



## **Discover how we maximise recovery and reuse of resources**

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### Key:

C = Caecilie Hougaard Pedersen

SM = Stuart Moss

JB = Jon Briggs

TK = Tasmin Kennedy

PV = Pete Vail

OV = Olaf van der Kolk

AG = Andrea Gysin

KG = Karyn Georges

C: Hello everyone. Welcome. Welcome back to anyone who's returning and also a big welcome to anyone who's joining for the first time. If you are joining for the first time please don't forget that you can access the full webinar series and all of the reporting of previous webinars directly on our website. If you go to the Discovery Challenge and look at 'entrance support'. Welcome today to discover how we maximise recovery and reuse resources. Feel free to introduce yourselves in the chat, who you are, your organisation, where you're joining from so that we can all get to know each other. Before we get started there's just a little bit of housekeeping. If you have any issues during the webinar please use the chat, our team is ready to help you and they'll also be sharing lots of relevant materials and links throughout the presentation.

At the end of the webinar, we'll have plenty of time for a live Q&A, so for the Q&A we are using Slido and the platform is live already so you can use the QR code on the screen or you can use the link in the chat to access the Q&A and you can add any questions that you might have. You can add questions during the presentation, but you can also add your questions during the live Q&A. We very much hope to get through all of your questions today but if you do have any questions that are left unanswered at the end of the webinar to reach out to us directly on email and we can address them that way. If your question is for a particular speaker do feel free to add that when you're adding your question but otherwise we will just open your

question up to the full panel. So without taking up any more time today I will hand us over to Stuart Moss from Isle Utilities and he will get us started.

SM: Thank you, Caecilie. As you heard this week, we are focusing recovery and reuse of resources. In the previous webinars we discussed water sources, treatment and distribution, usage by customers and discharge of sewerage in the sewerage network followed by the treatment of that sewerage so that it can be returned to the environment. This webinar will focus on the recovery and reuse of resources from the water cycle. So what are resources? Well, in everyday life we might see money, yes hard cash, as a resource. A resource is a stock, a warehouse of something that can be used or drawn down from when needed. Coal is a resource that for many years in the UK was stored and burned in the energy generation process. Thankfully this is now being phased out for more sustainable sources. Or in simple terms resource is something that can be used to help you. There are many different resources in the water sector, I'm not going to focus on human resources or monetary resources, in fact the water sector uses a lot of virgin resources in its activities, be that fossil fuels, chemicals or indeed raw water from the ground or river. I don't want to focus on those either. I want to focus on resources that are in the natural raw water, the collected wastewater, stuff that enters the wastewater from you and I or from the chemicals that are added during the treatment process. I want to focus on those.

If we can mine the raw resources why do we need to recover them? There are a few answers to this question. Cost, raw material can be costly, financially and to the environment. Resiliency, the water companies are reliant on a handful of chemical suppliers for example and therefore need to accept the volatile nature of the pricing. Waste, the water sector is producing a lot of waste that is either landfilled, incinerated or spread to land. Whilst land spreading is beneficial due to the nutrients contained within that biosolid many anticipate that this route land for biosolids could be removed, me included, and therefore the sector needs to be ready for this and therefore resilient. Depletion, raw sources can get depleted if we overmine and use too much of them. Empty quarries, dry lakes and reservoirs resulting in us needing to find alternatives. There are so many resource recovery opportunities in the water cycle. The main resource really that is being recovered across most of the UK right now in the wastewater sector is biogas from the wastewater solids. Typically, these solids are digested anaerobically to produce a biogas. This is a great example of recovering a resource that is contained within the wastewater as the water company receives it.

But there are many more options such as the recovery of minerals from the natural, raw water sources, chemicals or water treatment residuals from the coagulants used in the drinking water treatment process to produce perhaps soil additives or even recovery of the coagulants themselves to minimise the demands on virgin sources. Grit from wastewater can be recovered for use in construction materials, nutrients from the waste streams for use in fertilisers and as we previously mentioned biogas production and even water recovery. Typically, water is discharged back into the river once treated but why not use this water as a new source for drinking or maybe use it for hydrogen generation with an electrolyser. The opportunities really are vast. I can't wait to hear from our speakers as I'm convinced there are more sexy recovery options available. So there's definitely potential to go further in recovery of the likes of phosphorous which is present in the wastewater and causes issues

when discharged into the river, and to compound it, it's a depleting and costly natural resource that we really should be recovering it.

There are many options to innovate across this space and it's a hugely exciting area. We need to start to appreciate the value of these resources, work hard to find the market for the resources and all the stakeholders need to collaborate and create the value proposition and business case. So that's all from me, we have explored some of the potential resources that can be recovered from drinking and wastewater across the sector. I would now like to move on to our guest speakers and I'm pleased to introduce Jon Brigg, Tamsin Kennedy, Pete Vale, and Olaf van der Kolk. I have a series of questions for you all and I'm looking forward to your responses. Okay here goes, question one, what is your name, who do you work for and what does your role involved?

JB: Thanks, Stuart. My name is Jon Brigg and I'm Director at Stoic Options Ltd which is a company I started after a 30-year career in the water sector at Yorkshire Water, 10 years of which was in innovation and that's building and delivering a program of innovation to inform strategic direction and need within the business. I'm currently advising on innovation options and innovation implementation within the sector that's supply chain water companies, universities, the whole supply chain.

TK: Hi, I'm Tamsin Kennedy. I'm the circular economy lead at Scottish Water who are a publicly owned utility company and the sole provider of water and waste services in Scotland. My role is to look into the innovations needed to move us towards being a circular organisation and a lot of that is to do with resource recovery. I order studies, run pilot trials and sponsor academic research.

PV: Hello, I'm Peter Vale, I'm Severn Trent's carbon and circular economy architect. My role really is to seek out and develop those innovative technologies, approaches, that will enable us to meet our net zero commitments while really fully embracing those opportunities, those great opportunities that will come from fully embracing circular economy principles.

OV: Thank you for having me. My name is Olaf van der Kolk, I'm CEO of AquaMinerals and AquaMinerals is owned by the Dutch drinking water companies a Finnish drinking water company and eight water authorities from the Netherlands. Our main task is to bring residuals, waste, as we wish from water treatment to suitable destinations, preferably of course with a positive use for them.

SM: Thanks for the responses, all, and thanks for taking the time to share your expertise with the audience today, much appreciated. Straight into question two, tell me the biggest challenges related to recovery and resource of resources from your perspective.

JB: Well, resource recovery it's very much in vogue, quite rightly so. Multiple resources that could be recovered from within water and wastewater treatment that are currently not valued. So what are the biggest challenges related to the recovery and reuse? Well, there are many but the primary thing is that technologies that are brought forward to make sure that the products that are recovered or the materials that are recovered actually have a value and actually have a requirement. There're some incredibly interesting things that are coming through to the market that there are really valuable materials that are recovered. Delivering assets into the sector for compliance is one thing, but delivering assets where the value is in the recovery or the resource is a completely different thing and I'm a complete advocate of this where combined and happy consequence of resource recovery, but there has to be a value and it's making sure that the business case around that is thorough and valid which will then entice water companies to deploy or provide options for resource recovery to be delivered as a service.

TK: The biggest challenge we face in resource recovery is about the market for the resources. It's all very well taking something out of our treatment processes but unless you have somewhere for it to go it is another waste stream that we need to get rid of. There is also the whole regulation side of it but if we had someone who wanted to use the resource, we could work those out. It is likely the users will be outside of the water industry so that's where we need help to make those connections.

PV: So developing resource recovery approaches ultimately leading to moving away from conventional wastewater treatment as we see it today to biorefineries, resource recovery factories is a really key part of my role. It's not straightforward, it comes with some real challenges and it's not just technology, in fact I often think of it as a three-legged stool, so there's your technology challenge, there is a regulatory challenge and then there is an end market off-taker challenge. So obviously with the technology you need to be able to recover whatever resource you're after, be that nutrients, ammonia phosphorous or cellulose or bioplastic or going a bit further into the future maybe bacteria phages, proteins, enzymes, whatever it is, that technology has to be able to deliver the resource at the required quality but not only be technically feasible but it needs to be economically viable so if it's going to cost a huge amount of energy for example to recover ammonia if you're going to be steam stripping you need to factor that in. It could be technically feasible but economically not really viable. It also needs to be desirable, so it needs to fit in to a business model, is it something a water company wants to do, wants to get involved in for example supply nutrients as a fertiliser product or I guess going beyond that cellulose into bio-composite material etc. Does it fit with our sort of strategy.

So that's, I guess, the technical side and our approach has been to build a purpose built innovation facility, we call it our resource recovery and innovation centre, it's located on one of our treatment works at Spersnal near Redditch and that helps us accelerate technologies through the technology readiness levels and then our plan is to have a net zero hub where once the technologies are sufficiently mature to get them onsite and really try on that industrial scale. Which leads me on to the next two challenges, before you go to that industrial scale you've got to be confident clearly that you can do something with that

product, you can sell that product, there is a market for it. So we need to be working with end-users of that material making sure that what we're producing fits with their requirements in terms of a special occasion. One of the challenges we often face is if they're after a huge amount of resource, let's say phosphorous, but we can only supply a small amount is it something that is worth their time worrying about? Maybe not. So there's that side of it, we need to be well-matched with an off-taker.

Then there's the regulatory side, so if you're going to get something through to end of waste to becoming a product then there's a formal process to go through with the Environment Agency. So yeah, lots of challenges but all well worth the effort because the result at the end of it is, I'm sure, something that the whole society wants.

OV: The biggest challenge in creating new circular value chains is actually the complexity of the challenges. First of all, the topics ranging from financial issues to legal issues to value chain issues one side, the other side is the multiple stakeholders involved and both the topics as well as the stakeholders need to be aligned, combined in such a way that they want to work together. That is a huge effort and takes a long time getting all the proof that financial issues are solved, it's legally allowed but also bringing together all these stakeholders in such a way that they want to work together is, in my opinion, the biggest challenge.

SM: Didn't we get some great responses then. We heard that the products being recovered need to have value in a market or they would just be a waste again, very true. Oh I love this concept, we heard that wastewater treatment compliance could be a happy consequence of resource recovery, what a great aspiration to flip how we currently consider the sector to behaviour where compliance is king and resource recovery is a poor relative. Right then, on to question three, tell me about an innovative solution you tried, tested, reviewed to address the challenges described and what were the outcomes?

JB: Well in the style of modern politicians I'm going to answer that in a slightly different way, that question, also known as not answer the question! So in my career there are many examples across innovation and especially in resource recovery I could give, but I think the greater value would be in describing the challenges generically. That is the need to first of all understand the strategic need of a technology or a resource to be recovered, what it is that the business, society and the technology provider actually need out of this. Then look at how that could be achieved with both the technologies and the change that would be required within the business-critical element of innovation. Spinning out from that is the need to influence, providing the right information, the right data for the people who require it in order for them to make decisions in a cognisant way. So it's planning, which for those who know me is a bit ripe coming from me but it absolutely is. It's knowing what information you need and when in order to influence and understand all the dependencies that need to be correct, that need to be in place in order to deliver something which is potentially transformational within the business.

TK: I'm sure there is someone out there who hasn't had me talk about grit recovery. So let me go into that in a bit of detail. In case you don't know about grit in wastewater treatment it comes in from the network along with all the sewage from roads and the environment. At the start of the works, we take it out and it currently goes to landfill. In the beginning of designing a solution we were considering washing it ourselves and then selling it to companies doing back sale. However casting the net wider outside of our usual suppliers, we found out about recycled aggregate providers who take construction waste, clean it up and sell it on. Exactly what we were going to do. So now we are in the final trials to make this our business process which would save us an awful lot of money and carbon but also support construction to be more sustainable.

PV: A good example of one of the resource recovery technologies that we've done a lot of work on is cellulose. So it might not be intuitive to think that there're loads of valuable cellulose in sewage, in wastewater but there is, so there is cellulose from toilet paper. Toilet paper breaks down obviously into cellulose fibres in the wastewater and a Dutch company that we've worked with on a couple of European projects and subsequently on doing trial work at our innovation centre has developed a technology that uses two stages of sieving or filtering, and you can recover a clean cellulose material or fluff that you can palletise as well if you desire. So we've run a trial, a pilot trial and proved that yes we can recover cellulose fibres of decent quality and a sufficient recovery rate and now we're working with this company to explore markets for that cellulose fibre and there's loads of potential. They're already using it as a binding agent in asphalt in the Netherlands but potentially it can be used as insulation material, even as a feedstock into the chemical industry to make acetate or polymers.

So yeah, a really exciting opportunity and now we're talking to the company about the next stage, scaling up to industrial scale and actually recovering considerable amounts of this material that we can then sell. So yeah, that's certainly been one of our key projects of the last year or two in the resource recovery area.

OV: I'm afraid there's no silver bullet to solve all these complex problems in one go. However, at AquaMinerals we try to follow a couple of steps in order to increase the success rate of projects. First of all, we try to identify the crucial issues that need to be solved like legal, technological issues, financial issues and so on. After identifying them we make a plan to solve them, and we try to solve them simultaneously in order to see the currency between them and solve them all together. Second, we try to find the right partners in early stage, not just technology providers but also, for instance, the end users or the crucial stakeholders in the supply chain. If they are not interested, just ask yourself if it's a feasible new value chain. Third, during this whole valorisation process we hold each other's hands and by that I mean that we inform each other and also manage expectations. That way everybody stays on board until the end, at least hopefully.

SM: What an eclectic mix, grit recovery that makes so much sense, diverting away from landfills to be used in aggregates. Also great to hear about the stakeholders working

together. Cellulose recovery, bioplastics, proteins, enzymes. There we go with the sexy opportunities. I knew you wouldn't let me down. But we also heard about some of the additional challenges around ensuring all the dependencies were in place, the stakeholders lined up, that we can meet regulatory requirements, finding the right partners and making a plan to work alongside those partners and be collaborative. This is so much more than just the widget itself. Let's move on to the final question. Tell me about the key innovation opportunities that you see within resource recovery.

JB: A key innovation opportunity within resource recovery. Well there are multiple and varied aspects to this, and very difficult to answer. Saying one thing in this diverse area it would probably be remiss. So there are multiple factors here aren't there. There're carbon drivers, there're value drivers, there're environmental impact drivers, all of them distil down to cost invariably into a regulatory framework which is complex and has only got certain windows of opportunity within a very restrictive cycle of investment, a five-year cycle, the amp cycle that's within the water sector. So I think a key opportunity here is the potential for technology providers, especially those that can provide technologies in resource recovery or just more efficiently doing things that can sit on the end of a pipe kind of solutions rather than sitting in to a very prescriptive process. Those end of pipe, those technologies that can sit on the end of a process have got real potential here to be delivered in a commercial way. I think this is one of the things that Ofwat is very clearly signposting is the regulated capital route is well trodden path but is difficult in many respects.

So a commercial delivery of merchant plants that can derive additional value from resource recovery I think is a key area and I'd urge potential technology providers to think of how they can attract an investment that can deliver the service. Then that will push for things like the off and site procurement issue which isn't an issue in my view. It becomes a much simpler process to adhere to. So delivery in is a service where it can deliver much more rapidly than through a regulated investment, regulated capital investment and I think that's a huge opportunity area.

TK: A key opportunity I see within this area is around chemicals. We are a heavy user of chemicals which we buy in from virgin sources at vast expense. There is lots of opportunity here to change our technologies to reduce the amount we use, find other industries that produce these chemicals as a waste that we can use instead of buying in as well as finding alternative chemicals that could do the same job but have a lower environmental impact. I could talk about resource recovery all day but hopefully that gives you an idea.

PV: So I think there's a number of a really exciting opportunities at the moment for us to recover material, energy and of course water itself from wastewater. But I guess one that I'm really excited about and we're busy on with researching and developing is ammonia recovery. So ammonia is a pollutant in wastewater, it's toxic to fish so we need to remove it from our wastewater before we discharge it and at the moment what we do is convert it to nitrate and nitrogen gas which we do nothing with. Ammonia of course is a really valuable resource, it's required as a fertiliser, without ammonia you couldn't grow food to anywhere near the extent

that we need to feed the world. But it creates a lot of carbon emissions, it's formed by the Haber-Bosch process, really energy intensive process using fossil fuels. We've got this ammonia given to us for free if you like, so yeah I think massive opportunities for us to recover ammonia initially from sludge liquors, the concentrate that's produced when we do water, treated sludge, but also from wastewater directly. That ammonia can be used either as a fertiliser or as an energy store. So it can be converted to hydrogen for example, or it could be used directly. I think in the future we'll see ammonia engines. So yeah, ammonia I think is my top resource at the moment.

OV: The key invention opportunity in my opinion is actually enabling existing innovations, being brought to practice. It would help greatly if the water sector sets new standards for circular value chains. The current standards often hinder these new value chains. Once set and the new value chain meets these new criteria it often helps also opening other value chains. For instance, when we created the chain for calcite, from the softening process of drinking water companies into a new [unclear 0:30:08] material for the same drinking water sector the standards were so high that actually the cosmetics industry started using the same product.

SM: Thanks all. The sector setting new standards, I love that. Currently the sector needs to work within super-tight standards which do not really consider resource recovery and tend to favour virgin resources. So I think there's good innovation there to be had. Ammonia recovery, crazy that the fertiliser sector emits loads of carbon creating the fertiliser when we have it in the wastewater, and finally commercial merchant facilities, I think exploring that option is really exciting, but it will require that vast stakeholder engagement. Okay I want to thank our speakers today, Jon, Tamsin, Pete, Olaf, much appreciated. To summarise this session there is a need for the sector to be more resilient, less reliant on chemical providers producing less waste and exploring the reuse and recovery potential. There are vast amounts of resource recovery options but there are key challenges around the development of business cases and value creation, legislation with many stakeholders to work across. So we need to consider all those factors. This has been the fourth in a series of six webinars as we travel through the water cycle, so keep an eye out for the other two. We will now transition to the Q&A session; I hope you have been thinking through some questions and populating our Slido. I invite all speakers to come off mute, over to you, Caecilie, to chair the Q&A. Thanks again for your interest and engagement.

C: Thank you very much, Stu. We will very quickly jump into the Q&A, just a reminder that all the questions should be asked on the Slido, so use the QR code on the screen or you can use the link that was shared in the chat. We're quickly going to jump into the questions, they've been coming in nice and fast during the presentation as well so we'll jump straight into it. Just a quick reminder to everybody in the audience that around this time we always launch a little poll, it's five very quick questions. It'll help us gauge a little bit about how the content resonates with the audience and also where the audience is coming from in their interest in the Discovery Challenge. So do take 30 seconds just to answer those questions just while we get the Q&A kicked off. So first off coming in we've got a question here, Andrea



we'll ping that your way straight away. Karyn, if you could jump in afterwards as well. So the question came in around how big the issue around phosphorous pollution is.

AG: Thanks very much. So I guess the reality is most of the phosphorous we each consume in our diets passes straight through, our bodies only take out what we need and so everything else is going into the wastewater system. What that means in terms of the environment, so obviously where it's going into the wastewater system we're removing it before we discharge wastewater back into the environment but we have a legacy issue because we've got phosphorous coming from not only wastewater treatment works, we've also got it coming from agriculture in particular. In terms of the scale of the challenge in the water environment the EA estimate that half of rivers and about three quarters of lakes actually have too much phosphorous in them. In the context of regulation only 36% of our water bodies are meeting good or high status under the Water Framework Directive. Whilst that's not entirely due to phosphorous that is a big part of the challenge.

KG: I would just add that... Andrea answered it very well, but I guess from that water company point of view or the wastewater assets as well it is really challenging to remove it down to very low levels that are required because it's already quite dilute when it comes into the wastewater treatment works, biological processes will remove it. But the industry is seeing that bigger challenge in how to remove phosphorous and clearly it's a good, you know, potentially we can recover it as well and I can see some beneficial reuse of that too.

C: Excellent, thank you very much. We'll jump straight into the next one where we look at a question, I think we'll ping that to you, Jon, first but do water companies know how much resource they lose from CSO overflow?

JB: Okay, so as you'll have seen quite extensively on the news at the minute CSOs, combined storm overflows, are a fuse within the sewer system which allow in certain circumstances sewage to be released into the watercourse environment in a dilute sense purely compliantly. However, that isn't always the case and I think that's something that's probably a separate subject. How much is lost, I suspect that there is not as much as you'd think, if you think about the number of times CSOs spill and the amount of sewage which passes legitimately through a sewer network into the water, into the sewage works then loses through CSOs I would imagine are relatively small. That's not to say that they are not polluted, that's not what I'm saying but in terms of lost resources through CSOs as a whole off what it discharges into the sewer network, relatively small. What's lost from the sewage works is largely governed by the compliance standards that the sewage works has to meet in terms of phosphorous and ammonia or nitrogen at the final effluent point. Hopefully that answers the question.

AG: Yeah, Jon, I completely agree, and I think it comes back to Karyn's point that the point that the phosphorous in sewage is really dilute, which I guess is one of the challenges around recovery which I'm sure we'll come on to.

C: That's great, thank you very much, guys. Next one coming in we will throw the ball back to you, Jon, very quickly but the rest of the panel do feel free to jump in. Actually, I was just reminded as well, just to do a quick reminder to the audience that on these issues today we've got two panel speakers who have joined us who didn't get a chance to present themselves in the presentation. So before we jump into the next question I'll just give a couple of minutes to Karyn and Andrea just for you to get a chance just to share who you are and why you're joining today.

KG: Thank you, so I'm Karen Georges and I'm Managing Director for Isle in the UK. I have around 25 years of experience in the water sector, mostly around wastewater and bioresources, so the sludge, the solid parts and a lot around resource recovery especially around chemicals and things that end up in sewage and bioresources. My specialism I guess for the purpose of this call is around novel technologies and new ideas and new solutions coming through.

AG: Thank you, Karyn. So I'm Andrea Gysin, I'm the Water Strategic Advisory Director for WSP. So WSP's a large professional services company. We do engineering design, provide advice to clients across the sector and to help them to deliver the services they need to deliver to customers and for the benefit of the environment. My career spans more than two decades in the water sector during which time I've been a consultant, I've worked for start-up and growth companies and I've worked for a water company. So I was Head of Innovation for Thames so always a focus on new things, new technologies and I guess the one that's most relevant here is one of my start-up experiences was with a company that specialised in the recovery of phosphorous for use as a fertiliser. So a topic that's very close to my heart here.

C: Thanks guys, it's just good for the audience to know who's answering their questions and where they're coming from. So we'll jump into the next one, Jon, as I said we'll ping this one over to you as well. So what's currently the largest resource recovered from the water cycle?

JB: Probably one that isn't recognised and that's water, in that it's a continuous cycle. So that aside, so water discharged into the water environment, abstracted, treated and put back in again without doubt that's the biggest one. If we look at this on a different level then it's almost certainly bio-solids, so the solids recovered from the wastewater treatment which are usually extensively digested with anaerobic digesters, stabilised with water and then recycled to agricultural land which has been the standard really for decades. That is a good use of nutrients, however there are challenges and as Stuart said in the introduction there

are potential issues here which are being understood more than they have before about nutrient losses within that system. These are highly mobile nutrients that are applied back to land. But also understanding on contaminants such as microplastics, such as persistent organic chemicals like pfas and how they accumulate within the land. Less than that it is a good source of nutrients, the real potential for sewage sludge here is how can that system be improved upon. Again, this phrase I use is where compliance is a happy consequence of resource recovery. I think there are better ways of dealing with sewage sludge than digesting and applying to land. It is a net emitter of carbon quite substantially and that needs to be looked at.

C: Thank you very much. We'll jump straight into the next one. Jon, we might throw the ball back here as well, do feel free to jump in as well. So this question came in here around are the individual companies, water companies I'm assuming here, in charge of individual recovery processes or is there more like a national plan or structure for how this operates?

JB: Yeah, sure. So collaboration within the water sector, within the innovation teams, within the different water companies in the UK is stronger than it's ever been I would suggest at the moment. However, we have to recognise that each of the companies have different drivers, they are individual, independent, financial entities and will have different priorities. So whilst it's absolutely right that there should be highlighted agenda on a national footing, there will be prioritisations within each board's company and that should be recognised. So while there will be opportunities for national agenda common issue resolutions it is also quite right that companies that have a more commercial agenda, for example, will pursue either by themselves or in conjunction with a smaller group of collaboration, which might well be more rapid and adept. When the whole sector works together you've got many, many companies all working together and that can slow things down. So whilst collaboration is a very vogue word at the moment, collaboration at all costs in my personal view can also inhibit quite substantially. So having companies that are really future focused, commercially focused, can move things quite rapidly.

In terms of piloting, it should be the last resort. Do the due diligence stuff first, supply chain, come forward with your business plans thoroughly thought through of what you think the variables are and that will help the water companies select you as partners more rapidly.

PV: Yeah, thanks Jon, just to jump in on that. We heard from Olaf who couldn't join us for the Q&A but he runs a business in the Netherlands called AquaMinerals and AquaMinerals work on behalf of the whole Dutch water sector and I think a few in Belgium as well, where they agglomerate all of the drinking water sludges. So on their own probably not a big enough quantity to make a useful recovery of those resources but as they agglomerate them all together they can produce a critical mass of resources that then they can find a market for. So I think that model works really well in the Netherlands. I think there's potential to look at opportunities like that in a UK context, it requires some creative business models and perhaps some of that looking outside of the regulatory model as well, and some tenacious persons or organisations to be that broker I guess, to bring all those different stakeholders

together. Yeah, I like this idea of that agglomeration of resources to get the most out of what we've got in the national system.

C: Thanks both. Moving to the next question, Andrea we'll pin this one your way once I've given it a read. So the question that's coming from the audience around is there a real motivation within the sector to develop better recovery practices and if there isn't financially beneficial to the companies would they actually trial new ideas, like what is their motivation for putting better practices in place?

AG: Thanks, really interesting question and I think the answer is it depends. So the motivation, the financial motivation may come from a number of different directions and often the driver is regulatory. So there may be a net cost but in order to comply with regulations companies have to take certain steps. So in that scenario then absolutely the answer is yes, if there's a potential to meet regulation in a more cost-effective way than other options then recovery would be on the table. I guess in terms of a lot of the resources that are and could be recovered it's also worth bearing in mind that the driver isn't necessarily always the value of the resource itself. So if you take phosphorous yes it is a high value nutrient, it's really important but often the cost of recovery outweighs the value of the resource. The benefit comes through in terms of the operational benefits through the utilities so phosphorous is a real nuisance on wastewater treatment works. It precipitates out of struvite in all sorts of places which causes all sorts of operational difficulties, so water companies have to dose chemicals to deal with that problem. So the biggest financial benefit typically in phosphorous recovery is actually the reduction in chemical use at the treatment works not the value of the phosphorous itself.

Now what I would say is that that picture will change and evolve so as we're under increasing pressure to reduce carbon emissions and to improve sustainability credentials more generally it means that there is more and more pressure on virgin materials and typically around 45% of our carbon emissions as a society come from materials, not from operational activities. So if we can replace those materials with low-carbon alternatives then that has a benefit in terms of that legal commitment we have in the UK to reach net zero by 2050. So that will start to tip the balance in favour of recovering materials where the virgin equivalent has a significant carbon intensity.