estimate.

With methane, we are often trying to model complex biological processes, for example, the degradation of waste within landfill, and the use of carbohydrate within the stomachs of livestock and how that reacts and emits methane through enteric fermentation. These are complex processes that are not straightforward to obtain data for. We cannot go around monitoring every cow; we have to do something and do our best research to understand the herd, in that instance. We have to look at what evidence we have, what trials we have done and what production systems are represented by that work. We build up the bottom-up estimate per sector based on the best available UK research, but there is not much in the way of measurement at source unlike for some other gases.

There are some instances of that. If you look at the UK submissions under the Pollutant Release and Transfer Register—this is regulated by environmental regulators, such as the Environment Agency, SEPA[3], NRW[4] and NIEA[5]—out of about 300 installations that report over 100 tonnes per year, a small proportion of them report measured estimates. Those are mainly from the oil and gas sector.

A lot of the other sites, such as large landfill sites, are using models to estimate [methane] and to look at the inputs to their landfill sites and the degradation rates of waste. They are looking at what they can see being [6] captured and used in engines and flares. Each sector has a different approach in the inventory estimates, but there are many sectors where a UK-specific model has been developed.

Another example would be the downstream gas sector, where the Joint Office of Gas Transporters has a working group—a shrinkage working group—in which it develops models to try and best reflect the infrastructure that is delivering the gas to our homes and buildings. It looks at all of the different bits of infrastructure along the way. It has done trials to estimate the leakage rates of those bits of infrastructure and has come up with a model which gives a best estimate. But that is not measurement[7]; that is taking measurement of the gas content. There

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[3] Scottish Environment Protection Agency
[4] Natural Resources Wales
[5] Northern Ireland Environment Agency
[6] This is in reference to the monitoring of landfill gas being used in engines and flares on landfill sites, for which good date are generally available from energy statistics
[7] For example: the model does not use *emissions* measurement, but the model does use gas compositional measurements specific to UK gas supple, as part of the calculation approach

are elements of monitoring in there—we use gas compositions that are specific to UK circumstances, for example—but it is not actually a measurement that is similar to how it would be in a power station or refinery stack, which can be done in a discrete or continuous way.

Lord Giddens: Professor Allen, I note that you work extensively with satellites. We will come to that later in discussion, but you might want to shove in a bit about those, because it is so important at the moment, around the edges of consolidating the data.

Professor Grant Allen: Yes, that is right. I do not just work with satellites but with drones and aircraft. A lot of the research takes place in academia, much of which we have been involved in, with direct measurements. For example, there have been case studies of total methane emissions from London or from the oil and gas sector offshore through United Nations projects. Whenever we do those kinds of focused, measurement-led case studies, we sometimes find disagreements between the inventory and what we measure in a case study approach.

As Professor Rigby rightly mentioned, the national network inversion—the validation of the inventory—is very good for national-level emissions accounting. However, it does not get to the sector or site level. That is where the challenge is, both in academia and inventory accuracy: what is going on at the sector and site level? Whenever we do those kinds of case studies, we typically find discrepancies. For example, our 2012 study for London and a follow up in 2016 showed that the measured methane emissions for London were underestimated in the inventory by a factor of around 3 in the 2012 case, but over-estimated by around 30% in 2016.

One of the challenges with the methods we use for top-down accounting, is that quite often they measure the net emissions from a collection of sources. You can have situations in which there might be sinks or emissions from the natural environment that you might not want to account for in the anthropogenic or man-made emission sources. That is a challenge for both the modelling approaches and the measurement approaches.

Even with that said, the measured discrepancies we see when we compare to the inventory are likely to be much larger than those compounding factors alone.

Q27 **The Duke of Wellington:** I declare my agricultural interests, as detailed in the register. Mr Thistlethwaite, you just said that, of course, it is impossible to measure the methane coming from every cow and that you have to model it. Have you done any work on—or do you have an idea of—the difference between the emissions from a cow that is grazed on grass and fed in the winter on silage, i.e., a cow with pure grass in their diet, and a cow that might be fed partially or mainly on concentrates? Presumably the emissions are different. How do you model that?

Glen Thistlethwaite: I will have to declare that I am not an agriculture sector domain expert, but I do work with the team of researchers who have developed the agriculture inventory and all the methods underpinning that. That was developed through a large investment by Defra around 10 to 15 years ago to do extensive field trials with many thousands of data points to characterise the UK herd and its different production systems and different feeds. There are far more able professors around the country than me. In a written submission I can indicate the key people who have developed those methodologies.

The key work has indicated that dry matter intake primarily drives the enteric fermentation methane emissions, which is the largest proportion of agricultural methane emissions. The annual inventory methodology takes in detailed statistics on the herd—by breed, by type, holding level data, the weight and the killing out percentage. There are a lot of parameters that are put into the equations that derive the estimates.

One of the challenges going forward is to gather sufficient evidence to confidently assess the mitigation impacts of the various feed additives and the changes coming into the sector. This is an area that is common across the inventory where there are emerging technologies and mitigation actions; sometimes we are running ahead of the evidence.

We need a big investment in research to understand exactly what the impact of different feed approaches et cetera will be in different circumstances. The inventory is set up to accommodate that. It is done at a very detailed level. It is basically a grid inventory of 10 kilometres by 10 kilometres that is built bottom up. It takes all sort of climatic and soil characteristics into account so that it can model the emissions as accurately as possible. It is world-leading in that respect and very different to most other country's inventories. It is done at a very high resolution, which means that it is capable of accommodating future data around mitigation actions and changes in feed and nutrition.

However, there are challenges, certainly around emerging mitigation actions, and we need investment in research to fully be able to characterise and find out if the information we get from the laboratory studies is representative of what is happening out there in the different production systems.

Professor Grant Allen: It is really interesting science. There is a very good team of researchers at Royal Holloway, University of London, who study emissions from cattle. They do studies of breath and look at the potential interventions on feed that might impact enteric fermentation. There is some research on this and some very interesting things that agriculture is adopting voluntarily to mitigate emissions. This includes, for example, methane capture from slurry for energy generation. It is a sector that will naturally have emissions to do what it does, but there are some really interesting ways to mitigate or capture those emissions.

Q28 **Baroness Whitaker:** We have a lot of distinguished academic expertise, both in academic circles and in allied private sector organisations. I would like to turn to the role of government at the national and local levels. Who is responsible for verifying methane emissions? There are some differences of opinion in academic work sometimes. Where does responsibility for monitoring and enforcement for reporting lie within government? I do not just mean the department; if you are able to say which unit or postholder that would be very helpful.

Could you also go beyond agriculture? We hear a lot about agriculture, but I do not personally understand how it works with landfill or oil and gas. What can you tell us about that?

Professor Matthew Rigby: I can say something very briefly about the top down, but I will defer to Glen again for a lot of the detail. From the top-down perspective, it is important to say that, as far as I am aware, there is no requirement that we do this top-down evaluation. It is considered best practice in the IPCC guidelines, which lots of UK academics and inventory team members have been very important in crafting. It is considered best practice and we do it for that reason.

The responsibility in that respect is via DESNZ. The inventory team in DESNZ funds the UK monitoring network and the associated activities. The University of Bristol and the Met Office—Alistair Manning's team there primarily—put together this annexe to the national inventory report along with other partners such as the National Physical Laboratory and the National Centre for Atmospheric Science. From the top-down perspective, that is where the responsibility lies. On the finer scale regulation, I defer to Glen.

Baroness Whitaker: You say that there is no requirement. Is there no need for a requirement? Is the sharing of best practice and good will enough?

Professor Matthew Rigby: I am biased here, but I think that there is absolutely a need for this evaluation. We have learned an awful lot about the inventory from doing this activity. As Glen was indicating, there is a lot of information in the inventory that comes from a whole variety of places. A lot of it is based on modelling. I think it is essential that we have some top-level check that the numbers we are getting out of there are consistent with what we see in atmospheric data.

While it is not required at a national level, we are seeing more and more countries adopting this practice of atmospheric monitoring. A lot of countries are doing this now. At Bristol we are leading a European research project with eight other countries. We are going to try to adopt similar practices in these eight European countries, so that they all start submitting annexes to their inventory reports.

Baroness Whitaker: But you are not encouraging a requirement for other countries which are not so good at it.

Professor Matthew Rigby: As I said, there are only three countries in the world that do this as a best practice: us, the Swiss and the Australians.

Dan Wicks: I will just stress that there is some detachment between our inventory reporting and the requirements in an operational context. Typically, when the regulatory authorities and the other bodies that have some responsibility for this—Ofgem, the Environment Agency, the Office for Environmental Protection and the North Sea Transition Authority—are managing this on a daily basis, having good access to data, particularly about fugitive emissions, is necessary to take action. We are not necessarily capturing that level of granularity within the inventory work that has been described.

Baroness Whitaker: That is very diffuse. Is it co-ordinated within the various authorities?

Dan Wicks: There is some co-ordination through DESNZ and Defra. However, there are individual requirements within departments and agencies that are managed in an individual way.

Q29 **Baroness Whitaker:** Does anybody have any information about the role of local authorities with regard to landfill, because they are the government too?

Glen Thistlethwaite: I will jump in on a few issues. I take issue with Grant's comment on agriculture: there is an awful lot of research going on in lots of academic areas. There are a huge number of universities that are working on the development of understanding of mitigation actions. Defra is funding a large dairy demonstrator programme[8] to test the use of additives into feeds for cattle and the impact on the herd.

Moving on to the local authority role, DESNZ is the overall responsible single national entity for the national system—for all the reporting that feeds the evidence for the inventory. That flows down to the regulators at the different levels of government. There are DA-level regulators. SEPA and the Environment Agency have a big role on some of the industrial sectors.

Then there is the smaller scale. For waste management, as you rightly point out, there are many different sizes, scales and ages of landfill. The larger ones fall under the Environment Agency, SEPA, NRW and NIEA control, but some of the smaller ones fall under local authority control.

Regarding inventory data, we do not get access to information from the local authority-regulated landfills, but a lot of work has been done over many years to try to characterise the different types of landfill and obtain data on the waste deposited there. An IPCC methodology, an organic degradation model for decay, models the production of methane from different components deposited within the landfill.

To return to Matt's point about the discrepancy in the 1990s between the observations and the inventory, for both channels there are greater uncertainties in those years. As Matt will acknowledge, the verification

[8]Originally stated the incorrect title, Dairy demonstrator: systemic testing of multiple carbon saving measures in practice. See: https://tenderbase.co.uk/find-tender/1254431

work was in its infancy and had only one site from which to get the measurements. Now, we have a tall-tower network of multiple sites, so we have lower uncertainties in the back trajectory modelling that Matt and the Met Office—Alistair Manning and co—conduct, and in the inventory. The reasons for the decline in the inventory methods in the 1990s are dominated by the closure of coal mines, the uptake of landfill methane utilisation in flares and engines, which has addressed a lot of the methane coming out of landfills, and declines in livestock herd size.

On the landfill side, there are uncertainties around the 1990 values from the inventory methodology because the landfill model has to take data on all the waste that was deposited over the 30, 40 or 50 years prior to that. That data is scarce, so quite a lot of assumptions have to be made to come up with the best estimates of what was deposited in all these landfills, the rate of their degradation and therefore the methane that was being eluted. There are certain uncertainties, but the inventory is consistent with IPCC guidelines; it has gone through many reviews with experts poring over the models in the intervening period. We cannot get away from the fact that there are uncertainties.

However, I certainly echo the comments of others on the panel, in particular Grant, about the role of measurement here. A lot of different models are used to generate methane estimates consistent with IPCC guidelines for the inventory, but there is definitely a place for what we are moving towards. Probably both Grant and Matt would acknowledge that in recent years there has been a lot more dynamic working activity between academic agencies, academics, the inventory agency and DESNZ to try to harness measurement and look at measurements closer to the source, such as by having drones up and down a fence line of installations to get us better data to validate emission factors from landfills and so on. The NPL is doing a lot of work around biodigesters and the anaerobic digestion plant, which is about to be released.

This sort of measurement to calibrate the modelling in the inventory is the way that we are going and the way we need to go. We need to use the measurements to highlight the discrepancies and, if there seems to be a systemic underreport or overreport, to identify that, drill down into it and improve the evidence around it.

Q30 **Baroness Whitaker:** Finally, is there is enough local authority expertise or access to expertise?

Professor Grant Allen: It depends on the sector. You mentioned landfill, so I can speak a little to that. At the moment, there are methods for quantifying emissions from the landfill scale. We developed them in the UK more than 10 years ago. They are now in use internationally in the commercial sector, with regulation behind them. We do not yet have the same regulation in the UK, but landfill operators and others are adopting methods for quantifying those emissions. However, there is a bit of a mismatch between that data being collected and it then going to people such as Glen at Ricardo to put it into the inventory.

The other point specific to landfill is that there is no specific regulation about greenhouse gas emissions. I spoke to the Environment Agency about this yesterday, which was keen to point out that the regulation is about ensuring compliance and best practice with measures on site that mitigate emissions, such as looking at the integrity of caps on closed cells at landfills, which can cause leaks if they are not maintained, or the efficiency of gas capture and use on site to make energy. At the moment, Environment Agency regulation is all about mitigating emissions, not quantifying them for the purposes of reporting and not putting any sort of incentive on limiting what those emissions might be.

The approach to ensuring best practice is excellent; that is what we should be doing. But there is a dual purpose here, in that we need to collect the measurements that we would like to do at site-specific or sector scales and give that data to the inventory at the same time that the regulation is ensuring best practice on site. There is a dual purpose between best practice and mitigation and data reporting, and those two things are not as aligned as they could be.

Q31 **Earl Russell:** First, I thank you all for your evidence today and the work that you are doing. It is really reassuring to know that there are so many scientists working on these matters.

We have heard a lot about models—top down, bottom up, on site—and I would like to move on to ask you about how we verify our methane emissions in the UK overall. In the words of Ronald Reagan, let us "Trust but verify". I want to ask you about the methods and technologies being used and employed across the different sectors and perhaps to look at how these can help integrate this practice between the modelling and the on-site inspection side of the work.

Professor Grant Allen: There is a growing menu of available technologies. We have heard a lot already about the national-scale inversion, using the DECC tall-tower network that Bristol is responsible for, and then there are site-specific surveys, which are a bit hit and miss at the moment as to which sectors are routinely quantified. A lot of that work still takes place in academia.

That menu of approaches and technologies that we have for direct measurement includes things such as research aircraft, and perhaps in the future it will include commercial aircraft equipped with scientific instrumentation that can collect measurements, where there is a highly focused need to do that. We have developed UAV surveys in the UK, which are ripe for use. The menu also includes mobile surveys—cars equipped with vehicles that can drive around cities looking for leaks and so on—and tracer release experiments. It is a little technical, but there is a very good gold standard method to emit a tracer gas—not methane but some other gas that you can ratio with the concentrations of methane—that you measure, which gives you a very good handle on emissions at site-specific scales.

There is a quite a menu of approaches. No single method on its own is appropriate at all spatial and temporal scales. We need this menu of approaches and to pick the right things from it at the right time for the right sector and the right spatial-temporal scale.

Q32 **Earl Russell:** I completely agree with that. There is a lot of movement in this technological space, particularly with the capability of NTM and satellites. Is there more scope in the future for linking all these technologies together, perhaps starting with satellite data and then moving to drones and cars and whatever to pinpoint leaks and so on?

Professor Grant Allen: Yes, there is a really excellent example of this from last summer, when GHGSat detected a very large emission source in England. It was looking for emissions from a landfill and instead it saw a very large leak. A mobile team from Royal Holloway University London was then deployed to measure and confirm that emission source. The company was contacted, and the leak was shut down. That is one very good example of how these things can join up.

Satellites can measure the very largest emission sources, so they are not good for individual landfills in the UK, but they have a very important role to play in identifying the biggest sources. So, yes, there are good examples of how these things link up.

Glen Thistlethwaite: That bit of work Grant just referred to was published two days ago. It was a really good example of the academic and the inventory team working together to pull the information together and alert the operator. I agree with what Grant just said; satellites are primarily useful for super-emitter events, at the moment. There are examples, and there may be improvements in resolution and the ability to focus at a higher spatial resolution that can help us to understand the source.

There are also examples of where the use of satellite data has not proved to be the technology to take forward. One of the biggest emission sources is the downstream gas network. Leakage of methane from that distribution system is about 6% of UK totals. The industry has gone through a process of reviewing all the different technologies as they develop the model to calibrate it better to UK circumstances and to take more measurement on board. They are not going to take forward satellite data. They are going to use more drones, road transport, mounted measurement systems and so on, rather than using satellites.

Dan Wicks: Thank you for flagging the Cheltenham example. There are a lot of very capable technologies that are delivering good impacts today, but we are still probably some way from implementing them in this context. There is absolutely a need for intercomparison and validation exercises, the implementation of standards and defining the protocols for use of these technologies.

I stress that in the private sector there is a lot of evidence of the adoption and use of these technologies directly. This is being driven by a range of factors, not just the need to understand and report on emissions but reasons of social licence, health and safety and financial risk, where the finance community is taking a deeper look at the environmental credentials of organisations. Understanding how the initiatives of these private sector businesses to implement use of these technologies can also meet some of the needs of reporting must be looked at.

Q33 **Baroness Bray of Coln:** Thank you to our guests for being here today. This is a fascinating session. What exactly are fugitive emissions and methane leaks? Why typically do they occur? Can I ask that of Professor Rigby?

Professor Matthew Rigby: I would like to defer to Professor Allen. He is more down at the coalface on this.

Professor Grant Allen: Yes, that is what I spend a lot of time trying to measure. Fugitive emissions are defined as emissions that potentially are controllable or mitigatable. They represent very low-hanging fruit for emissions reduction potential because they are potentially controllable.

Fugitive emissions can be represented by two broad categories: known and unknown. Known fugitive emissions can be metered or measured[9] directly from individual companies, operators or emitters and might be reportable under regulation for some sectors. For example, the offshore oil and gas sector reports its known fugitive emissions to the Oil and Gas Authority.

Unknown fugitive emissions are just that. We do not know what they are. We know that they exist and examples of sources of fugitive emissions include very small gas network leaks which have been measured in cities by mobile surveys, routine fugitive emissions from pressure release valves, phalanges and wastewater treatment plants, and landfill site leaks from open cells. There are many examples of these fugitive emissions. They are everywhere. Some of them can be measured or metered, and others are simply unknown. [10]

Glen Thistlethwaite: They are in the inventory, but they cannot be measured directly and we must use periodic research studies to understand what the overall impact is. If there are emissions from fissures on a landfill cap, that can be modelled over time. We can gather evidence and try to characterise what is typical for UK landfill sites of different designs. That is how we try to fill those gaps. Completeness is a fundamental for the inventory. The IPCC methods are designed to enable countries to estimate those anthropogenic emissions even if they cannot be metered and monitored.

As Grant outlined, for instances such as venting, flaring or process fugitives in the offshore sector, we get inventories of what the infrastructure is on those plants and the estimates using various methods that are often derived from American research on the leakage rate per

[9] Or modelled

[10] The inventory does attempt to include fugitive emissions using the best-available data and modelling, but it is likely that there are fugitive sources that are very difficult to quantify accurately

flange per compressor per pressure valve. Those estimates are generated bottom up for offshore and onshore energy producers.

Similarly, on downstream gas, while the inventory has not got the spatial resolution to be able to say, "Yes, there's going to be a leak from this pipeline on this road in central London", we can get a picture of the overall network and where those leaks are likely to occur over time and characterise that through this research. That is where the measurement will help to calibrate that, but it is not fair to say that they are not in the inventory. It is just that they are hard to characterise because they are diffuse in nature. Low-volume, low-concentration methane is hard to pick up from many different sources in a given area. That is why they are difficult to measure.

Q34 **Baroness Bray of Coln:** Is there any part of the UK where these things typically tend to occur more often?

Glen Thistlethwaite: You could identify sections of infrastructure. For example, within the downstream gas network there are different above-ground installations which you can anticipate will be more prone to this, through maintenance or events. Often these are pressure management systems. There is often a health and safety aspect to why these things must happen. Some of this venting is the need to depressurise the system from a health and safety perspective. However, generally around the country it comes down to the source. It is possible to identify a landfill or piece of infrastructure, but not geographically or otherwise.

Dan Wicks: I would highlight regular flaring and venting from oil and gas as a contributor. Also, to build on a point that has been made, we rely significantly on self-reporting of this data to contribute to the overall reporting. There is a need for independent verification. As has been highlighted, fugitive emissions are very difficult to measure but technologies (e.g., satellite) can contribute in that way, even if not providing a full solution at this moment in time.

Glen Thistlethwaite: On the oil and gas point, we did a research project a couple of years ago that was published by DESNZ. It is transparent in the areas of greatest uncertainty for the upstream oil and gas sector, which is all to do with the emissions from flaring, whether they are lit or unlit.

I point to work that Grant did in 2022—a survey of 50 to 60 installations—which came up with the same assumption that is applied in the industry as the default of 98% oxidation of flares. This is an instance where the measurement community has validated the current estimate and the current assumption that is applied within the reporting by operators, and which is reflected in the inventory.

Baroness Bray of Coln: As I understand it, the major leak in the Cheltenham area was first detected by a woman who said that she had smelt gas. How are these fugitive emissions usually detected and what level of confidence do we have that that they are being detected, apart from people smelling gas occasionally?

Professor Grant Allen: Yes, as I said, some of these fugitives are simply unknown. They are not quantified. They are estimated in the inventory, but they are subject to high uncertainty. That is fair to say.

You mentioned odour and smelling gas leaks. There is potentially an interesting role here for citizen science, for better reporting when members of the public smell gas emissions. If there was a public message, so that they are aware that they could be doing something to mitigate climate change by reporting these emissions, it would be a big plus.

Q35 **Lord Duncan of Springbank:** The question I have here has already been answered but I have a different question. In the discussion so far, we seem to now have a lot of data from various sources in the UK but that does not seem to be the case across the globe. There seem to be a limited number of countries that are actively capturing data in a way that can be meaningfully deployed. How then do we move forward, if there is only a handful of nations, to get to global figures and understand the real impact?

My second question is about where those countries are likely to see improvement. Who will be making the big steps coming up afterwards? What are we seeing with regard to the COP process incorporating this into meaningful data thereafter?

Professor Matthew Rigby: I will briefly say something about the national scale, top down. You are right; regional networks are springing up all around the world. Europe has a very mature network called ICOS. However, it is fair to say that that data has not made its way into the national reporting of those countries. The data and modelling capability are there but the relationship with the inventory teams is not necessarily where it is in the UK.

Satellites will be there to fill part of this gap. As well as the satellites that Dan talked about that can look at these point sources, there are satellites that look at larger areas—the global-mapping satellites. You might have heard of TROPOMI, which is currently up there, and new ESA and NASA satellites will be coming up in the next few years, so we will start to be able to fill in some of those gaps.

Lord Duncan of Springbank: Who will co-ordinate that? The satellites exist and the data is there but if no one is gathering it meaningfully and synthesising it, it is lost data.

Professor Matthew Rigby: That is an excellent point. Initiatives are under way, mainly through the World Meteorological Organization, to try to come up with frameworks and guidelines for doing this, but you are right; it is in its infancy, and we need co-ordinated international action.

Dan Wicks: There are a few examples of where that action is happening beyond the World Meteorological Organization. The Oil and Gas Climate

Initiative is funding monitoring campaigns in different parts of the world to try to build a baseline of understanding. I would also mention the UN's International Methane Emissions Observatory, which is a big user of satellite data of all types, as a way to employ monitoring in different locations globally.

Glen Thistlethwaite: I definitely agree with all that about the international actions going on. The European Commission will imminently pass the methane regulation, which is another changing moment. It will require more reporting of evidence of methane emissions, abatement and so on, not only of member states but of anybody exporting fossil fuels into the EU market. That will come in in a couple of years.

A separate point is that, going back to the global reporting dataset, you are right that, at the moment, under the COP process and the historic reporting to the convention, only a handful of countries have been doing it in the same way as the UK. As we move into the Paris Agreement, as of this year in 2024, hundreds more countries will submit inventories, developing data. That will create a regular reporting mechanism within lots of countries and a requirement to report an inventory and against the Nationally Determined Contributions. I hope that that will build a requirement for more bottom-up data development in all those countries.

That process is happening. We can all see that the COP process progresses at a relatively modest pace, but we are going in the right direction. This is another area where UK plc has lots to offer. We have a lot of experts and a lot of people who have drafted IPCC guidance and understand inventories and the UN process, and we do a lot of capacity building with a number of countries.

There are lots of international initiatives on methane, but they need pulling together. The UK needs to find its role, put our methane action plan out there and get on with it.

Lord Duncan of Springbank: I am slightly troubled that the major nations of the world are probably missing from this. In China, the US, Brazil and so on, you can see significant potential emissions which are perhaps not being captured in the way that we would want. That missing leadership and co-ordination, and, presumably, money to support it, is a real issue. We will have to find some way of funding it because otherwise it will not happen.

Professor Matthew Rigby: I mentioned the European systems, but the US now has a quite bold plan for greenhouse gas reporting and monitoring. A lot of initiatives have been launched in the last few months in the US, so it is certainly taking this seriously. There is also a lot of activity in China, from what I understand, although we will have to see how that is integrated into the global monitoring systems. Regional networks are starting to spring up but, I agree, we are nowhere near covering every industrialised country on earth.

Q36 **The Duke of Wellington:** The set question has more or less been dealt with, in various ways, so my question is different. We were told in a previous session—I hope I remember this correctly—that, between 1990 and 2020, or thereabouts, methane emissions in this country reduced by about 60%, which is a surprisingly good figure. However, Professor Rigby said earlier that it now transpires that some of the calculations made in the 1990s, between top down and bottom up, showed major discrepancies. How confident can we be that the measurement of the reduction between 1990 and 2020 is as great as we have been told?

Professor Matthew Rigby: I wish I could give you a good answer. You are right; the trend that we see in the top down is not as large as the trend in the inventory. Glen has already pointed to some caveats that we need to make here. Back then, we did not have any sites in the UK; we were relying on a site in Ireland and one in the Netherlands for the top-down quantification, so there is a possibility that, for some reason, that led to an underestimate in the top down.

When we repeat the calculation in recent years, we get consistent numbers with the inventory, with just those two sites, but there could be issues to do with the changing source patterns and so on. Similarly, as Glen said, there may be factors in the inventory to do with the capping of landfills and the closing of coal mines that perhaps were not accurate in the inventory. It is very difficult for us to go back and work it out now, which is why I said we need to make sure that we have measurements and reporting processes in place in the future in case these discrepancies occur again.

Glen Thistlethwaite: The inventory is the official statistical record. There are uncertainties in all the methods that we are talking about. Error bars are presented on the inventory data. The uncertainty in the trend is less than the uncertainty in a given year because a lot of them correlate. The national inventory report outlines all this transparently. If we look at the uncertainties associated with methane compared with carbon dioxide, we see that the uncertainty boundaries are about 2% for carbon dioxide. For methane, the uncertainty, as presented in the inventory using all the IPCC methods, is more in the tens of per cent; it is around 15% to 20% over the time series.

But the uncertainty in the trend is not that great. The data is as it stands in the inventory, but there are uncertainties. As Matt indicated, the key thing is to make sure that we are improving our monitoring going forward. As we move towards net zero, methane will become more important. It is a challenging gas to understand and characterise, so we need more measurement and research to make sure that the current emission sources and the future technologies that are coming on stream, such as the development of bioenergy sources, are all monitored, reported and characterised accurately within the inventory.

Q37 **Lord Grantchester:** I declare my interest of having a dairy farm. What could be done to reduce these fugitive emissions and leakages in the UK? Does some responsibility for self-monitoring already exist on sites to build up the data? Are there responsibilities on the operators to detect and therefore report leaks? Is there something behind all of that that could be used to help reduce these emissions and leakages further and more quickly?

Glen Thistlethwaite: The Environment Agency will imminently produce a methane action plan, which will be very informative for the committee. I do not know when it will be published, but it has been looking at their toolkit, if you like—the range of regulatory mechanisms that it has to enforce controls on operators. There are certainly ways to develop Leak Detection And Repair requirements within permits, and it can use other requirements in the regulations on other pollutants, such as non-methane volatile organic compounds, which will also have an impact on methane.

There is a lot of bottom-up LDAR work that goes on, but it does not necessarily get used to generate calculations for mass emission rates on an annual basis, which is what the inventory tries to characterise. This is because, by nature, you have individuals who are going around looking at individual items of plant, identifying a leak and seeking to get it fixed. We do not know for how long that was happening or, necessarily, what the emission rate is.

There are technologies coming around that will help to improve the capability of operators to estimate the impact of those. Hopefully, that can be used to generate annual emissions estimates. This goes back to something I think Dan mentioned around the needs for protocols and standards to be able to process these systems and develop them into a more accurate reporting methodology. One way forward is to use more technology to identify leaks, characterise them better, work out what that means in terms of mass emission rates and then include that in the reporting. However, there are regulatory levers that need to be established to do that.

Dan Wicks: Simply more systematic monitoring would add significant value. The Cheltenham example, which has been cited several times, was something that we came across by accident. If we were trying to see these things, it would invite the question of what improvements we would find. It is about understanding more fully what the relative strengths of the different approaches are and when to employ them. Certainly I would not advocate that any single solution or technology as the answer. We need to find a way through that understanding.

Q38 **The Chair:** Before we move on to Lord Ravensdale and emerging technologies, we have heard a lot about the self-reporting of data leaving gaps in information knowledge and enabling leak detection and repair. Do you think that regulation at sector level is needed to support monitoring? To what extent do sector-specific regulators, for example the NSTA and the Environment Agency, have a responsibility to monitor and enforce methane reporting? We have not heard very much about enforcement.

Professor Grant Allen: I think you hit the nail on the head there. It is a good summary of everything that we are all saying. The thing that is lacking is coherent regulation across the different regulators and government departments that oversee the different sectors. At the moment, I am not aware of any enforcement activity that concerns greenhouse gas emissions and the quantity thereof, for obvious reasons. It is an enormous technical challenge that still needs academic work behind it to find solid methods for quantifying emissions, even at site-specific scale, but there are mature technologies.

The time is right for coherent regulation. That will need conversations between regulators and departments to work out something that they all understand, and which is fit for purpose for the different sectors under each department.

Dan Wicks: Many of the private sector organisations we work with in relation to their emissions look to regulation to set the approach to the way in which data is captured. It is a barrier to progress in that area, I suggest. As well as the regulation in itself being a lever of change, I point to some of the work being done in the US where the EPA has introduced much more stringent rules around emissions, particularly in relation to oil and gas, with severe fining that is driving action on the ground.

Professor Matthew Rigby: I do not have anything to add. I agree with what Dan and Grant have said.

Glen Thistlethwaite: I agree with much of what has been said. On whether it needs to be regulatory systems or it could be financial mechanisms and other voluntary reporting that is co-ordinated is another matter. The ETS, the emission trading scheme, has been very effective in generating a very good evidence base for CO_2. In other countries, methane has been included in the scope of trading schemes or similar financial mechanisms.

There is a case to be made for it to be the environmental regulators, which has always had the mandate to regulate emissions—the Environment Agency, SEPA, NRW and NIEA on shore and then the OPRED team offshore, under DESNZ. Industry regulators, such as Ofgem and NSTA, have historically had more of a role in ensuring industry financial performance, value for money the consumer and so on. There is a case for saying: "How do we co-ordinate their action with the environmental regulator?"

To go back to the downstream gas example, 6% of our emissions are coming from that system. What is the environmental regulation that goes on in that space? I am not an expert in that; you will need to talk to others. But Ofgem will clearly have a role and there may be some capacity that it needs to bring into play to understand how it can integrate and help to develop a methane action plan that targets the emissions, as it is now tasked with working towards net zero—as many regulators have been in the last few years.

Q39 **Lord Ravensdale:** I declare my engineering and consulting interests in the register. We have touched on technologies throughout the discussion and I have a few more specific questions. First, I have one for Professor

Rigby. We have talked a lot about top-down and bottom-up estimates, but could you give us an idea of the size of the discrepancy between those datasets? You spoke about the 1990s and today where there is much better agreement. If we could get an idea of what that discrepancy might look like in percentage terms, that would be quite useful for context.

My second question is for Mr Wicks and is about detection limits for satellites. Clearly, many methane emissions are low level and spread out so the detection limits of satellites are quite crucial. How do you see that evolving in the future as new technologies come online? Any other comments on key emerging technologies for measurement would also be useful.

Professor Matthew Rigby: On the magnitude of the discrepancy, I do not have the exact numbers off the top of my head. However, in the last decade the agreement has been very good—so, less than 10% between the top down and bottom up.

I will touch briefly on your last comment about emerging technologies. Focusing on the large-scale top-down approach, I think there is a lot of work in the research community. I would summarise it as targeting three main areas. The first area is trying to improve the resolution of our estimates. I have spoken a lot about larger national scales, but we are trying to move down to devolved Administration or smaller scales. That is happening by increasing the density of the network, and trying to build in the remote sensing products that I spoke about.

The second priority for methane is to try to disentangle the different sectors. We are doing that by increasing the spatial resolution and bringing in other types of measurements—for example, we can use co-emitted gasses from gas leaks to tease apart that source from the others. Using methane isotopes can help as well.

Finally, the third priority is to try to reduce the latency of the estimates that we provide. There is a UKRI-funded project called GEMMA, which is in its first year. It is being led by the National Physical Laboratory. There, we are trying to build the systems so that the top-down information, and hopefully the bottom-up information, can be put together more quickly and provided to the public and policymakers so that we can hopefully act on it more quickly as well. We talked about remote sensing. That is obviously a big part of future technology as well.

Dan Wicks: A number of factors will influence your ability to achieve a certain detection limit. One of the biggest contributors is the wind conditions at the point of measurement. Today, GHGSat is the world leader in providing a high detection threshold. We cite 100 kilograms per hour at a 3 metres per second wind speed. We have made detections at a lower level than that.

Other attributes are important though. The resolution of the data and therefore your ability to attribute a measurement to a particular point location is important, as well as the frequency at which you can take measurements. As we know, many of these emitter types do not emit consistently. Their behaviour is variable, so you need routine measurements to properly characterise what the emitting behaviour is. Those characteristics are all important.

We are working on an improvement in the detection threshold. We expect to see significant improvement with our future generations of sensor technology. A number of other private and public sector organisations are also developing space-based capability for the detection of methane, which will push the boundaries around those different characteristics that I have described.

Professor Grant Allen: There are quite a few other new technologies, some of which are already planned to come on stream. Perhaps Matt would also like to mention expanding the UK measurement network. We have just installed a new node on that network at Jodrell Bank, for example, which will add new data for north-west England. As we have talked about, drone surveys are excellent for site-specific surveys, as are tracer-release methods and next-generation satellites.

Earlier, a question was asked about the discrepancy between the inventory and the inversion model in the 1990s. I have a graph in front of me that Matt and I were looking at a few days ago. We need to put this in our written evidence as well. The numbers estimated by the inventory in 1990 were 150 teragrams of carbon dioxide equivalent per year. That equates to 150 megatonnes. The inversion model quantified just over 60 megatonnes, so there is a discrepancy of over 100% between those two numbers. But, as others have said, there was no measurement network available in 1990 to do this well, so we need to be very careful of interpreting that discrepancy.

Lord Ravensdale: Professor Allen, could you go into detail on the current discrepancy? Professor Rigby said that it is around 10%. Would you agree with that?

Professor Grant Allen: That is certainly what the figures to date show. They converge really well, especially since 2012. But, as I said near the beginning, there are things that are not in the inventory, such as biogenic emissions—natural emissions from peatlands, for example, that are not managed. There are things that you would call non-manmade emissions that are measured by the network but are not necessarily part of the inventory. You would perhaps expect there always to be some discrepancy, but it has aligned very well since 2012.

Glen Thistlethwaite: I will add some data. The graph that they are referring to is published in one of the annexes of the NIR, as Matt will know. The discrepancy between the observations and the inventory are transparently described in our national inventory report, which is submitted to the UN.

At the moment, methane contributes about 14% of the total UK emissions. Back in 1990, the estimate was that it was about 18% of the total. We can compare the uncertainty in the trend with that for CO_2. As I said earlier, the uncertainties in CO_2 are a lot lower, so you can get within plus or minus 2% for each year for CO_2. The central number in the latest inventory report is down 44%, with a range of 42% to 45%. So, for CO_2, you can see the trend uncertainty—our estimate of our progress—is down 44%, with a range of 42% to 45%.

If we compare that with methane, with its higher uncertainty in each year, we have an uncertainty in 1990 of around 24% in that estimate, looking at the inventory methods and applying in the IPCC uncertainty analysis, which every country has to do. In the latest year, the uncertainty is around 30%, so the central number is that we have declined 62%, but the error bar, the range, is 42% to 91%. Even in the inventory report, we are transparent that the uncertainty in the trend that is reported for methane is a lot greater than it is for CO_2. Those figures inform the significance of this.

Q40 **Lord Trees:** Before my main question, I will quickly ask another one: what is the difference between a fugitive emission and a leak? Is there one?

Professor Grant Allen: No, there is no difference; it is just a posh word for a leak.

Q41 **Lord Trees:** That was a good answer. The semantics are important. Carbon leakage is used in the context of our exporting emissions by importing goods, so leakage has different meanings in different contexts.

Coming back to measurement approaches, my main question is: what are the benefits and limitations across different measurement approaches? To follow that, to what extent, with anthropogenic sources of methane, could we get near to a position of remotely sensing and detecting pretty much everything in real time, as real observed data?

Professor Matthew Rigby: I will start, I guess. You might get some lively discussion on this one. I emphasise that, as Dan said, there will be no single approach that ticks every box here. We need a suite of measurements and the inventory; it all needs to work together.

At the national network, we are good at doing large-scale aggregation of sources. We have a good handle on national total emissions. As we go down to smaller scales with that data, we get less and less information, so we are not so good at sectors from the national inventory, nor spatial disaggregation. That will improve as satellites get better, but we absolutely will also need these smaller-scale approaches from GHGSat and other point-source detection satellites, as well as from drones, mobile surveys and so on.

To answer your final question of whether we will get to a point where we can have a satellite that sees everything, my assessment is that we probably will not, mainly because the UK is a pretty cloudy place. Satellites will be an important part of a larger suite of observations.

Dan Wicks: I will broadly address the strengths and limitations point. With a detector on the ground, you can achieve very high accuracy and precision localised to that specific point. You can even have continuous monitoring at a given point if you put something in situ. But you are limited in your ability to have a representative measurement over a larger area.

As you look at approaches to bridge that, you end up with tall towers, drones and those sorts of technologies, where you are able to cover and have a representative measurement over a larger area, while still achieving a relatively high degree of location measurement. That goes all the way through to space, where you have this extreme flexibility, being able to acquire measurements anywhere in the world, without limitations. Space is evidenced to be able to take measurements and attribute them to industrial facilities, but you do not have continuous monitoring. I hope that that broadly gives an overview of that spectrum of capability.

Q42 **The Chair:** Mr Wicks, where does your revenue stream come from? Is it private contracts, or do you have a contract with DESNZ and Defra?

Dan Wicks: We have contracts with both the private and public sector. A lot of our business comes from private sector customers. Regarding our public sector customers, here in the UK we are currently running a programme funded by the UK Space Agency, which is making our data available to any UK organisation, public and private. That has been designed as a stimulus to explore the possibilities of the data and testing it. We also have contractual relationships with the European Space Agency, for example, which is another important mechanism for innovation. It is a range of sources.

The Chair: Do you feed your data into the NAEI via Ricardo, or is it the other way round?

Dan Wicks: We do not currently, but we are actively exploring the opportunity to introduce our measurement capability into the top-down approaches that have been discussed today.

The Chair: Mr Thistlethwaite, would it be of benefit to you to have the data that Ricardo records?

Glen Thistlethwaite: I think you meant the data that GHGSat records. The issue here is that the inventory needs to generate source-specific bottom-up estimates, as are required by every reporting party. We need to use the IPCC methodologies.

As we said earlier, with all these measurement techniques it is horses for courses. We need to use the appropriate one to calibrate our understanding of the processes that are going on. To have a satellite data point on an emission from an installation does not give us the necessary detail of the process that is leading to that emission and how we can mitigate it. The devil is in the detail. We will still need measurement that is closer to the source to understand fully the importance and spatial and temporal resolution of different emission sources, so that we can understand how to mitigate them.

Going back to the original question regarding whether we can do it in real time, as an aspiration let us aim for that but, at the moment, it is a huge cost and a massive undertaking. We need to invest in the agencies that are out there gathering the data. Maybe investment is needed for accelerating access to data from regulatory agencies and process operators through to users to break that time lag. The inventory is only as good as the data that is available for it. We need to focus on where we can best use these measurement techniques to generate better evidence for all these source estimates. Where can we break down those uncertainties by characterising these biological and hard-to-calibrate processes better by more measurement?

Professor Grant Allen: Going back to the comment that a few of us have made, there is no single solution. Satellites are excellent for seeing these super-emitters, but they need to be looking in the right place at the right time. They need to be tasked for a specific purpose. They are not a routine monitoring capability, but I am sure that they could be used in that mode to some extent, if there is a careful design of how that should be done.

The Chair: So do you think that they may not be as useful in adding to the data collection inventory, but more useful for identification and enforcement?

Professor Grant Allen: It is exactly that for the largest emitters, especially for responses to events like national emergencies, such as the Elgin oil rig disaster in 2012—for seeing big emissions and quantifying them, then saying that it is okay for engineers to go to the site and shut them down. All those things can result in huge emissions reductions and can save the economy a lot of money. The early shutdown of the Elgin blowout in 2012 was quantified as having saved the economy £1 billion or more. There is a paper on that.

Dan Wicks: Just to add a quick comment, I stress that we need to look internationally if we are importing energy, for example, and understand the footprint of that energy. We do not have the ability to deploy other measurement techniques. That is another example of where satellite has a unique strength.

The Chair: Do you think there is scope for companies like yours to work more closely with government?

Dan Wicks: Absolutely.

Q43 **Baroness Bakewell:** We have heard a lot of information today, and thank you very much for that—lots of data, lots of practical suggestions and lots of ideas—but where do we go now? What is the barrier for co-ordinating this abundance of opinion, attitude and intention?

The Chair: Who would like to start off? There you are; you have stumped them.

Professor Grant Allen: Somebody has to. If you ask a scientist what they need, the default answer is "more data". That is what we live off and are hungry for. You could spend the entire nation's GDP on methane monitoring and you would reach a point of limiting returns. Your point is important; it is where we find the right balance.

The regulation needs to lead here. We need incentives for emitters to reduce their emissions. There are already good examples of win-win situations where methane can be captured, burned and used for energy generation in all sorts of sectors. There are win-wins to be had. There might need to be financial incentives or breaks to allow that to happen.

We need regulation that starts to look at greenhouse gas emission fluxes, the number of kilograms emitted per hour, and have sensible limits on what that should be for different industries. I cannot answer what those are today. Working that out is a big exercise and then we need enforcement action.

As with everything that is successful, it is about a carrot and stick approach, led by regulation with some improvements to monitoring to ensure that everything is being done as efficiently as it could be, but it needs to be designed well. Designing this well is a very large undertaking that I could not answer on today.

Baroness Bakewell: Who is the leading authority on that?

Professor Grant Allen: That is a good question. I would probably say that that would come from DESNZ. If any government department leads that, it should be the Department for Energy Security and Net Zero by default. As net zero is already on our statute books, we need to do this. It is in law to do this. Academia can advise, as we have today, but I certainly cannot say exactly what that should look like. It is incredibly complex.

We need a bit more monitoring. We need standardised methods and validation. We need regulation that is about enforcement and emissions quantification. All those things need to be aligned.

As I mentioned earlier, one of the biggest gaps is a coherent approach to regulation between the different sectors, regulators and departments. There is a different spectrum of how that is done. Possibly, we also need good skills in the Civil Service to understand the philosophy of what academia wants and needs. You have this dual purpose of regulating and minimising emissions but, at the same time, providing those emissions to people like Glen to use them in the inventory. There is scope to align that.

Baroness Bakewell: What about political will?

Professor Grant Allen: I feel like there has been very good political will recently. The UK's green credentials are still very strong. I would not like to comment too much more than that, but we have a net-zero plan; that is law. We have a lot of great science going on, which is funded reasonably well. We have a lot of good ideas, and a lot of good things are happening. I feel that there is political will, but I do have some concerns.

Dan Wicks: I think there is an opportunity to influence the way that regulation is developed through an understanding of the technology. That is essential, and you can look at parallel examples in agriculture, where satellite data is used for verifying subsidy claims, for example. That regulation is developed with good knowledge of how the technology can support the approach. I think I have said enough, as colleagues have, around the need for validation of standards and protocols. It is essential that we do some work in this area and it needs to happen at scale to be effective.

I will end by highlighting that, as a person who comes from a private-sector organisation, there is a huge amount of innovation happening in that space. We need to figure out how to harness that and work collaboratively with the academic sector to solve some of these challenges.

Professor Matthew Rigby: I completely agree with everything Dan and Grant have said. I will add that there is so much good work across academia and in the private sector, in places like Ricardo, but it is somewhat piecemeal at the moment. We might want to consider how to bring all this expertise together. It would potentially be useful to look at the US model. I think the US has just announced a virtual greenhouse gas centre; we might want to think about something like that. It seems like low-hanging fruit to bring this information together.

The Chair: Would you write to the committee with more information on that?

Professor Matthew Rigby: Yes, I can do that.

Glen Thistlethwaite: I agree with all of that and with looking overseas for best practice. It is not all doom and gloom; we have a lot of the mechanisms in place. I believe we have the political will generally. We are world leading. As Matt outlined, we are one of the three countries that does this verification. We are transparent about looking at how to improve our inventory, how to challenge it and seeking ways to improve it.

There are systems in place. DESNZ manages a cross-government working group that it brings together twice a year to discuss the priorities for improvement in the inventory—scientific and methodological improvements. It is investing in an improvement programme every year.

I also point to the Defra investment in the agriculture inventory 10 to 12 years ago. We have some excellent people in our Civil Service who have led world-leading development and have shown commitment and drive to get the funding, implement the research and do that in a rigorous way to develop a world-leading agriculture inventory.

There are existing systems in place. There are lots of methane action plans out there. The North Sea transition deal has a methane action plan associated with it. The downstream gas network team is already working on improving its model and using this measurement. There are lots of good stories that are already happening and there are already mechanisms that DESNZ manages that can be played upon to accelerate progress. Ideally, we need to develop more methane action plans for more sectors and make sure that responsibility for that is owned. Someone said that DESNZ has the main responsibility. Clearly Defra, with the policy responsibility for agriculture and waste management, also has a big role to play, and I believe it is.

We also need to think about how we prioritise our actions. There are key sectors in which we need to achieve mitigation. There are key challenge areas where the evidence is scarce. We should start with those. Let us try to work out how we can prioritise funding towards those more difficult hard-to-decarbonise sectors. This goes back to the discussion about cattle feeds and the requirement for research to look at how the impacts of that can play out across all sorts of climates, soils and production systems. There is a big evidence need.

Baroness Bakewell: I would like to add that it is important to pass on this message, not only to universities, but to schools, apprenticeships and young people. It is going to be their role and their world which are going to have to deal with it. I would like to see action taken to do that.

The Chair: With that, it remains for me to say thank you very much to all our expert witnesses. Your testimony has really added to our wealth of knowledge for this inquiry.