Official Report
Aithisg Oifigeil

DRAFT

Climate Action Committee

Comataidh Gnìomh air a’ Ghnàth-shìde

Thursday 5 November 2026

Session 7

The Scottish Parliament
Pàrlamaid na h-Alba

© Parliamentary copyright. Scottish Parliamentary Corporate Body

Information on the Scottish Parliament's copyright policy can be found on the website—
www.parliament.scot or by contacting Public Information on 0131 348 5000

Thursday 5 November 2026

CONTENTS

	Col.
INTERESTS	1
ENVIRONMENTAL IMPACTS OF HYPERSCALE DATA CENTRES	2

CLIMATE ACTION COMMITTEE
8th Meeting 2026, Session 7

CONVENER

*Stuart McMillan (Inverclyde) (SNP)

DEPUTY CONVENER

*Ariane Burgess (Highlands and Islands) (Green)

COMMITTEE MEMBERS

*James Adams (North East Scotland) (Con)
*David Barratt (Cowdenbeath) (SNP)
*Martyn Day (Falkirk East and Linlithgow) (SNP)
*Sanne Dijkstra-Downie (Edinburgh Northern) (LD)
*Donald MacKinnon (Na h-Eileanan an Iar) (Lab)

*attended

THE FOLLOWING ALSO PARTICIPATED:

Alejandro Gallego Schmid (University of Manchester)
Craig Melson (TechUK)
Thomas Morstyn (University of Oxford)
Wim Vanderbauwhede (University of Glasgow)
Andrew Weir (ScotlandIS)

LOCATION

The Robert Burns Room (CR1)

Scottish Parliament

Climate Action Committee

Thursday 5 November 2026

[The Convener opened the meeting at 09:15]

Interests

The Convener (Stuart McMillan): Good morning, and welcome to the eighth meeting in session 7 of the Climate Action Committee. I welcome Donald MacKinnon to the committee and look forward to working with him, and I extend members' thanks to Claire Baker for her work on the committee. Under agenda item 1, I invite Donald MacKinnon to declare any interests that are relevant to the committee's remit.

Donald MacKinnon (Na h-Eileanan an Iar) (Lab): Thank you, convener. I draw members' attention to my entry in the register of members' interests. I run a crofting business that is in receipt of agricultural support, and I am a shareholder in a common grazing that has an interest in peatland restoration. I imagine that both subjects will come up from time to time on the committee.

The Convener: Thank you.

Environmental Impacts of Hyperscale Data Centres

09:15

The Convener: Agenda item 2 is our second week of evidence sessions as part of the committee's inquiry into the environmental impacts of hyperscale data centres. As I did last week, I will say a few words about our inquiry before I introduce our witnesses.

The committee agreed its approach to the inquiry on 17 September and 1 October. Our aim is to find out about the environmental impacts of the operation and construction of hyperscale data centres in Scotland. We will consider aspects such as water consumption, air quality, noise pollution and energy use, including back-up generation. We are also interested in the impact of growth in the sector on Scotland's ability to meet its carbon budgets and on the climate change plan. We specifically want to know what systems should be in place to mitigate any negative impacts on the environment and what Scotland can learn from other countries.

We are gathering information in three ways. First, the committee is collaborating with the Economy, Tourism and Energy Committee in running a call for views. I encourage people to share their views on the issue with us. Details can be found on the committee's website.

Secondly, committee members recently visited a data centre in North Lanarkshire. The visit to the DV1 site, which is run by DataVita, allowed members to see how a data centre operates.

Thirdly, we are taking evidence from experts over three meetings. Last week, we heard evidence from witnesses with an environmental background and then from witnesses with experience of data centre development in Ireland. Today, we will take evidence from a panel of witnesses from the technology sector and then take evidence from a panel of experts on sustainability and greenhouse gas emissions. Next week, we will finish the first part of our evidence taking on data centres by speaking to witnesses on issues relating to water and waste heat. The committee has agreed to consider a second phase of work following the conclusion of those evidence sessions.

I re-emphasise that the committee is not engaging in scrutiny of individual planning applications, which are matters for local authorities. At this stage, we are gathering information that will be shared with the Scottish Government in advance of its production of national planning guidance.

I welcome our first witnesses: Craig Melson, associate director of techUK, and Andrew Weir, chief executive officer of ScotlandIS. I look forward to hearing your evidence.

I will ask some opening questions before I bring in my colleagues. Mr Weir, in the written evidence that you submitted, you touch on opportunities, competing demands, financially robust contracts and identifying delivery partners. Much of the evidence and communication that we have received so far has centred around the fact that there are at least 23 applications for data centres in Scotland. It is clear that, for some of the applications, end users are already in situ, whereas others are speculative applications. Given that, would it actually help not only this committee and its work, but the Scottish Government, too, as it considers the upcoming guidance and guidelines that it is going to produce, to have something that is a bit sharper? In other words, instead of looking at everything to do with the 23 applications, at least, for data centres, I wonder whether, if there are applications with an end user already lined up and a contract potentially signed, it would be better to take a more focused approach that allows those with an end user to progress to the next stage of consideration and those that are speculative not to be considered.

Andrew Weir (ScotlandIS): First of all, I thank the committee for asking us along to discuss this very important subject. We welcome the discussion, and obviously we support responsible hyperscale data investment.

On the specific issue of end users, the individual projects are at various stages of application, and they have various life cycles in terms of the developer, the grid status, their challenge in respect of local sustainability issues, their access to end users and the funding partners and parameters. Although a simple statement of access to the end user would be helpful, you do need to look at the projects across a range of factors, and a key point that we want to represent today is that proportionate standards should be set around the climate factors, the local environmental factors and the net social value that will stay in Scotland through the lifetime of the project. Simply looking at the end user does not guarantee that all of those factors will be addressed. Therefore, we would recommend something a little bit more nuanced and balanced than that simple statement.

That said, end users are a key part of the funding package and the developer's confidence in moving standards forward, so that sort of thing would always be helpful.

The Convener: Thank you. Do you wish to comment, Mr. Melson?

Craig Melson (TechUK): Thank you for your kind invitation to address the committee today.

I would just reiterate that this is a moment in time. We are seeing a lot of growth globally and a lot of applications going in across the world for hyperscale and indeed, other forms of data centre, but we do not know how long this moment in time is going to be. There is a lot of community reticence and concern that this is going to be some forever thing and that we are plotting to have data centres on every street corner. However, that is not going to happen—this is not the new normal. We are not there yet. This is a moment in time, and the challenge for Scotland and the rest of the United Kingdom is to get as much of the investment as we can and ensure that it is deployed in a responsible way that mitigates any potential harms.

The Convener: With regard to any guidelines that the Scottish Government publishes, do you think that it would be beneficial or helpful to have separate consideration of the battery energy and storage systems? If so, what type of information would it be useful to gather?

Andrew Weir: When you look at energy measures, you need to look at energy in the round. Data centres are very energy intensive; energy is going to be a major part of their cost base, and consumption can vary depending on the time of day, the time of year, access to renewable energy and so on. You have made a very important point about access to back-up and back-up generators, and we would expect that to be factored into the total cost of ownership, with clear standards given for overall energy usage.

We would reinforce the importance of data centres and technology to critical national infrastructure and the fact that that is increasing hugely at the moment, and we would like a significant joining up between energy policy and digital infrastructure policy, to ensure that the consumption of energy and access to energy, the grid and different types of renewable power are all looked at in terms of total demand and the total cost of ownership instead of on the basis of a narrow question about access to generator-type back-up. That back-up will be needed, but it needs to be looked at not just in the case of individual project applications but in totality with regard to the digital and energy infrastructure of Scotland.

Craig Melson: The national policy framework for data centres has a preference for green data centres, but at no point is it specified what that means. There are no specific metrics on water efficiency, energy efficiency or renewable obligations. It has created a bit of concern among the industry that we have a vague target in the policy framework but no meaningful metrics

behind that. However, that will change, for various reasons. The new national planning guidance will be welcomed by the sector, because what we have had so far has been too vibes based. It has not been really based on actual metrics and what we need to meet to satisfy the policy direction that the Government wants to take.

The Convener: That is very helpful, because that is the subject of my next question. What would you like to see in the definition of a green data centre?

Craig Melson: There is no right or wrong, because the data centre market is very varied. Your inquiry is focusing on hyperscale data centres, but there are also co-location data centres. They are provided by data centre companies, but those companies do not own any of the information technology in the centres, whether that is for AI, what I colloquially term normal computer stuff such as storage and data processing, or high-performance computing. Other people move their equipment in. There are also smaller edge data centres, which will be more important for things such as low-scale AI inference. That is not about training AI models but about using AI to make things such as autonomous vehicles and smart city technology. Each of those types of data centres is different.

The industry moved towards what is called power usage effectiveness and water usage effectiveness, but I think that there is now movement within the sector away from that, to be honest. Those are still seen as the main metrics, but we are moving away from them because they are quite immature. Nevertheless, having specific energy efficiency and water efficiency targets would be good. Even if people do not necessarily agree on the numbers, they will know what they have to achieve.

The other thing is to look at what is happening in the rest of the United Kingdom and in Europe. Having the same metrics in different parts of the UK will make it really tricky if you have ambitions for only one or two data centres. If there are different policies, that will make a real difference in relation to choosing to site a data centre in one place over another.

Andrew Weir: I will give a similar answer. The growth in data centres and hyperscale data centres is a global phenomenon and there is emerging consensus on standards and frameworks. There are European Union data centre frameworks. Considerable work is being done in a similar climate in the Nordics, and Ireland has a similar geography. There is huge consensus around the UK on standards and measures.

What is important is not just a green data centre standard or charter, but a commitment to ongoing transparent measurement of that and an ongoing ambition to keep improving and adhering to the standards. We see great interest and confidence from our membership and industry in doing that. It is in their interests to have the lowest cost of energy. Energy and water are two of their major ongoing costs, so it is very much in their interests to be on top of the efficient and transparent management of those resources, not just in relation to the local community but in relation to power consumption across the nation.

With data centres, it is not just about local communities; it is about accessing the infrastructure and the power, which can be spread across Scotland, the UK and indeed the globe, depending on the application of the resources. We have to look at the green data centre issue in a wider manner. Thankfully, there is an increasing amount of science coming to help us, as well as many other international frameworks that we can work towards quickly.

09:30

The Convener: I will ask a final question before I bring in other members. You touched on the position in other countries, and the inquiry's remit includes consideration of that. Lombardy, in Italy, passed a law in June that came into effect in October, and it is already looking to make amendments to strengthen what was recommended. Australia is looking for large-scale data centres to underwrite power supplies, limit their water use and pay for any extra water infrastructure. The developers of data centres in Ireland are to fund any new renewable energy projects. Would it be useful for the Scottish Government to include such approaches in its guidance?

Craig Melson: Data centres are already underwriting many of the offshore renewables projects that are being developed off the north-east of Scotland and across the whole North Sea. Data centre developers are often the biggest off-take customers, so they underwrite the investment by signing a piece of paper that basically says, "We will buy lots and lots of renewable energy at a great price for ages." The renewable energy project owners can then say to their investors, "We have real confidence behind this—can we go ahead, please?" That is already happening in the commercial world. There are commercial power purchase agreements, which are deals that are cut with energy providers to lock in reliable, consistent and generally low-carbon power for decades.

The water issue is particularly interesting. You can see why such rules might be attractive in a particularly water-stressed area, but data centres across the UK are not big users of water. The data centres tend to be newer and do not use water-

based cooling. Instead, they use air cooling and closed-loop cooling, which involves the system being filled up with water once and the water then moving around—basically, it is like what happens at the back of a fridge. The trade-off is that that uses a lot of energy. Even if water consumption decreases, a lot of energy is used to replace water in the cooling system.

Therefore, in a non-water-stressed area, where there is an abundance of water, it might be better to use water-based cooling, but we do not tend to see that in the UK. Some older enterprise data centres that companies set up decades ago might still use water, but they are all being replaced by much more mature technology.

Andrew Weir: I will try to address some of the key points. We see an opportunity to marry data centre energy demand with national energy demand from all the different power sources. That provides a key opportunity to secure investment, particularly in Scotland, where we have renewables.

Scotland also benefits from a naturally cooler climate with lots of water, so there is perhaps slightly less anxiety about the water issues, especially when we can carefully manage cooling through different sources, including fresh water and waste water.

Our industry and membership are keen to support environmental standards, which are applied to the full life cycle of energy consumption, not just narrowly to the data centre's consolidated site. Clearly, greater planning of the capacity with the electricity network will be of huge value.

Donald MacKinnon: I thank the witnesses for joining us. I will continue the convener's line of questioning from a slightly different angle. We have been talking about green data centres, but what would a responsible hyperscale data centre look like? What criteria should be used to identify sites? When answering those questions, it would be helpful if you could tell us what you think the definition of a hyperscale data centre is. What are you talking about when you talk about a hyperscale data centre?

Craig Melson: I will need to respond in writing on the actual definition, but we are increasingly talking about data centres that involve 100MW of capacity. Data centre size is not measured in square feet or the number of computers or racks; it is measured in power output. We are conversing about 100MW. I will have to go back to the team and see whether there is a more sophisticated definition, but I think that that is what we are using.

Most of the emissions impact will be related to the power source. If that is renewable, that has to have the biggest individual weighting in considering what size of data centre is sustainable. What is its power input and where is the power coming from? If it is from renewables, that is great. There is also the issue of water efficiency and cooling, and you can measure the social value. Is there a way to off-take the waste heat? Data centres generate a lot of heat, so, rather than it just going off into the air, can it be piped to community facilities and homes in the area?

What certifications does the data centre have? Does it meet the green building standards? What International Organization for Standardization—ISO—certifications does it have? Is the owner a member of certain industry schemes? For example, in Europe, we have the climate neutral data centre pact, which many of the hyperscalers belong to and which has a target for climate neutrality. Is the owner using voluntary standards, and, above that, meeting streamlined energy and carbon reporting—SECR—obligations and other mandatory obligations? Is the owner uploading carbon emissions data to the carbon disclosure project? Is it signed up to the greenhouse gas protocol?

Biodiversity is a tricky one. On brownfield sites, a data centre is not necessarily consuming more nature or using nature in an irresponsible way. One of the Lanarkshire ones is an old hospital car park. How much nature is being displaced there? The nature impact is increasingly crucial, not only with data centres but across the tech sector.

On siting, there is a mixture of opportunities and constraints. One issue is where you are allowed to build. Are you going to get the permits and planning permission, whether that is from the Scottish Government or a local authority? There is also the issue of access to customers. Although you can have an AI training data centre pretty much anywhere, if latency is important, you need to be close to the customer base. Also, the staff need to travel there, and you need to have ready access to logistics and transport networks to take racks in and out and to move engineering stuff. Another issue is fibre. You need to go where there is strong fibre connectivity.

Donald MacKinnon: You mentioned interactions between a data centre and the surrounding area, whether that is about employment opportunities or off-taking heat. How important is engagement with the local community in the responsible development of hyperscale data centres?

Craig Melson: It is absolutely essential. Over the past 30 or 40 years—or even 50 years, if you include some of the telecommunications-led data centres—data centres have not been subject to the level of scrutiny and attention that they are getting now. The industry is wising up to the fact

that you need early and regular community engagement. Some of that is because of misinformation. For example, people say, "It's going to put up our power bills," but it will not. That has happened elsewhere—for example, it has happened in bits of America, but we are not in America. You need to dispel some of the myths and fears that create concern, but you also need to bring people along with you, as with any other infrastructure development. You would not want to put an A road through a town without working with the town and making sure that everything is mitigated or, indeed, considering whether it is a good thing to do.

You need to be more present in the community and show the benefits, whether those are about local employment in the construction or ongoing usage phase, or opportunities to cluster. Some very clever things are going on where data centres are not just a shed with computers in them—you can have co-working spaces and clustering of technology businesses that use the compute power and share the energy resources. Heat networks are trickier, because they are hard to do and because you lose heat quickly due to the rules of thermal efficiency. Therefore, that is really useful only for data centres in urban environments.

Working with the community is essential, because you need a social licence to operate, and I think that the data centre industry has struggled with the increasing concerns from local councils and authorities.

Donald MacKinnon: My colleagues will probably pick up on those points about electricity. Andrew Weir, what does responsible development of hyperscale data centres look like to you?

Andrew Weir: That is a good question. Again, there is some nuance to the issue. Data centres have been around in very small units for 30 or 40 years or so, going back to my early career. We have had several of them in central Edinburgh, which are now being turned into luxury developments.

We are moving forward into a very different environment. The word "hyperscale" seems to be more associated with a huge physical scale, size and presence. It tends to be associated with the major cloud providers, Microsoft, Amazon and Google, and the large language model providers such as Anthropic and other AI companies. If we try to chisel those elements down, what would a good data centre look like?

Donald MacKinnon: Would you put a power usage definition on it, like Craig Melson did, of around 100MW?

Andrew Weir: When we talk about definitions, we all want more precise definitions of size, scale and usage. The data centre industry is committed to giving transparency on usage, statistics and reporting, so that we can be measured against that. For something of this size and scale, we will need to have more tightness and accuracy.

Donald MacKinnon: So, it is about more than just the power usage. It is related to things such as physical scale.

Andrew Weir: Absolutely. We are moving to a world where we want to have a view on the overall climate impact of a responsible data centre operator, and responsible data centre operators are very alive to that request. They would probably accept that there is more to be done to dispel some of the myths and legends around data centres and bringing them to life. That comes across in power usage and sources of power; in comparisons with other industries, which have perhaps, over recent years, not been subject to significant scrutiny on their power and water usage; and in international comparisons.

Data and digital infrastructure is a global phenomenon. It is not at all only a Scottish phenomenon—the growth in hyperscale data centres is moving at pace in America, China and across Europe. We are making those comparisons and can see that those things are going to happen.

In response to your question on what good would look like, good would very much look like a data centre operator that is transparent about their power usage, that is involved in an ecosystem and that gives a view of its energy consumption and the climate effects of digital infrastructure on the local, regional and national scales.

You made a point about consultation with the local community, which is extremely important with regard to the set-up of construction jobs and the initial disruption of large-scale construction projects in areas such as ongoing noise and how it can be managed. There is an initial economic boost in relation to construction jobs. In the longer term, we believe that access of schools and campuses to compute power and AI infrastructure will bring significant benefits to the economy.

Donald MacKinnon: The UK Government has outlined a policy on artificial intelligence growth zones. How has identifying areas around the country for those growth zones usefully encouraged responsible development?

Andrew Weir: They are helpful in identifying responsible development, because we are in a very fast-moving industry. As we have seen from the growth in interest in AI and data over the past two to five years—in particular, look at how technology is driving stock market growth on the Nasdaq and S&P 500—there is clearly an enormous economic incentive to deploy the right

type of infrastructure in the right manner. There is a recognition that climate is extremely important within that, and that we have to balance the energy, power and water needs effectively.

09:45

On AI growth zones, a lot of the data centre infrastructure that has come alive is in existing brownfield industrial sites. Nuance and detail are everything in some of the debates. We are looking at redeveloping large brownfield industrial sites that have been used in industry for decades and, indeed, centuries. Their access to power and their impact on biodiversity and soil, for instance, is completely different from that of other sites. The AI growth zones have shone some light on brownfield sites and on areas that might benefit economically from growth. Because of our collective industrial history, that kind of special development area has been a feature of industrial policy for decades.

There is plenty to build on and plenty to learn from. Scotland has the opportunity to set standards for responsible development that factors in not only the benefits from AI but how we manage the climate and sustain the energy and water demands.

Ariane Burgess (Highlands and Islands) (Green): Good morning to the witnesses, and thank you for joining us. I have a number of questions: one is on siting and one is on land use.

The National Energy System Operator suggested that siting data centres in Scotland could reduce constraint payments, investment in transmission grids and, ultimately, electricity bills, and the Economy, Tourism and Energy Committee heard from Dr MacIver, who said that data centres would help if they were on switched-off wind and were north of the B4 boundary.

Mr Weir, in your submission for ScotlandIS, you accepted that grid connections are a decisive barrier. I would be interested to hear from you about what the Government's guidance should say about where data centres should go and how much capacity Scotland can take. You have touched a little bit on capacity, but I am interested in that and the guidance.

Andrew Weir: The most important factor is joining up energy and digital infrastructure planning as much as possible so that, when we examine capacity, we consider the strongest form of aggregate demand. If industry is going to make huge capital investment, it needs certainty of demand and as much certainty as it can get about planning capacity.

The most important point is to consider capacity in the round. It is difficult to isolate specific energy questions and be exact. Each project will be approved at a certain point in time. It is important that we have a clear understanding of the path for projects to get on the grid, their likely energy demand, how that can be met—how it can be split up between renewables—and how it can be funded within the developer's project plans.

Craig Melson: There are 15 terawatts of surplus renewable capacity in Scottish energy generation. NESO also estimates that more than £1 billion—it could be up to £2 billion—is already being paid to providers to switch off. Those are the constraint payments. There is a huge capacity, which is well in excess of what is needed.

It is worth saying that Scotland currently does not host a hyperscale data centre primarily for cost reasons and because of grid constraints. If we had a joined-up approach to policy, particularly on brownfield areas, Scotland could become a natural home for data centres in the same way as the Nordic countries have.

It really comes down to that low-cost—and huge—surplus of renewable power that Scotland already has, which can be built on further if there are incentives on, say, locational pricing. I am not going to get into the ugly zonal debate that has occupied a lot of the energy policy world for the past year, but it would be good to have the right locational signals and the right brownfield sites. For all the reasons that Andrew Weir has set out, brownfield sites offer many more advantages with regard to nature protection, resource consumption and economic renewal that we would not necessarily get with greenfield sites. However, it all comes down to that abundance of cheap renewable power that is already in the system and that just needs to be transmitted for someone to use.

Ariane Burgess: Given Craig Melson's definition of a hyperscale data centre as one of 100MW capacity, that would mean that the 23 applications that have been made would basically amount to a pipeline in Scotland comparable to 90 hyperscale data centres, because the ones in the planning application process are much bigger than 100MW. Is it realistic for Scotland to host that much? What should the guidance say about how much is acceptable?

Craig Melson: To be honest, I do not think that it is realistic for the UK as a whole to host that many, because the costs are so high. I have to say that many of those applications are speculative, and they are a mixture of people who are, frankly, trying it on, and people who need to put in duplicate applications. They might have a plan for one data centre, but, because they expect it to be turned down four times, they might put in five applications for grid connections. Ultimately, there is going to be only one, but they know that, for

various reasons, they are not going to be able to build it.

Therefore, there is a lot of artificial inflation, and we have been working with the energy regulator—the Office of Gas and Electricity Markets—and NESO to try to weed that out. In that respect, we have been moving to the curate process that Ofgem has been working on for a while, which looks at taking a strategic approach to grid connections. It is not a first-come, first-served approach in which a new supermarket, say, has to compete with a new housing development, a new data centre or some other infrastructure project. Instead, it is a more strategic approach, and, when it happens, I expect that figure to come down a lot.

There are data centres with capacity in the hundreds of megawatts, but some are a lot smaller than that. What we need to see is a viable project that has a grid connection, the right planning permissions and so on. It is also worth saying that the 100MW is total output—it does not necessarily mean that a 100MW data centre will be putting out 100MW of compute capacity all the time; it just has the potential to do so. If it is hosting a mixture of high-performance compute, cloud storage and data processing facilities for large enterprises, it will not be doing all those things all the time, so actual utilisation will fluctuate greatly.

Ariane Burgess: With regard to land use, you talked about ensuring that we do not build on greenfield sites and good farmland but prioritise brownfield sites first. Given that, should the Scottish Government's guidance include a requirement to prioritise brownfield sites first?

Craig Melson: Well, not every piece of agricultural land is equal; it could be unproductive or not that great, so some flexibility is needed. However, there should be an expressed preference for brownfield—and realistically speaking, I would say that that is what we are seeing in the sector in general. It is also about proximity to other facilities, whether it be a substation, fibre or road networks, but it is already kind of the preference.

In any case, there should be requirements for very strong environmental impact assessments and a very strong insistence on scrutiny, so that the local authority is able to say, "We've looked at the trade-off between building this piece of infrastructure and nature, and we don't think it is right to build that sort of data centre." Ensuring that the information is available through the permitting and planning processes and that impact assessments are carried out would be a better way of approaching the use of greenfield sites than some blanket ban.

Ariane Burgess: Thanks very much. In the interests of time, convener, I will pass back to you.

The Convener: I think that Donald MacKinnon has a brief supplementary. Did you want to come in as well, David?

David Barratt (Cowdenbeath) (SNP): I will ask the next series of questions after Donald has asked his supplementary.

Donald MacKinnon: I have a quick question for Craig Melson. I do not dispute what you said about the amount of constrained power in Scotland, which is obviously a concern, but you seem to be linking that to demand. Do you recognise that the issue is not just one of demand and that it is also a question of getting the power to where it can be used? The development of the grid is really important in that respect, because the proposed locations of hyperscale data centres are some distance away from where that large amount of power will be generated, whether that is offshore or in onshore wind farms in the north.

Craig Melson: Yes, it is absolutely essential that a joined-up approach is taken, as Andrew Weir said. Grid constraints and a lack of grid infrastructure, whether we are talking about substations, pylons or underground cables, will feed into decisions about where to site data centres. It is fundamental that a properly joined-up approach is taken.

We have had 50 years of underinvestment in the grid all over the place. Renewable technology is not particularly new, but, as we have transitioned to being a country that is primarily wind powered, the connections to towns and cities across the UK have not kept pace with the development of wind turbines. Historically, there has been underinvestment, and we need to fix that.

The Convener: Before I bring in David Barratt, I want to follow up on your comment that Scotland—sorry, the UK—does not need to have so many hyperscale data centres. I will ask this question of Professor Vanderbauwhede, whom we will hear from later. In his submission, Professor Vanderbauwhede suggests that the UK's planned data centre capacity is on the same level as that of China, notwithstanding what is being considered for Scotland. I thought that that was quite a startling point. Does the UK need to have the same number of hyperscale data centres as China?

Craig Melson: No, but I do not think that China has been particularly honest about its energy usage or the number of data centres that it has. A total capacity of about 6GW for the UK has been bandied about, but, frankly, we will never be a leader internationally until we sort out our energy pricing. The cost of energy here is just too expensive in comparison with other markets.

In many ways, China is a fascinating country when it comes to energy policy. China is doing

everything on a bigger scale. It turns on one new coal power station a week, but, last year, it turned on more solar energy production than Europe has ever done. China is doing things on a huge scale, but it is not particularly honest or transparent about its digital infrastructure or, indeed, any of its energy policy.

The UK will, I hope, get to a capacity of around 6GW of compute, but it will be really hard to achieve that, given the grid connection issues, the pricing and the global scramble that we are having to contend with. The projects that we are talking about are not being designed or conceptualised with the UK in mind. People are asking, "Where can we get reliable, affordable power and good-quality climate resilience, skills and labour and access to customers?" The UK generally is a competitive place for that—we might be the biggest or the second biggest data centre market in Europe, but the Nordics are catching up, as are Spain and Italy.

The Convener: Okay.

Craig Melson: I have one more thing to add. The UK has a competitive edge when it comes to climate and general sustainability, and Scotland will score higher than the UK average in that respect. A UK data centre will produce 70-ish per cent fewer emissions than data centres in other markets. That figure will be higher for Scotland, because it has huge unmet wind potential.

Andrew Weir: I thank Craig Melson for his point about Scotland's natural advantages when it comes to climate, renewables, power and so on.

I want to go back to the themes that were raised earlier in relation to development. In any development pipeline, you need to segment projects, because some are fully funded, fully committed, have a good management team, are well backed and have a responsible attitude to climate change, transparent measurement, value for the local community and access to the grid, whereas some are more speculative developments. When we see the aggregation of metrics to extremely high numbers, I counsel that we should whittle those back down to the real projects that are on the table, where we have confidence in the developers, the management teams, the funding packages, the access to the grid and end users, and, as Craig Melson said, the opportunity in Scotland and Britain to be responsible about developing data centres and factoring in climate and community impacts.

10:00

David Barratt: In essence, the case has been made that Scotland should host lots of data centres because it will reduce constraint payments, the climate is cooler and we have lower carbon intensity in our grid. Last week, we heard evidence that, in order to effectively address constraint payments, developments need to be north of the B4 transmission boundary, which Ariane Burgess also referred to today—that is one of the arguments that are used by people who are opposed to data centre developments. In essence, that is north of the River Tay, but none of the developments being proposed are in that area. There has been investment in interconnectors that are already planned or under construction—the eastern green link connectors to England, for example—and will be in operation before any of those hyperscale data centres could feasibly be built. Therefore, before they come into operation, the problem of constraint payments might already be solved. On top of that, renewables are fundamentally intermittent energy sources, but data centres' demand is constant, so they will always rely on back-up generators. If the back-up generators are fossil fuel based, are the data centres truly green?

Before any of this came along, our transition away from oil and gas—away from petrol and diesel, towards electric vehicles—was already challenging. We were on a cliff edge in relation to climate change and it was already a massive challenge. If data centres alone consume all the available renewables, could that not simply mean that other users of energy have to go back to using fossil fuels? Are the arguments being undermined, particularly in relation to constraint payments?

Andrew Weir: That is a very specific energy question for a technology trade body to answer. We are here to support the economic case for digital infrastructure and to discuss its importance to critical national infrastructure and how we position Scotland in that regard in the UK and internationally. Let us be clear that the demand for data centres is a global feature, and the impact on the climate will be global. Whatever numbers we talk about in relation to large or hyperscale data centres in Scotland, the numbers that are being developed in China and America at the moment are significantly larger. Indeed, in any type of climate change debate, compared to Scotland, climate effects created by other parts of the world are significantly more impactful on overall climate change and global consumption.

That said, we need to narrow some of the debate down and look at what responsible data centre operators will do. They will look at hourly reporting on energy usage, so that they can manage some of the peaks and troughs and access renewable power when required. A lot of the traffic going into data centres can be managed—it is not always needed on demand. That said, it is clear that what other sectors are going through in relation to digital infrastructure will

be absolutely mission critical for much of our day-to-day living, so there will be a need for back-up generation. Therefore, we are looking for clear guidance, including from the industry, on what the standards are, and we are asking developers and operators to be transparent in their measurement and reporting.

We must bear in mind that, whatever happens in the room today and whether or not Scotland goes forward with these data centres, there will be a global demand for data centres, which will have an impact on the climate, and that will be at a level and scale significantly above what happens in Scotland. We must always balance the climate agenda with international learning, and, with our ability to get on top of that, we must provide responsible data centre infrastructure in Scotland.

David Barratt: Craig Melson, is the specific case for data centres in Scotland sufficiently robust in the context of curtailment and the solutions that are already under construction?

Craig Melson: Yes, because the quantity is vast. I think that we are talking about a 15TWh surplus, which is crazily high. Ultimately, if we have more interconnections, we can have more off-take.

David Barratt: The interconnectors are also vast.

Craig Melson: Yes. The UK's total energy consumption is about 45GW, but that will obviously change not only as we electrify data centres but as we move to electric vehicles and electrify old industries such as steel and other manufacturing plants. That is also on the basis that the wind turbines that are being built will be the same ones that are there in 10 or 20 years. More projects are being approved, so there will be even more wind power. We are not at 100 per cent renewables. The objective is to get there, but we will need more and more wind turbines.

On the issue of back-up, a lot of the industry has moved towards using vegetable oil—waste oil from restaurants and other sources is being used to replace natural gas. There is also more and more interest in battery storage, with vast grid battery farms being built to store power. Another way to avoid a constraint payment is to not just use power but store it, so that customers—whether in towns, cities, big industrial sites or hospitals—can utilise vast levels of stored energy. Clever things can be done with the grid to provide the energy more intensively at cheaper rates at different times of the day. Scotland has some really promising developments in that area, but there has not been the rapid build-out that there has been in other countries. That is another way to minimise the potential use of gas turbines in data centres.

David Barratt: Data centres involving nearly 9GW are in the queue for electricity connections in Scotland. I was going to ask whether that is feasible, but you have both already given a clear answer on that.

It has been suggested that some projects are potentially trying it on and that we need to weed out the real projects among them. That says a lot about what people have been thinking—they think that some of the applications are speculative and have been submitted by chancers. I will not be cruel in asking you which ones are the chancers who are trying it on, but witnesses at last week's meeting argued that we need to develop a clear statement of need. How should that statement of need be framed? You do not need to tell me which ones are chancing it, but how should the policy be written to ensure that the right decisions are made and the right schemes are developed?

Andrew Weir: I go back to the earlier themes—we need to consider the quality of the management of the data centre developer and operator, their track record, their access to end users, their funding sources, their funding covenants and their overall layout and plans. We would expect them to have cohesive plans to interact with the local community and a strong commitment to measurable reporting on climate factors.

However, all the developers and all the projects will need a more joined-up energy and infrastructure policy. We will need to aggregate the demand more often. It is a bit soon to segregate the level of speculation relating to some of the projects. We should examine in detail the individual projects, which should have a certain amount of definition and will have to commit to reporting, but we have to consider the overall national impacts on energy, water and ongoing policies. It is not quite as easy as going down the line and winnowing out some of the applications. We should focus on the ones that are right in front of us now and are accompanied by real concrete plans, funding, ambition and responsible management.

David Barratt: I think that it is fair to say that the chancers among those applicants have done real damage to the industry. The amount of opposition that has been generated on the back of applications that are not credible has done real damage.

Craig, you mentioned that you think that we are aiming for 6GW of capacity. Is that in Scotland or across the UK?

Craig Melson: That is across the UK. We think that, UK-wide, there are probably about 8GW to 15GW of viable-ish projects in the queue. We hear various campaigners citing 100GW or 70GW, or

whatever it is, but only a tiny fraction of those projects are going to be viable.

Of course, viability will change through the planning process, given the length of time that it takes to get anything built. You might get a connection and then, in eight or nine years' time, your viable project might change and you might think that you should consider locating the project in Germany, the Netherlands or Norway.

It is frustrating that a lot of damage has been done to the sector by poor computer-generated imagery of what data centres are going to do to lovely bits of greenfield land and prime agricultural land not only across Scotland but elsewhere in the UK. We have seen that in south-west England and west Wales, and in areas such as the lake district as well as up in the Highlands. It is very frustrating. A lot of silly claims are being made, usually to attract overseas investment from people who are not credible data centre operators. The credible data centre operators—as Andrew Weir said—have been caught up in that and are being treated like the bad guys in many ways.

David Barratt: Sorry—to pick up on my point again, 6GW of UK-wide capacity is generally what you, as an industry representative, think that we should be heading towards. What proportion of that do you think should be located in Scotland? Is it a proportionate share in terms of population and geography or a disproportionate share because of our cooler climate and access to renewables? A proportionate share for Scotland, at about 10 per cent, would be 600MW of total installed capacity. Do you think that it should be higher than that? I am thinking about the statement of need that the Government has been asked to produce.

The Convener: Before the witnesses answer that, I will flag up that we will move on afterwards.

Craig Melson: I believe that the 6GW is a NESO figure, taking a UK-wide approach.

London and south-east England are still the dominant data centre market—there is a lot of support in the finance industry and that sort of thing—but there is no reason why the Glasgow area cannot get a good chunk of that. The AI growth zone in North Lanarkshire, which will benefit the new hospital, has been a way to encourage companies, whether that is DataVita or others in that world, to build out infrastructure.

There is no reason why Scotland cannot get into the region of hundreds of megawatts. Ultimately, however, siting is a commercial decision taken by data centre operators, who look at the policy situation with regard to the grid, planning permission sustainability and so on. They also have to link that in with fibre access, skills access and whether there are customers who actually want to use the data centre service. That is very much down to commercial realities, and we see intra-UK competition there.

Andrew Weir: There is much more to the use cases than just a simple power target. London, as a massive international global financial centre, has very different needs from much of the rest of the United Kingdom. Scotland has some great advantages, such as a cool climate and access to renewables. There are broader questions around sovereignty of data and how much the UK wants to keep within its control. Perhaps, in some of those arguments, Scotland is very well placed to take more than its share. Again, do we take a share by population or by geography? There are very different balances and metrics involved in each of those measures.

10:15

I would hope that what would come through from this discussion is just how important technology is to critical national infrastructure. The hundreds of thousands of people who are going to their work in technology in Scotland today are probably thinking less about some of the parameters around power and water, important as those are, than about resilience and the cyber attacks that are going on across much of France, which we are thankfully not experiencing here. The story in technology about cyber, cyber resilience, the potential of AI and what that is going to mean for skills, and the wider AI strategy for Scotland is much bigger than the issue of the metrics around power and water that we have been looking at.

I think that everyone in the data centre industry very much appreciates the need to be responsible on climate and to act in a transparent, measurable manner against clear frameworks. We, as a trade body, would be looking to see that coming through, so that we can have a proportionate response to climate change and Scotland gets the best chance to make the most of its ability to grow the industry and ideally get some co-investment going into renewables.

The Convener: Before we move to questions from James Adams, I remind everyone that, while individual data centres and planning locations can be briefly mentioned in order to demonstrate a wider point, it should be noted that the committee will not be making any comment or recommendations in relation to specific planning applications in its findings or conclusions. Answers should therefore be focused on the general issues that the committee is exploring as is set out in its remit.

James Adams (North East Scotland) (Con): Good morning. Andrew Weir, in your written submission you note that Scotland's cooler

climate, paired with appropriate cooling designs, could potentially

"offer a competitive water-efficiency advantage"

for data centres in Scotland. With that in mind, how do you assess the impact, or the potential impact, of hyperscale data centres on water resources in Scotland, both nationally and at a local catchment level? How can high levels of water usage potentially be mitigated?

Andrew Weir: Again, it goes back to having clear standards. With regard to water usage issues—where water is sourced from and how it is used in the actual data centre, and the efficiency within that—closed-loop technologies that can reduce such usage are available in data centres. There are also other technologies that, if they are employed, will use more power, so there are trade-offs to be made on both of those aspects.

Standards, measures and clarity of operational efficiency would seem to be the path through that. In Scotland, we should be confident that, with our cooler climate and significant access to water, such usage would be a much smaller part of the climate puzzle—if I have phrased that correctly—than it would be in many other regions. That gives Scotland some advantage in attracting investment.

To go back to one of the key points in the digital infrastructure debate, the data centre industry is a global phenomenon and will be progressing across China, America, the middle east and Asia. We see all the time, in news broadcasts, the demand for AI coming further forward. Scotland has considerable natural advantage in terms of climate and responsible data centre operators who are willing to work on using the most appropriate measures to manage water.

In addition, when we talk about water in this debate, it is incumbent on us to shine a light on other industries' use of it. The data centre industry is not the only industry using water, and it is important to compare and contrast situations where water is being used. I am sure that the water industry itself will see a significant need for investment in capital infrastructure over the next 10 to 30 years. As with the argument about joined-up energy policy, having data centre demand mapped out and factored into that will allow more sensible investment to be made over the next 10, 20 or 30 years, as that type of infrastructure becomes more and more critical.

James Adams: You mentioned the trade-offs. Can you give us a bit more detail about what relationship exists between the cooling technologies and energy efficiencies with regard to water use? I am relatively new to this subject. If water use is mitigated and goes down, what else happens? Does energy consumption go up?

Andrew Weir: We are a technology trade body and technology is a broad church that covers software, applications, skills, procurement and the AI strategy that Scotland has developed. I do not pretend to be an expert on cooling technologies, but I will put this as simply as I can. Water will come from a source—it could be fresh water or reused industrial water, which has a bearing on the process. It will be used in various aspects of the data centre's operations for cooling and keeping the temperature appropriate, but that will depend on the equipment that is available at the data centre. You then get down to a lower level of detail about the type of cooling machinery that is needed and how often it will have to operate. There is quite a bit of engineering detail in that, which I am not sufficiently qualified to cover.

The trade-off would involve finding an appropriate source of water and minimising its use, taking account of the temperature of the environment or the amount of heat that the data centre machinery produces, and using an appropriate method to mitigate that. It is in data centre operators' interests to keep their water and power costs down, because it means that they can keep the pricing of their ongoing services at an economic level. There is a mutual interest in keeping on top of water usage and keeping the costs of it to a minimum.

Craig Melson: We are working with Scottish Water to understand how industrial waste water and treated sewage water can be sent to data centres for use in the limited areas in which they use water in Scotland. Scottish Water has estimated that 13 data centres are currently on its network, accounting for 0.006 per cent of daily water use. That is less than the amount that libraries use, although I am not saying that water use in libraries is particularly intensive. Scottish facilities tend to be newer, so they bypass the legacy problems that we see in other parts of the UK, where companies must incrementally upgrade old facilities. If you are building a data centre from scratch, you will go for the latest and greatest technology, which is a closed-loop system.

That being said, we still need to talk to Scottish Water to find out the areas in which data centres use water. When you open up a site for the first time, you consume a fair bit just by filling up your closed-loop system, but it is a once-and-done process. How can we ensure that it is not drinking water and that it comes from other supplies? I stress that Scotland is not a water-stressed region, and the trade-offs are quite punchy. An energy penalty of about 50 per cent is associated with using a closed-loop system compared with using water, but no one really wants to go back to using water, because the system is, in itself, an obsolete technology. We have moved away from that now.

James Adams: What information on energy use, water use and environmental performance should data centre operators be expected to report publicly, to be transparent? What should they be honest and open about?

Andrew Weir: There should be a transparent set of standards. I think that power usage effectiveness is the current metric that we use. Given the amount of global investment that is going into data centres, we will see an increasing standardisation of metrics. Aspiring to follow international standards will be key, so that we know that our operators in Scotland are performing to the highest possible standards.

Craig Melson: PUE has historically been the prime metric, but you can also look at total output and total energy consumption. You can look at the percentage of consumption that comes from renewables—that information should be available from your PPA provider.

I am sure that the committee is familiar with the concept of renewable energy guarantees of origin, or REGOs. Basically those are certificates that say, "We bought this amount of energy and you are going to certify that it was renewable." However, much of the time, that certification is not necessarily backed up by what the energy provider has done. We are therefore moving towards half-hourly settlement, which will provide a lot more data. However, PUE, water usage effectiveness and total energy consumption, along with the proportion of that that is renewable, are fairly reasonable metrics.

Andrew Weir: There is also the management of peaks and troughs in energy usage. There is a vast difference in energy usage between the worst week in winter and the worst week in summer. There is considerable nuance around where you have to access and source power for those scenarios.

There is also a huge opportunity to optimise the technologies in data centres and in the entire digital infrastructure when it comes to energy usage. That applies to data centre operators, but also to end users in terms of our day-to-day behaviours. Again, there is a need to look at the issue from end to end and also at the peaks and troughs. The industry is committed to increasing its use of science and method as we continue to rely on digital infrastructure more and more.

James Adams: Thank you, both.

Martyn Day (Falkirk East and Linlithgow) (SNP): I have a few questions on the impact of noise. What evidence is available on the noise impacts that are associated with large-scale data centres?

Andrew Weir: Some of that is emerging as the pace of hyperscale data centres picks up. Obviously, we are trying to navigate into an area where we see hyperscale or huge-size data centre development progressing. The history of data centres in the past 20 to 30 years is not one of huge noise, but, going forward, we have to segregate the noise of construction and the noise of operation. All suppliers of data centre technology such as the tapes, racking and power sources work hard to minimise the noise in the design of data centre operations. That is still an emerging risk that has to be managed.

Craig Melson: Local authorities have the power to regulate the noise that comes from industrial sites—that is the main approach. The primary noise generation from a data centre is from its back-up power, which will be very lightly used—it might be tested every now and again, but the concept of back-up power is that you should not really have to use it—and the cooling systems. However, noise limits can be imposed by local authorities, and environment agencies across the UK will provide permits for maximum noise levels, too.

Martyn Day: Would it be reasonable, as part of the planning process, for restrictions to be put on the hours for testing back-up generators, for example?

Craig Melson: I will need to follow this up in writing afterwards, but I believe that that is already the case and is already part of the permitting process.

Martyn Day: What noise level would you expect to come from a data centre? We have seen evidence suggesting that, in Northern Virginia, the level is consistently around 60 decibels or higher, which is a worrying level, given the concerns that the World Health Organization raises about noise levels.

Craig Melson: I am sorry, but I do not have a decibel level. However, Northern Virginia is very different from the UK. The data centres there tend to be less regulated and they operate in a much hotter environment, which means more demand for cooling. The noise is proportional to how much you have to whack on the cooling. In colder environments, that is a lot less, but I do not have an exact figure for the average decibel level.

Martyn Day: Andrew, would you like to add anything?

Andrew Weir: I would give a similar answer. The size and scale of what is being done in Northern Virginia and in the middle east are not particularly transferable to what would be happening at sites in Scotland. They would be smaller and in a significantly cooler climate.

I think that you have been to the DV1 DataVita site. We have been out to the EPCC facility, and we certainly did not see evidence of significant noise.

10:30

Martyn Day: That is a much smaller centre than what we are considering. I assume that many things could be done with soundproofing, acoustic insulation and so on. Would the other measures taken to reduce the sound pollution increase the cost of cooling the equipment? Would we need more energy to do that?

Andrew Weir: That is a very specific engineering question, on which I would have to take further guidance. It is not in the interests of developers to build cost into their operations. With the sophisticated technology that is deployed, data centres are driven to minimise noise. There are ways to shield it using the different sorts of padding that goes around the racking. Minimising noise is at the front and centre of running an effective data centre. The industry is certainly committed to minimising it.

Craig Melson: There are some clever things that can be done on the outside of a building. Living walls can absorb some of the sound. The blades can direct some of the noise. There is also the selection of building materials, despite the severe capacity and supply constraints on many of the innovative, interesting materials. There is lots of stuff that can be done at the design stage—in the actual architecture—and there are things that can be done within the data halls. Noise is directly proportional to the level of cooling need. Cooler environments will generally provide a quieter data centre.

Andrew Weir: As a national comparison, Scotland does have comparative advantage in that type of thing, noting the demand for digital infrastructure and its critical nature in relation to economic development. Scotland is relatively well placed in managing water and noise.

The Convener: If you could write to the committee after today with the further information, as you suggested, that would be really helpful.

Andrew Weir: On?

The Convener: In response to the question that Martyn Day asked, you said that you would take it away and seek further information. If you could write to the committee later, that would be helpful.

Martyn Day: My next question is less technical, you will be pleased to know. I am thinking about data sovereignty, which you touched on a bit earlier, Andrew. Can our Governments have significantly more security or control over data if it is processed domestically?

Andrew Weir: They can. It depends on the explicit use case—what the data will be used for and what data is very important. We need to debate how important the need for sovereignty is. That said, a huge amount of the memory, chips and technology that are used in data centres is sourced from abroad. The hyperscalers themselves are often from America. We have to take great care to work through where we want sovereignty—within which industry and in which use case—and then apply proportionate rules around ownership, jurisdiction and regulation of data sovereignty. We need to factor that into our overall demand: the need case for data centres going forward and the need to balance that with the economic cost of building the infrastructure, which could go up to a crippling point. A trade-off is needed around sovereignty, so that we get the right use cases for the right sectors.

Martyn Day: Craig Melson, would you like to add anything?

Craig Melson: We have to have a clear definition of sovereignty. The fundamental IT that goes into building a data centre is a cloud offering and will not be made in the UK. The telecommunications services will not use British-made fibre and switching gear. The building materials might come from the UK but could also come from elsewhere. If you prefer to have controls on the data, which you can have through contractual clauses if it is a public sector contract or through data protection rules, you will kill off the demand for the Scottish data centre industry. The technology sector would be vastly less accessible if you had onerous data localisation rules or rules that inhibited the UK being an open-faced trading nation, because the idea is that data centres provide cloud services and will support customers locally and across the globe. In Scotland, I suppose that you could do that, but whether you would want to is a different question.

Martyn Day: Our data use is increasing over time. What scale of data centre use would we need to keep our domestic data within our own borders in, say, 10 years' time?

Craig Melson: I do not know how to answer that question, because no one has quantified the level of UK data consumption. UK people use American cloud services, which could be hosted in data centres in Abu Dhabi, Texas, Spain or Italy. In the data centre market, the UK is strong in what is called co-location. That is where you host other people's services in your infrastructure. Someone will bring their racks in and clip them into your data centre.

A cloud service could handle customer data from anywhere in the world, so it would be really hard to know what the UK or, indeed, Scottish data consumption is and put that into an equivalent computing capacity. The other point is about efficiency. There might be a lot of people using the same services, but it is much more efficient to have them in a really big hyperscale facility in the US.

Andrew Weir: That is a very difficult question to answer, in the light of the globalisation of data uses that has gone on over the past two or three decades. Layer on top of that the different use cases between defence, health, social media, the creative industries, travel, tourism, banking and financial services. Each industry has its own specific data requirements and usages, which makes giving a quick answer to that question almost impossible.

That said, it is important to recognise our increasing dependence on digital infrastructure as part of critical national infrastructure, whether that is in banking, financial services, payments, the public sector or health. Our reliance on digital infrastructure being available, resilient and cyber secure is increasing every day. To be honest, it is what most of our membership will be working on this morning.

Sanne Dijkstra-Downie (Edinburgh Northern) (LD): Before I pursue my line of questioning, I will make a comment: the average annual temperature in West Virginia is only about 11°C and, in summer, it is 23°C. It is perhaps slightly warmer than in Scotland but not so different as we might interpret it as being from your answers.

I want to ask about electronic waste, because recent reports have highlighted that there could be a big rise in electronic waste from hyperscale data centres, from servers, batteries or other equipment that has a limited lifespan. Does that concern you?

Craig Melson: Yes. However, before I answer that question, I want to quickly challenge what you said about Virginia. I was talking more about northern Virginia—the bit around Washington DC. West Virginia is quite mountainous and quite cold, but, when I spoke about what we are seeing in Virginia, I was referring to the bit around Washington DC. Lots of gags can be made about the fact that it was literally built on a swamp.

We are very concerned about e-waste. It is not necessarily in the gift of data centre operators to control that, because the IT in a data centre is often not the data centre's own IT—it could be from a bank, a university or the NHS. Those organisations will bring their servers and put them into the racks, and they are generally the ones who are responsible for managing their waste. The UK as a whole is the second largest producer of e-waste in the world, per person. We produce quite a lot of it.

The Scottish circular economy strategy is very advanced when it comes to product stewardship and requirements for the treatment of waste electrical and electronic equipment. That is mainly focused on consumer tech. The story is a bit better when it comes to the business-to-business process. Many of the companies that produce the racks provide them on a leased or servitised basis. Let us say that we are talking about the NHS. The IT will belong to the service provider that it has used, which will have reconfigured it.

An interesting project was done in which an attempt was made to put a pin on the line for the optimal time for an organisation to replace an old server with a new one, so that it would benefit from the energy efficiency gains while phasing out the emissions that were embodied when it was created from scratch. I think that that period is about four and a half to five years. A lot of work is being done on that.

WEEE from data centre environments will have a much higher reuse rate than that of equipment in a more consumer-facing environment, such as laptops.

Sanne Dijkstra-Downie: What sort of rates are we talking about? Are you talking about reuse as opposed to recycling or the recovery of materials?

Craig Melson: At the moment, for the blades, the reuse rate will be nearly 100 per cent, because it is possible to just take out the processors, reconfigure them and resell them.

The old Compaq factory in Erskine is now the renewal centre for HP. A lot of the work that is done there is on a consumer or domestic level, but it is increasingly dealing with enterprise-grade IT. It is really cool.

It is particularly challenging to recover the semiconductors from chips, but we are talking about tiny volumes, at least in terms of weight, which is how such things are measured, and many of the raw materials are extremely abundant—that is the case with silicon, for example.

When it comes to server equipment, the reuse rates are extremely high because it is expensive, which means that reuse has a lot of value. The equipment can be used time and time again. It does not necessarily have to be used for clever AI stuff. It can be used for storage or processing. When the worst comes to the worst and it has to be recycled, it is very simple to take apart, in comparison with more complex devices such as mobile phones.

The industry is championing Scotland's circular economy strategy, which is really far ahead of what is proposed not only in the UK but in Europe.

Sanne Dijkstra-Downie: Andrew, do you have anything to add?

Andrew Weir: You are right to call out the need for data centres to be responsible for the full life cycle of their energy consumption. I think that everyone recognises that their energy consumption is huge. We are not talking only about the power from renewables that might help with the day-to-day running of data centres, even in the cool of Scotland as opposed to the heat of mid-summer in Virginia or the cold in Virginia in mid-year. That comparison aside, it is very important that account is taken of the end-to-end life cycle, which will vary from site to site and from development to development. As we said in our submission, we would expect developers to articulate clearly how they intend to use power for operations and for back-up and maintenance over the full life cycle. It is a question of asking for environmental performance to be demonstrated as the sites are committed, built and managed.

Sanne Dijkstra-Downie: If I understand you correctly, you would like that to be part of the guidance that is issued—is that correct?

Andrew Weir: The cost of ownership is part of the total cost of running things, so we need to look at that as well.

10:45

Sanne Dijkstra-Downie: A large amount of released heat is currently wasted, and the committee wants to understand how feasible it is for waste heat to be captured and used in heat networks.

Craig, you touched briefly on the proximity to high-density heat demand, and I think that you implied that there might be an inherent tension when it comes to community buy-in to those projects. With that in mind, how feasible is it for that waste heat to be captured for heat networks?

Craig Melson: It is very feasible. If you see what has happened in Denmark and bits of the Netherlands, and in some trials in the UK, it is viable. They are already doing it in some places, so the engineering challenge has been solved. It is more the joined-up policy and the commercial side that have not been solved in the UK. Realistically, you can run one from anywhere to anywhere, but you need co-developments. You need something new if you build a new data centre, as it is very difficult to retrospectively fit a heat network underneath an existing housing development.

We are working on standardised guidance that the data centre industry can use when it wants to build those heat networks, but you need the buy-in from the local authority. You also need buy-in from all the other landlords and property owners in the area, and you need standardised contracts.

The engineering challenge has been solved and it is operational in many places around the world, but it is really tricky to do here. The fundamental thing is that you need to be near other people who can use the heat. It does not necessarily need to be homes, because many data centre developments in the planning process are on old industrial sites. It could be other industrial sites or a big facility such as a college, a warehouse or a hospital.

It can be done—it just needs the willpower and the joined-up planning.

Andrew Weir: I will bring back some similar points. Heat waste is part of the end-to-end total life cycle, so there is some opportunity to use it, but doing that needs strengthened joint energy and digital infrastructure planning around capacity. The capacity then needs to be split between real capacity in the here and now and speculative capacity several years down the track. To get those things to work, we need clear estimates of demand, timing and funding to find the economies of scale in order to manage the potential that is there.

Sanne Dijkstra-Downie: In your organisation's submission, you stress that it is only actual delivered heat rather than the theoretical recovered heat that should be counted.

Andrew Weir: We have things happening. Other countries are making advances in that, and the potential is there, but we have to get the individual sites and their links to power lined up in order to deliver that type of activity.

Sanne Dijkstra-Downie: What needs to happen for that to become a viable and almost standard way of using the waste heat from hyperscale data centres? How can we embed that?

Andrew Weir: We can embed it through clear standards and measurable reporting, but we also need to factor in the prize for Scotland of attracting investment into the sector while making the climate demands on investment proportionate to the individual sites and our overall strategic policy on data centres. We need to balance the prizes that we are going for with the need to have responsible investment and management of the sites.

Craig Melson: The EU code of conduct includes wording that we think it could be really helpful for Scotland and other UK Governments to copy. It says that there has to be heat reuse for new builds

such as big housing developments, industrial complexes and campus sites. Part of the reason why different European countries have been able to scale this up pretty well is that they already had heat networks in place. They might be old and quite inefficient, but they were already there.

The most helpful thing is to make sure that new builds are ready to enjoy the benefits because they have underpinning infrastructure that data centres and other generating sites can pipe into. The EU has done that, and it would be helpful if the Scottish Government copied it.

The Convener: Before we finish, I will ask two brief questions. The first is for Mr Weir. Earlier this morning, it was touched on that UK energy costs are among the highest in Europe or in the world—I cannot remember the exact phrase that was used. In your written evidence, in the "Energy demand: opportunity and constraint" section, you state:

> "Whether households and businesses benefit through lower bills is an empirical question, not an automatic consequence."

Domestic consumers are already paying vast amounts for energy. Do you agree that any proposals that go forward, whether they involve a smaller number of hyperscale data centres or a larger number of smaller facilities, should not involve domestic consumers being penalised through higher energy bills?

Andrew Weir: There are many more factors to energy bills than just data centre usage. That is why we made our statement that we cannot guarantee lower bills. I do not think that we can get involved in an exact trade-off such as that. Data centres will bring increased usage, but that guaranteed increase in usage will allow a different investment profile for some of the upgrades to the grid, a different profiling of access to renewables and different access to funding for renewables. That should bring some cost advantages. However, there are other factors in overall energy pricing that weigh in above data centres, which is why we make that point in our submission.

Data centres have huge energy requirements, but they are not the only industry that has huge energy consumption and they are not the reason why UK energy prices are higher than those of other countries. We should not conflate that issue with data centres. They bring opportunities for co-funded investment and opportunities to use more renewable power. If they are built correctly, they could and should reduce the cost of investment. However, whether that saving is passed on to consumers in the future is another question.

The Convener: If applications are successful and hyperscale data centres or smaller ones are installed, there will be rates benefits for the local authorities whose areas they are in. In order to get some additional gains for those areas, would it be worth establishing regional wealth funds, which could be akin to the Highland wealth fund, so that there are longer-term financial benefits for areas in which data centres are developed?

Andrew Weir: We want all developments to bear in mind the impact that they will have on the local economy. We expect them to set out how centres will provide apprenticeships, jobs, access, skills and compute power. We absolutely want the community impact to be spelled out.

A wealth fund at individual site level feels difficult, because, if we consider the nature of the data industry, a lot of the benefits are felt much more widely than at the specific site. A site may be put in place A or B in Scotland, but the usage of the computing AI and the technology will be dispersed across Scotland, the UK and possibly the globe, so it is difficult to define where we would tap in to do that wealth funding. However, developers should pay a lot of attention to their impact on the local community, and they should be transparent in the way that they do that.

Craig Melson: On energy costs, to power a 100MW site in the UK, we are looking at £200 million-plus. To do that in Sweden, it will probably cost about £60 million. To do it in America, the cost will probably be £50 million. Until we sort out the pricing, we will never really be a global winner in data centres. We are probably going to see the Nordics catching up. However, Scotland has an abundance of extra power, which is a huge benefit.

On additionality, data centres are vast consumers of energy but they can underpin investors and customers. So many wind farms are viable only because of the hyperscale investments. They are not taking all the power, but they are taking some of it, and they could use the rest. There is therefore huge additionality.

On community impact, I note that there are regional wealth funds. We have seen policy in Ireland and the Netherlands to that effect. It does not apply outside England, but we have the data centre covenant, which involves a huge refocusing towards the social licence to operate. Data centres have perhaps not had to worry about that before. As communities and legislators have increasingly noted, data centres are large infrastructure projects that need buy-in, and that approach can be one way of doing it.

Local authorities already have powers that can be used. England has section 106 agreements, whereby compensation can be deployed. That approach could be adopted by local authorities in Scotland, although they would need powers from the Scottish Parliament to do that. There are already ways for local authorities to mandate

things and get them out of data centres in the pre-planning stages, but I think that empowering local authorities would be the best way to do that.

The Convener: Thank you for your evidence, which has been very helpful to us.

I will suspend the meeting for a short comfort break and to allow a change of panels.

10:57

Meeting suspended.

11:04

On resuming—

The Convener: I welcome the second panel of witnesses, some of whom are joining us online. We have with us Alejandro Gallego Schmid, reader in circular economy and life-cycle sustainability assessment at the University of Manchester; Wim Vanderbauwhede, professor in low-carbon and sustainable computing at the University of Glasgow; and Thomas Morstyn, associate professor in power systems at the University of Oxford.

We will proceed straight to questions. My first question is directed to Wim Vanderbauwhede. Would you mind if I called you Wim—would that be okay?

Wim Vanderbauwhede (University of Glasgow): Of course.

The Convener: Thank you.

My question is based on your written submission, which is really helpful—thank you for providing that. There are more than 23 applications for hyperscale data centres in Scotland, some of which will already have an end user in situ while others are purely speculative.

Would it help the committee with the work that we are undertaking, and in making any recommendations to the Scottish Government on its upcoming guidelines, to state that only applications with an end user should progress to further consideration? More generally, would that help with regard to environmental and development-related matters?

Wim Vanderbauwhede: Yes, because that would mean that there would be far fewer applications. There are two problems with hyperscale data centres. The first is the number of data centres, which determines the total amount of resources that are needed to run them. Secondly, each data centre, because of its scale, has a local impact. At the very least, therefore, if you proceed with only those applications that have an end user, you will partly remedy the first aspect.

The Convener: The evidence that the committee heard last week on energy and water usage was based on all the applications under consideration across the country. You refer to that point in your submission, as I said. To help shape the discussion and dialogue, a more focused approach would be beneficial.

Wim Vanderbauwhede: Yes. In my submission to the committee, I looked at the evidence that the network operator, NESO, had provided to another committee. It had an overall figure that would presumably represent the upper limit of what would be deployed in Scotland—the actual sustainable limit, let us say, would be a lot less, as I argue in my submission. In that sense, it is hard to say, even if an application has an end user in mind, whether that already represents a commitment towards that end user. For example, there was a planned data centre in Essex with Microsoft as the end user, and it decided not to continue with that because the electricity price was too high locally. Having an end user will not guarantee that a data centre becomes operational.

The Convener: This question is for all the witnesses. How should a green data centre be defined, and what should a company be required to do or demonstrate in that regard when making a planning application? I put that question to Alejandro Gallego Schmid first.

Alejandro Gallego Schmid (University of Manchester): Hello—I do not know whether you can hear me.

The Convener: Yes.

Alejandro Gallego Schmid: Okay—thank you. First, thank you for the invitation to give evidence.

With regard to green data centres, we have to consider various aspects. The first is where the electricity for a data centre will come from. We must maximise the amount of electricity that comes from renewable sources, so that will define a fully green sustainable data centre. We also have to consider the water aspects; I heard the evidence on that from the witnesses on the previous panel. We must consider not only the amount of water, but the timing of its consumption. That is quite important—a data centre will not consume the same amount of water during the winter as it consumes during the summer, so there will be less and more competition for water during those periods. Another important aspect is how the heat will be reused. There are also local impacts to be considered—I totally agree with Wim Vanderbauwhede that, due to the magnitude of the hyperscale data centres, we have to consider what the local impacts will be in terms of noise, air pollution and effects on communities.

One aspect that we have not spoken about much concerns all the embodied impacts associated with the hardware that is used in data centres. That is quite important as well. There is quite a lot of energy use and water consumption associated with developing the hardware. Obviously that will not happen directly in Scotland; the hardware will be produced in another part of the world. However, that does not exclude the fact that we have to consider it, because we are in a global community and carbon emissions, for example, are independent of where they are produced. That is important. Related to that is another issue that has been touched on, which is the e-waste that will be produced.

There are quite a lot of aspects to consider in deciding whether a data centre qualifies as sustainable. Some of them, such as carbon emissions, are more global, while others are much local.

The Convener: Over to you, Professor Morstyn.

Thomas Morstyn (University of Oxford): I have a slightly different perspective on what makes a green data centre. What is important is that the UK is moving towards a clean electricity system through the clean power 2030 policy, so the key point is how data centres, particularly large-scale ones, are integrated with the grid. The big risk is that, if you push data centres to have off-grid generation—that is, gas power—it will be between seven and 10 times more emissions intensive than the clean power 2030 grid would be, and if you push them offshore, they will probably end up in regions that are more emissions intensive than the UK anyway.

When you are considering a net zero electricity system or an electricity system with a lot of renewable energy, as you have in Scotland with offshore and onshore wind generation, power flexibility is more important than energy efficiency. The key point is that you have abundant, clean, low-cost energy but it may not be available at every moment, and you have to worry about grid transmission constraints and that kind of thing. Flexibility is key in enabling the data centre to interact with that net zero energy.

In data centres, you have a range of potential sources of flexibility. You might have on-site generation, on-site battery storage and, to an extent, smart cooling systems. Increasingly, there is also innovation around computing flexibility, so you can reschedule workloads and move workloads between data centres, and you perform fast-timescale graphics processing unit and central processing unit power orchestration as well.

The issue is that those flexible arrangements, particularly where they interact with the grid and grid connection, need to be negotiated and arranged between the data centre and the grid operator up front. If you rely on the traditional types of flexibility markets that we have used for obtaining flexibility from other sources of demand response and battery storage, that will not work well for data centres, because they place such a huge value on energy. Because the value that they place on energy is typically, for AI workloads, five to 10 times higher than the wholesale price of energy in the UK, once they are connected to the grid, if they are allowed to use energy, they will definitely use their full grid connection. Flexible connection arrangements will be increasingly important, as will the negotiations and agreements between grid operators and the data centre. In considering what makes a green data centre, therefore, you need to think about a data centre that is compatible with and integrated into a green electricity system.

11:15

Wim Vanderbauwhede: We need to distinguish between a few different aspects of what it means for a data centre to be sustainable. Alejandro Gallego Schmid talked about local noise and heating, and potentially heating water, unless there is closed-loop cooling. Then there is the global side: the data centre should not make global warming worse. For that, it should be powered by renewable energy. The problem is that manufacturing the servers in the data centre leads to a lot of unavoidable emissions. The energy that is used to make them is a large component of that, but there is also the mining of the resources needed to make the chips, and the gases that are used in chip manufacturing have a very high greenhouse gas factor. We end up with very high embodied emissions from making the servers, which cannot be avoided. They are real and they contribute to global warming.

In my submission, I quantified how much that would be in Scotland: about a megatonne of CO_2 per gigawatt of data centre, assuming that the data centre does not have any operational emissions. That is the other aspect. Okay, the servers are not made in Scotland, but the emissions are global, so proceeding would make global warming worse.

The final point, which is related, is that, if you want data centres to be sustainable, you should deploy them at a speed that will not result in them using more energy than we can cleanly supply. At the moment, a lot of data centre operators ask for connections to the gas network because they think that there might not be enough energy and they would therefore like to use gas turbines. We should not think that that is an acceptable thing for data centres to do, as it would increase our emissions instead of even keeping them steady.

I would say that there is no such thing as a sustainable data centre. It is a matter of scale. If you do not have too many of them, and if each of them takes all the precautions that my colleagues and I have presented, it is okay, but if growth is too fast, it is not possible.

Donald MacKinnon: I will come at that question from a slightly different angle. What would a responsible hyperscale data centre look like? What criteria should be used to identify the sites?

It would be helpful if each witness could also touch on the definition of a hyperscale data centre. I put the same question to the previous panel of witnesses, and the figure of 100MW was mentioned. We also considered the physical scale, not just the energy usage. When the committee took evidence from campaigners last week, they suggested that even 50MW was too high a threshold for a hyperscale data centre. What would a hyperscale data centre development look like?

Wim Vanderbauwhede: It is important to set the scale of it. At the moment, all the data centres in Scotland together amount to 30MW. That means that even a single 50MW development is very large scale. The word “hyperscale” has no intrinsic definition. Within the community of those interested in data centres, people would consider around 100MW to be hyperscale. It is about the order of magnitude, however, meaning that 50MW would also be hyperscale.

This is a huge departure from all the data centres that we currently have in Scotland, which are much smaller. Typically, they are less than 1MW. I would probably agree that we should put the definition at 50MW, because that is the cut-off that has been used, beyond which the local planning authorities must notify the Scottish Government. There is some wisdom to that.

Donald, your question was about what it would mean for a data centre to be “responsible”—is that the word that you used?

Donald MacKinnon: Yes.

Wim Vanderbauwhede: Some of a data centre’s effects are impossible to mitigate. The fact is that data centres take in energy to produce computation but most of that energy ends up as heat in the local environment, which you cannot do anything about other than by not running them. A very important factor is the need for a clear assessment of the effects of heating. If you place a data centre in a rural environment, where it might affect crop growth, local forests or whatever, that is very different from placing it in an urban area, where there is already urban heat, so the effects would be only a little worse. That is very important to consider.

You can mitigate water use—in fact, water use is a bit of a red herring. Data centres use water for evaporative cooling because it is cheaper and allows for a more efficient system that produces more computation for a given amount of energy, thereby generating more profit. If that is not possible, they use closed-loop cooling—essentially, it is like a fridge—but that requires more energy, so you cannot use that energy to deliver services. That is less desirable, but it is always an option if they face too much opposition to water use.

In that sense, you could argue that, if no adequate supply of water is available, the data centre should at least use a closed-loop system. However, the outcome is very dependent on the local environment where you place the data centre. Whether a development is responsible depends on how it affects the local area. The overall climate effects depend on the total amount of capacity that is allowed, which is not the responsibility of individual developments. It is essential to have a clear understanding of the local impact that a given megawatt capacity will cause. Some of those impacts cannot be avoided with data centres, so the question is whether they are acceptable.

Donald MacKinnon: Thank you. I have the same question for Alejandro Gallego Schmid. What would a responsible hyperscale data centre development look like? It would help if you could touch on definitions in your answer.

Alejandro Gallego Schmid: When the previous panel was asked that question, I checked but found no agreed definition of a hyperscale data centre. The different definitions range from 40MW to 100MW. I agree with Wim Vanderbauwhede that, in Scotland, an environmental impact assessment is required for any development with a capacity of more than 50MW. That makes for a good answer, given that there is no consensus.

Regarding responsible data centres, there are two sides to my response. From an environmental perspective, we must understand that everything has an impact. That means that we should avoid those environmental impacts where possible, or, if it is not possible to avoid them, minimise them. That is highly variable, because the same data centre will have a totally different impact depending on whether we put it in one specific place or another. If water is scarce, particular care must be taken with regard to how the data centre cools itself.

If we give a responsible data centre a wider definition, we must consider the social aspects, which relate to what Wim Vanderbauwhede said about local communities. Obviously, there will be some impacts in local communities associated

with noise and pollution, so it is important to examine how the people who are behind the data centre will compensate local communities for the impacts that are generated, if those cannot be totally avoided.

Donald MacKinnon: Thomas Morstyn, what does responsible hyperscale data centre development look like? What are your views on the discussion on definitions?

Thomas Morstyn: I will focus on the power system questions. On the definition of a hyperscale data centre, there are two components to classifying data centres from a power grid perspective. One is whether the data centre is connected to the distribution network. Is it in a local medium-voltage area of the grid, where other industrial customers and end users are connected, or is it connected to the high-voltage transmission system? The answer to that changes which stakeholders are involved and what grid impacts you have to worry about. For the distribution network, data centres of less than 30MW may have the potential to be connected but, in general, higher-power data centres, and certainly those of 100MW, would be at the transmission scale.

The other key component in classifying data centres is the type of workloads and computing hardware that they have. The big change that we are seeing is the movement towards AI data centres. Within those, there are AI training workloads and AI inference workloads, which have very different characteristics as a result of the timing requirements, the variability of the loads, whether the whole data centre is doing one thing at a time and can have large power fluctuations and that kind of thing. The workload division and hardware division of data centres might be useful when you are considering the impacts on the power grid and the other systems that are associated with a data centre.

On the question of how to make data centres responsible or what a responsible data centre development looks like, one thing about the power grid, which I touched on, is the idea of flexibility and integration with the local grid operator's flexibility requirements and its studies of the grid and grid impacts. With a data centre, there are fast timescale control issues that you need to consider. Low-voltage ride-through and ramp rates of power of a data centre are really important for the wider impacts on grid stability. Nowadays, in some regions, we see data centres of multiple gigawatts suddenly coming off the grid, which can cause stability issues. Those issues need to be thought about, and you need grid codes and standards to enforce them, as well as suitable on-site flexibility arrangements to prevent that from happening.

Also, on a longer timescale, you want flexible arrangements that allow the grid operator during periods of grid stress—when transmission constraints suddenly become activated or where there is a stability event on the grid—to call on the data centre to respond to that. You want those arrangements to be robust and pre-tested, and you want the data centre operator to be happy with the integration—it has to fit with the operator's commercial arrangements. You want to minimise the impact on computing but simultaneously be able to meet any emergency flexibility requirements.

On water, as has been touched on by other witnesses, there is a trade-off in the cooling system of a data centre. Evaporative cooling tends to increase the efficiency of electricity use, whereas you can have fully electric cooling with recirculating water that uses much more energy. You must also consider that, if you use fossil fuel generation, there is the potential for that to involve evaporative cooling, so you might simply be shifting water use to another location.

Really, the point is to think carefully about whether there is abundant water resource in a particular location or whether water is a constraining factor, in which case you need to consider the trade-off on power usage. What is responsible will be different in different regions and according to the particular conditions. Using water or energy is not necessarily bad as long as the energy or water use is sustainable in that society.

11:30

The other aspect related to that is the impact of the data centre development on overall power system costs, which flows into bills for end consumers. If you are building large data centres, particularly for AI workloads, to which there is a huge economic upside, it does not make sense for a bunch of costs to be socialised and subsidised across wider energy consumers who do not directly benefit from that. Therefore, if a data centre development requires grid upgrades, it makes sense to ensure that those are suitably accounted for and paid for. That will also incentivise more flexible arrangements from the data centres to avoid that responsibly.

However, the impact of a particular development on energy bills is not obvious. If you cause a bunch of grid upgrades or balancing issues on the grid that will be socialised across other consumers—

Donald MacKinnon: Can I jump in there, Thomas? Some of my colleagues will touch on the impacts on electricity, so we will move on from that. You can come back to that later.

Thomas Morstyn: Sure.

Donald MacKinnon: Can I have one more question?

The Convener: If it is a brief one. Can we have brief answers, please?

Donald MacKinnon: I have one last question, which I will throw open to one witness—whoever is most keen—to respond to. It relates to UK Government policy on data centres. I am interested in your views on the use of AI data centre growth zones to encourage development in certain areas. Does anybody want to pick up that point?

Alejandro Gallego Schmid: The initial idea to establish what areas could be in the best position to develop data centres is good. However, there has been a lot of criticism that environmental sustainability has not been considered properly as part of the criteria for selecting the zones—that it has been associated more with economic aspects and accessibility to digital services and the grid, with environmental criteria not being at the core of the decision. For example, there are areas in the south-east of the UK that already claim that they have water scarcity. The idea itself is good, but we have to give more importance to the environmental sustainability aspects in the decisions about what areas will be selected as artificial intelligence growth zones.

Wim Vanderbauwhede: I will respond on the same question—perhaps you do not want one opinion on it. It leads back to the question about responsible data centres.

It is okay to say that we have AI growth zones because we think that AI is an important aspect of the economy, but a question should be asked about the utility of the data centre. Most of the growth comes from AI data centres. The growth of non-AI data centres is a consequence of the growth in AI data centres, but they provide very few local jobs, for example, so the utility must lie elsewhere. However, if the data centre is owned by a large overseas corporation, there is not much utility to the country. That should be taken into consideration. It is fine to say that a data centre is critical infrastructure that we need for the country, but it should then work for the country. That is not part of the environmental issue, but, if you are going to say what "responsible" is, it is a factor.

Ariane Burgess: Wim, I will direct my first question to you. Your written evidence sets out a compelling argument that the energy consumption of the hyperscale data centres that are currently proposed would make it very difficult for Scotland to achieve its net zero targets by 2045. Has there been enough scrutiny by Government of the cumulative impacts of data centre energy consumption?

Wim Vanderbauwhede: By the Scottish Government?

Ariane Burgess: Let us talk about both Governments, maybe.

Wim Vanderbauwhede: I thought that that was exactly what this committee and the Economy, Tourism and Energy Committee were doing. That is why you are holding these meetings with us. The UK Government did a similar exercise in May this year. I do not know whether it is sufficient, but, at the very least, people with expertise similar to mine and that of my colleagues were heard, and they gave similar perspectives on the fact that it is important to look at the total projected growth, which is incredibly large. If the growth is not regulated in some way, there will not be enough clean energy to power all those data centres.

The awareness is there, but both the UK Government and the Scottish Government—well, I do not know, of course, because I do not have an insight into their workings. Because the process of scrutiny works typically through meetings such as this, the main thing is not to rush but to do the consultation work thoroughly, and that will inform policy. Maybe I am too optimistic, but it is probably up to you to criticise that.

Ariane Burgess: Thank you. I am hearing that you would need to be able to see behind the curtain of what both the UK and Scottish Governments have been doing. Maybe we do not have a sense of that from them and they are not communicating well enough about what they are doing with regard to the cumulative impact of hyperscale data centres.

Let me turn to Thomas Morstyn—[*Inaudible*.]

Sorry, I was muted.

You talked earlier about the grid—"stability" and "grid stress" were among the terms that you used. I am interested in getting from you a sense of how feasible you think it would be to assess the cumulative impact of data centre energy demand in Scotland.

Thomas Morstyn: It is definitely feasible; it is just that this is a big change to system operation. Data centres, at least globally, are now the fastest-rising source of electricity demand, so the modelling tools and the capabilities are rapidly being developed and rolled out by new start-ups as well as by grid operators, which are trying to figure out how to integrate that modelling into their processes as well as developing new flexible connection products and so on. That is all very fast moving, because of the emerging challenge. All the technical capability is definitely there, and, increasingly in the UK, the data to do it is also there. The issue is more to do with the institutional and organisational change required.

An interesting point is that distribution network operators actually have arrangements in place for flexible connections and assessing headroom because they have been forced to do that by local renewables developments and battery storage. However, at the national scale, with NESO, there is a bigger challenge in terms of the transmission grid connections, because, at the hyperscale that we are talking about, the data centres are introducing grid issues that are quite new and that are changing with the way that the GPU and training work. Basically, there is a real push needed in this area.

Ariane Burgess: I will stay with you, because you mentioned NESO. NESO suggested that siting data centres in Scotland could reduce constraint payments, reduce the need for investment in the transmission grid and, ultimately, reduce electricity bills. On top of that, electricity carbon intensity is lower in Scotland. I would like to get your view on those points about constraint payments and investment in the grid, and on whether it really would—[*Inaudible.*]

Sorry—I keep getting muted. I do not know what is going on.

Anyway, at our previous meeting, we heard from the folks in Ireland that their electricity bills have actually gone up. I would like to hear your thoughts on that.

Thomas Morstyn: My research group works on that area specifically, modelling the UK transmission grid in high detail, as well as the GB balancing mechanism, which is the main market for supply-demand balancing and transmission grid constraint management. It has become increasingly important because we have increasing congestion in the system, excess renewables that are being curtailed, and so on. The balancing mechanism used to be a relatively small portion of the electricity market, but now it is redispatching up to 50 per cent of the energy flows.

There is a certain amount of data on supply-demand balancing and bulk dispatch at a national scale, which is available from Elexon and is easy for researchers to understand. However, the procedures and operation around transmission constraints, which resources are flagged as affecting transmission constraints and how those are redispatched are quite opaque, outside NESO and even within it, because the procedures around that rely on a lot of tacit knowledge and human control room operator processes, which are quite complicated.

There is an issue in that modelling the impact of new technologies on the grid and how that will affect transmission constraints, and therefore constraint costs, is very difficult for researchers, so there are definitely opportunities for more data to be made available around how transmission constraint management is done. There also needs to be more rigorous investigation of what happens when these technologies go in and how that will flow through market operation, which has a big impact on the actual outcomes in terms of bills, as well as curtailment and so on.

Ariane Burgess: Great. Thank you for that.

Let me come back to Wim Vanderbauwhede. Paragraph 45 of your submission to the committee, on the "Impact of embodied emissions"—you might have touched on this a little bit already—outlines the challenges of meeting net zero posed by embodied emissions from AI data centres. At the end of that paragraph, you say that

"If the capacity was capped at 500 MW, the increase"

—it gets a bit technical after that—would be "acceptable".

Do you think that capping total capacity at 500MW by 2030 would be acceptable? Should the Government put such a limit in its guidance?

Wim Vanderbauwhede: I think that whether or not it is acceptable is probably a political decision, but it is definitely advisable, because, if the growth is not regulated at all, the chances that too-fast growth will lead to all kinds of problems are very real.

The problem with the embodied emissions—the emissions from building the data centre and putting the servers in, and from making those servers—is that they are not avoidable. You will have them whatever you do. You will also have them afterwards—even if the grid is completely decarbonised, we will still have those embodied emissions. They will go down eventually, when the entire mining supply chain and so on decarbonises, but that is probably very far in the future.

For the foreseeable future, meaning several decades, you will have those embodied emissions, and, as I calculated, you could miss the targets for decarbonisation purely because of them. Even purely based on the other argument, it is better to have a cap on how much capacity you want to have installed by a certain time.

Ariane Burgess: Thank you for that.

I will come to Alejandro next, on land use. I am interested in hearing your perspective on what the Government's guidance should require on land use for data centres. Should they be built on brownfield sites first, with protection for farmland and nature? Do you have any examples from other countries that we could learn from?

Alejandro Gallego Schmid: Yes, definitely. One of the important aspects that we have to

consider is biodiversity—again, I insist that, in each case, we have to analyse what the best location would be. Using brownfield sites, which were used for something else before, would minimise the impact from a biodiversity point of view compared with putting a data centre in the middle of a national park.

11:45

Another important aspect for Scotland is peatlands, which we definitely have to protect. We need to avoid having any kind of infrastructure there. That is important not only for biodiversity but for tackling climate change. As was mentioned in the previous session, these data centres are already being put on brownfield sites in the south of England. That makes sense, as they are near to certain services and infrastructure. They are close to cities because of the infrastructure but also for the demand that those cities have. I would definitely consider establishing data centres on brownfield sites first. I am not aware of any specific international legislation that has regulated this area, but I think that, from that perspective, it is about common sense.

David Barratt: To follow on from Ariane Burgess's question on NESO and the comments that it has made, the case for development in Scotland has been made around the need to reduce constraint payments and the fact that we have a cooler climate and lower-carbon-intensity electricity. Essentially, we have an excess of renewables. The counterargument is that we have in train the solutions to constraint payments in the form of the eastern green links cables and interconnectors linking Scotland to England.

Thomas, I was particularly interested in your comment about modelling. What does that modelling tell us, particularly about the EGL interconnectors, and does it sufficiently address the problems of having an excess of renewables and the constraint payments?

Thomas Morstyn: Modelling the effect, especially on balancing costs, is quite challenging to do, particularly when we are working independently with the data that is available. There is a subtlety that means that additional data would help you to do that in a better way.

Another broad point is that, as I understand it, the clean power 2030 policy involves a very large amount of additional onshore wind and offshore wind being built, and even the transmission upgrade projects or new transmission developments tend to have a 10-year plus horizon. My understanding is that the transmission constraint costs are therefore projected to remain an issue, and even to rise, without substantial market reforms to how we do balancing as well as a lot of advances in access of demand flexibility, roll-out of battery storage and so on. Constraint costs remain an issue because, although you are massively scaling up transmission capacity, it will take a very long time for that to come on to the system. At the same time, you also have ambitions to significantly scale up renewable generation.

The other issue is that a lot of the analysis has been done mainly without a clear view of the projected rise in data centre developments. As we have all said, where exactly that is—whether it is 6GW or 8GW—is very unclear, and there are so many projects in the queue that it is hard to know which of those would go forward and which to include. That analysis remains to be done in a robust way.

David Barratt: I put the same question to the other witnesses. Do you think that the case for siting these developments specifically in Scotland has been sufficiently robust?

Wim Vanderbauwhede: I think that the main reason for siting them in Scotland, from the developers' perspective, is that the cooling cost is lower. From their perspective, that is a robust case, because it is cheaper. Whether it is good from the perspective of the needs of the country is a different question.

I do not know enough about the grid interconnectors, for example, to say that it is a good choice. I cannot add much to what Thomas Morstyn said on that.

Alejandro Gallego Schmid: In the same vein, I would say that Thomas Morstyn is really the expert in this area.

We have to consider that data centres work for 24 hours—like hospitals—which is why they need a back-up system. However, electricity from wind is not produced all the time. That implies that we have a challenge: how are we going to provide electricity when we are not getting wind? How are we going to cover that part? That is important. There are solutions—Thomas talked about flexibility in the grid, and we can consider the role of batteries.

What I am trying to say is that the fact that we have an excess of renewables does not mean that we can use that excess to its full capacity as and when we want it. There is a challenge that we have to address. How do we use the excess of renewables to the maximum, and how do we cover the needs of hyperscale data centres, which are big buildings that consume a lot of electricity, when we do not have that wind available?

Wim Vanderbauwhede: I want to add a point about the excess of renewables, which I wrote about in my submission. If we do not install data centres, we will clearly have an excess of

renewables for meeting the decarbonisation targets, but we will need most of the renewable energy to decarbonise transport and heating. The capacity being built will therefore largely not be available for powering data centres unless it comes at the expense of those other purposes.

David Barratt: That partly addresses the question that I asked the first panel, on how this all impacts our existing challenge of transitioning away from oil and gas and petrol and diesel towards EV. It was already a massive uphill battle to do that, and this would potentially add to all that.

There is nearly 9GW of data centre capacity in the queue for electricity connections in Scotland alone. We heard from the witnesses on the previous panel—and the UK Government has set out—that we need about 6GW of capacity in the whole of the UK, not just in Scotland. Proportionally, the figure would probably be 500MW to 600MW in Scotland.

Is it credible, therefore, to talk about developing anywhere near 9GW of capacity in Scotland? Is it credible—and is it sensible—to develop much beyond what has already been set out for the Scottish growth zone in Lanarkshire? That is on a scale of around 500MW, which means that it is potentially already meeting the Scottish proportion of that demand.

Wim Vanderbauwhede: I think that I commented before that I would advise capping capacity at 500MW. On the question whether it is credible—or advisable, I would say—I think that any capacity greater than that would be highly problematic for many reasons.

On the other hand, a lot of the proposed developments are not really credible. It looks like several of the companies that have proposed building very large data centres in Scotland—for example, the one in Chapelcross with a proposed capacity of 1GW—have no experience of building data centres. That means that they have another purpose in mind, because they do not really have the capability to build a data centre. Therefore not all the proposals are credible—let us put it like that. I do not know what proportion of the proposals fall into that category.

Some of the proposals do come from companies that have built a lot of data centres. The data centre in the growth zone belongs to DataVita, which is the company that has most of the current data centre capacity in Scotland, so it is clearly in the business of building data centres. However, that is not the case for others, and very careful scrutiny is needed to see which of those projects in the planning pipeline are considered to be credible. That goes back to the convener's question about whether they have customers. That is probably a good starting point—if there are no customers and the proposal is purely speculative, it should be treated with a lot more caution.

To round off, the capacity should be capped, and the size of the AI growth zone in Lanarkshire is probably an advisable size at which to cap it.

David Barratt: Thank you. That was really helpful.

We do need to work out how we scrutinise the highly speculative applications, but what guidance should the Scottish Government prepare to help us root out the chancers? I put that question to Thomas Morstyn initially and then to Alejandro Gallego Schmid.

Thomas Morstyn: It is true that we need to think about how the developments will impact the different areas that we have talked about, such as sustainability policy targets and, indeed, consumer energy bills, which are definitely a major issue. The flipside, though, is that some data centre development is necessary—or, at least, it has a strong priority associated with national security or has other such direct applications across the country. Another component is economic prosperity and national sovereignty in the wider age of AI.

A key point is that lot of the challenges with these data centres are linked with the value that they put on energy, which, at £1,000 to £5,000 per MWh, can be up to 10 times its wholesale price. That means that, although it is very difficult to dispatch them—they put a kind of blocky load on the system and so on—underneath that is the idea that, at the moment, there is a huge amount of economic value linked to what the data centres are doing. That would imply that, if you could integrate them into the system in a way that did not undermine policy targets or increase bills for end consumers, that would bring benefits for society.

Therefore, putting a hard cap on the centres might not be the best approach. Instead, it might be better to have rigorous regulation and standards, and to appreciate that, where such an approach does make sense, you can benefit from the economic opportunity that it creates.

Alejandro Gallego Schmid: Sometimes, it is important to put these numbers into context. For example, we are talking about 9GW, but the consumption of all households in Scotland in one year is 1GW. Therefore, if the data centres were a reality and they were working at full capacity for a year, their consumption would be nine times that of all the households in Scotland. As I have said, it is important to make such comparisons, because we sometimes get lost with the numbers, and I think that we can agree that that is not something that we can assume will happen, at least in a short period of time. I therefore agree totally with Wim

Vanderbauwhede and Thomas Morstyn that we have to think about how many of these projects are actually credible and how many have a real purpose and come with a financial commitment.

On top of that, and building a little bit on what Wim has already said, I would just point out that we do need to electrify many other things; the problem is that we sometimes make the mistake of looking at them in isolation when we need to take a systemic view. If Scotland wants to achieve its commitment to be net zero by 2045, we have to decarbonise road transport, heating and several other industrial systems, and that will have to happen through electrification. Can we do all of those things at once? Probably not, and that is where we have to decide what the priorities are, which is the role of policy makers.

12:00

The key aspect is that we must decide how to divide the cake. If we look at things individually, we can say that data centres will not eat the whole cake, but we must take a full perspective of all the sectors that require electrification. From my perspective, that is when the point about Scotland having an excess of renewables becomes a bit weaker, because that excess of renewables will be needed for the electrification of other sectors. My recommendation is that we should never think only about data centres; we should take a system perspective and consider all the potential uses for that electricity.

David Barratt: Thank you.

James Adams: Wim, in your written submission, you note:

"Data centres require cooling. If a river or canal is used as a source for evaporation cooling, surface water quality will be affected because the water level will drop."

Alternatively,

"If groundwater is pumped locally, this will very likely lower the water table."

Earlier, you noted that the water usage of hyperscale data centres is a bit of a "red herring". Can you clarify how we should assess the potential impact of hyperscale data centres on national and local water resources in Scotland?

Wim Vanderbauwhede: By "red herring", I mean that a data centre project developer can start by saying that the data centre will be water cooled, in the expectation that there will be local opposition to that, and then attempt to appease that criticism and opposition to the data centre by saying that there will be closed-loop cooling. That will simply lead to higher emissions. There will be less effect locally, but the global effect will be worse. A data centre developer would prefer to use water cooling, because it is much more effective in getting higher utility out of the system. However, if no restrictions are put in place on how much water a data centre can use, there is a risk that local water resources will get depleted, depending on how much water the local area has.

James Adams: Thomas, do you want to say anything about water use?

Thomas Morstyn: In the previous evidence session, there was a question about how much of a difference certain systems make. In relation to the amount of energy that is used for cooling, whether evaporative cooling is used instead of recirculating water can make a really big difference. I have seen estimates that evaporative cooling uses 60 to 90 per cent less energy than a system involving recirculating and then directly cooling water.

On the other hand, data centre cooling is becoming increasingly efficient, and you get some economies of scale as a data centre becomes larger, so the cooling load might account for only 5 to 10 per cent of the energy use of the very large data centres that are being developed. There is definitely an issue, but the cooling component accounts for a relatively small share of a data centre's overall energy use compared with the information technology load.

James Adams: Alejandro, do you have any additional points to make?

Alejandro Gallego Schmid: If we use water for cooling, more water will obviously be used. We also need more cooling during the summer, when water availability is more restricted, so it is important to note that the issue is not only how much water will be consumed but when it will be consumed.

We also need to look at specific locations. We tend to look at Scotland in general as a place where water is abundant, but there were water restrictions in parts of Scotland last summer, especially in the east of the country. That issue would have to be considered if there was a desire to locate a data centre in those parts of Scotland.

I agree with Wim Vanderbauwhede and Thomas Morstyn—there are options to reduce water use. There are almost waterless options, but those involve the trade-off of consuming more energy, which has environmental implications.

James Adams: When I speak to members of the public in the north-east of Scotland, they tell me that they are concerned about the environmental impact of proposed hyperscale data centres on water use. What information on energy use, water use and environmental performance should data centre operators be expected to report publicly?

Wim Vanderbauwhede: Are you asking what data an operator should submit for their planning application?

James Adams: Yes.

Wim Vanderbauwhede: At the very least, if they are proposing to use evaporative cooling, they should list the volume of water that they will need and what source they think they will use for that. That is very important. Of course, they will need to list the total capacity of electricity that they intend to consume, but they will usually do that anyway, because that is how an operator expresses the size of their data centre.

The key questions are how much water will be used and where it will come from. It is not okay to say, "We'll put a data centre here and we'll worry about where the water comes from later," regardless of whether there is a supply.

James Adams: How easy is it for data centre operators to estimate that for the lifetime of such projects?

Wim Vanderbauwhede: If, for example, an operator intended to use pumped water and to evaporate it, they would eventually deplete the water table so much that that system would not work any more, so a clear prediction would have to be made of how much they would need. That would definitely have to be taken into account, given the huge effect that it would have on things such as local farming and so on.

James Adams: Thomas and Alejandro, do you have anything to add?

Thomas Morstyn: I do not have anything to add specifically on metrics for the reporting of water use.

Alejandro Gallego Schmid: As I mentioned, it will be important to know how much water will be consumed during the summer. [*Inaudible*.] Can you hear me?

James Adams: We can now.

Alejandro Gallego Schmid: Perfect. I think that I was muted.

For the reasons I mentioned before, it is important to know how much water will be consumed during the summer. In addition, it will be interesting to find out what kind of water will be used. Obviously, for cooling, it is not necessary to use drinkable water. It can be rainwater that has been harvested or water that has come from waste water treatment facilities.

James Adams: I assume that waste water would have to be treated or cleaned before it was used for cooling. What that add to the emissions load for the project?

Alejandro Gallego Schmid: We are talking about water that would have to be treated anyway.

James Adams: No additional treatment would be needed for it to be used in data centre cooling.

Alejandro Gallego Schmid: No. That is the key aspect. I am talking about urban waste water that has been treated, which is not directly drinkable but could be used for cooling purposes. The use of drinkable water for cooling purposes should be avoided as much as possible.

James Adams: Thank you all very much for those answers.

The Convener: I have one point of clarification for Alejandro Gallego Schmid. Is it the case that rainwater could be used for cooling without any additional activity to clean it up before it goes into the system?

Alejandro Gallego Schmid: I do not know whether any specific treatment is needed, but I can get back to the committee on that specific point.

The Convener: Thank you.

Martyn Day: I have a couple of quick questions on data sovereignty. To what extent is it important to maintaining our data sovereignty that Scotland and the UK have a large expansion in data centre capacity?

I put that question first to Alejandro Gallego Schmid.

Alejandro Gallego Schmid: Data sovereignty is not my area of expertise, but it is important to consider the types of use of artificial intelligence and why we need the expansion of data centres. Most of the data that we use in artificial intelligence is not for the noble purposes associated with research or national security. To put it into context, I do not have the specific numbers for the UK, but, in total, ChatGPT receives 2.5 billion requests per day. That gives you an idea that much of the required growth in data centres is not necessarily associated with data sovereignty or those noble purposes of artificial intelligence. I am not an expert in how many data centres we will need to guarantee data sovereignty, but it is important to highlight that much of the increase in the need for data centres is associated with other kinds of uses.

Martyn Day: Last week, we heard from witnesses that the EU has said that, for data security, it might need to triple the number of data centres. Does that sound about correct for that usage?

Alejandro Gallego Schmid: As I said, I am not an expert in that topic. Sorry, but I cannot comment on that.

Martyn Day: No problem. I put the same questions to Wim Vanderbauwhede.

Wim Vanderbauwhede: When it comes to data that you store somewhere, you need disk capacity more than data centre capacity. Disks and also long-term storage do not use that much energy, and they are compact to store, so you do not need to expand data centre capacity hugely to have data sovereignty.

In the context of AI, the problem is different. The UK does not create the large language models that are commonly used, and it also does not create the GPUs that are used to do the inference on those models. Therefore, the only data that you would own would relate to the queries that you send to the models. However, if you do not have control over the data centres that run the GPUs that operate the models, you do not really have sovereignty.

If you do not like the idea of Government and public sector data going outside the UK and you want to keep that data local, you do not need huge capacity for that. You say that the EU proposes to triple the capacity that it has at the moment, which would probably be very reasonable for that purpose.

Martyn Day: Thomas, would you like to add anything?

Thomas Morstyn: I am more focused on the grid integration issues of data centres, but my understanding, from national Government policy and initiatives such as AI growth zones, the AI sovereignty fund and some of the other national level plans, is that there is a recognition that the trajectory of the technologies is uncertain. It is uncertain whether the capabilities will plateau in a few years or will continue to expand. However, at least at the moment, there are credible risks and it is thought that the technologies will increasingly be critical for things such as cybersecurity and remaining at the cutting edge of research.

12:15

There are major initiatives in the UK to compete at the frontier of AI model development. For those high-risk and critical applications, you are going to want to be able to run them on local computing capability. For example, at Oxford, we recently had the British Open-ended Learning and Discovery—BOLD—AI lab, which is funded by the Government. The idea of that is to take different and novel research approaches. There is ambition to compete in the frontier AI model space, so there is at least the need to consider seriously the requirement for sovereign domestic AI infrastructure capability.

Martyn Day: My next question relates to the noise impacts of large-scale data centres. What evidence is available on those?

Thomas Morstyn: I do not have evidence on the noise issues. I guess that the location of data centres relative to population centres is important. As was mentioned in the committee's previous evidence session on that, there is an issue about the noise associated with on-site generation assets. If you have fossil-fuel local generation, that will definitely be a significant contributor to noise.

Wim Vanderbauwhede: I cannot give figures, because I have not looked into that, but it is clear that the noise is proportional to the size of the data centre. It will mostly be cooling fans that create the noise, so the bigger the data centre, the more need there will be for cooling infrastructure. Another issue is that evaporative cooling is quieter than closed-loop cooling, because, with the latter, you are operating the equivalent of a fridge, so you have more than just the fans—you have compressors and so on—so the infrastructure is noisier. I cannot put decibel-milliwatt values on that, but, if you imagine the noise from the cooling infrastructure of, say, a supermarket and then multiply that by many, many times, that is the noise that you will get.

Alejandro Gallego Schmid: To build on what the other witnesses have said, the cooling is crucial in relation to noise. If, in Scotland, less cooling is needed, that will have an influence and will lead to less noise.

The back-up systems are quite noisy. Those are not continuous, but they need to be tested every once in a while. Obviously, that is not a continuous noise such as the one associated with cooling, but it is quite noisy when those systems have to be tested.

Obviously, there are options to isolate the noise so that it does not affect the nearby area, including biodiversity there, which is another important issue to consider. We tend to think about the issue in urban areas, but, if data centres are in more isolated areas that are close to biodiversity hotspots, it is important to consider how the noise can affect biodiversity as well.

Martyn Day: Thank you.

Sanne Dijkstra-Downie: Good afternoon, everyone. I have questions on e-waste. Alejandro Gallego Schmid mentioned the embodied carbon related to the production of hardware. Clearly, the equipment has a limited lifespan, which means that there is potential for a rise in electronic waste resulting from data centres. How concerned are you about the impacts of that?

Alejandro Gallego Schmid: I am concerned, for different reasons. Hardware for the new types of data centres that are associated with artificial intelligence has a much shorter lifespan than that for normal data centres. That is not because the

hardware does not last as long but because there are continual updates and some of the hardware will be updated quite quickly. Potentially, that will increase the e-waste that is associated with those data centres. Studies show that the hardware for normal data centres can last for six, seven or eight years, whereas that for artificial intelligence-related data centres lasts for about two or three years.

That has many implications. A percentage of e-waste is hazardous. In the global south, the implications go beyond the environmental impact; there are also social impacts. In those countries, hazardous waste cannot be treated with the same safety requirements as it is in the UK.

There are potential solutions. We have to try to apply circular economy strategies in data centres and see how we can expand the life of the hardware in a modular way. For example, if we had a new, more modern and up-to-date GPU, we would not have to change the whole system; we could simply change the GPU. That relates to the design. If new hardware becomes available, it does not mean that the existing hardware cannot be used in other places, such as universities or small and medium-sized companies. We can repair, refurbish, or remanufacture components and, once we have used the hardware as much as possible, the components can be safely recycled at the end of their life.

Sanne Dijkstra-Downie: That is helpful. Thomas Morstyn, I saw you nodding. Do you want to add anything?

Thomas Morstyn: I do not have much to add. At the moment, at least, the prices for the older GPU hardware for two generations ago are staying the same, or even increasing, because there is strong demand and there is a significant reuse market for those things. One of the benefits of data centres being centralised is that it creates economies of scale around reuse for other applications. The GPU servers are becoming increasingly expensive and power dense. They have sophisticated components, so there is huge value relative to the raw materials if we consider the price compared with the material that is in them, which might also help.

Wim Vanderbauwhede: I have a slightly different perspective on that. I would estimate that the amount of computing that we do in Scotland is about 500MW—tops. If we are going to have servers for 1GW data centres that will typically reach the ends of their lives after two or three years, there is simply not enough scope for reuse. There are too many computers; we could reuse only a fraction of them. Effectively, the rest would become waste.

The picture is not limited to Scotland; the growth in data centres is repeated globally. That means that we would end up with an enormous number of computers that were no longer usable by anyone, because we have too many computers.

The other part is that things such as data centre inference servers can be used to do AI inference but their use case is extremely specific. You could use them to do scientific computing, but we already have supercomputers that do that. So, again, there is not really much use for these things once they reach the ends of their lives. Therefore, I am afraid that, if we do not have more limited growth in data centres, we will end up with a huge amount of e-waste—many times more than we have at the moment.

People are working on the issue, trying to repurpose and refurbish computers and so on, but, if the scale is too large, all that you can do is reclaim the materials that are inside the equipment, and we do not have an ability to do that effectively at scale yet—that is an extremely energy-intensive process at the moment.

Sanne Dijkstra-Downie: If I hear you correctly, you are saying that, in theory, the computers could be reused, but there would be an oversupply. I appreciate that this might be difficult, but can you quantify that oversupply?

Wim Vanderbauwhede: That is what I was trying to do. I will explain the simple calculation that I did. There are 5 million people in Scotland. If they all have a laptop or a desktop computer that uses 50W, then we will have 500MW of compute. That is a huge overestimate, although, of course, we would have to include all the enterprise computers as well, but that is an indication of the level that could be reused. If you had 500MW of data centre capacity, and if it were like for like—that is, if those servers could be given to people—that is the maximum that you could ever reuse. However, it would not be like for like, because we have very specialised servers that can be used only for very similar purposes. That means that the percentage that could be reused would be much lower—less than a fraction of what you would produce.

Sanne Dijkstra-Downie: Thank you. That is helpful.

I want to turn to the issue of heat networks, which we discussed with the previous witnesses. Thomas Morstyn, a lot of heat that is produced is wasted if it is not reused. How feasible do you think it is for that heat waste to be used in heat networks?

Thomas Morstyn: Using the waste heat from data centres is technically feasible. It is not necessarily the best source of waste heat, but, on the other hand, if you are building very large data

centres, that is definitely a resource that is available to be tapped. There are challenges, however, such as having to have the data centre in a location that makes it convenient to use the waste heat. There is also the question of how you think about building a heat network, particularly if you already have buildings that are not connected to heat networks. There are challenges around planning in relation to building new developments versus connecting to older buildings.

I have been involved with research that looked at various sites where there were existing data centres. In the case of Google data centres around Europe, we estimated that it might be possible to use around 25 per cent of their waste heat. That is the figure that sort of makes sense, but it is very specific to the particular development.

The key point is that, when you are thinking about responsibly developing a data centre site, heat reuse should definitely be considered in the planning process, as there can be environmental benefits.

Sanne Dijkstra-Downie: Wim Vanderbauwhede, you say in your submission that, from the perspective of optimising heat reuse, building smaller data centres located close to population centres is a better choice. Can you explain why that is the case?

Wim Vanderbauwhede: If you build a hyperscale data centre, you end up with an enormously large amount of waste heat. If you want to distribute that heat to where it can be used to heat homes, you will have to build considerable infrastructure that does not currently exist. That will take time, and there is also the question of who will pay for that infrastructure. The challenge is a lot less with smaller data centres that are close to population centres. First, the fact that they are smaller means that the amount of heat that has to be transported is a lot less. Secondly, the distances are shorter, so the infrastructure costs will be lower. Therefore, from the perspective of heat reuse, it makes sense to have smaller data centres closer to population centres.

12:30

The data centre does not necessarily have to be hyperscale in order to be useful. There are companies that, for example, offer products that you can use to heat a swimming pool. Those are container-sized data centres and they have almost no infrastructure. Those solutions are under development. There is a whole spectrum of possibilities.

With a hyperscale data centre, the amount of waste heat is extremely large, so you would have to build a dedicated network to transport all of that heat to where it could be used.

Another problem is that you can use that heat only during cold times of the year. You will not use that waste heat in summer, because there is nothing that needs to be heated. You could argue that some sites need heating all year round, but I have tried to estimate that, and it represents a very small amount of our total heating needs.

Sanne Dijkstra-Downie: Alejandro Gallego Schmid, what size of data centre would you consider to be optimal for supplying waste heat to heat networks?

Alejandro Gallego Schmid: I agree with the points that have been made about the proposal being more feasible in relation to small data centres. As Thomas Morstyn said, it is not so much a technological problem as one associated with the necessary infrastructure. We have the technology to do what is proposed, but the difficulty is the need to build the associated infrastructure.

That is also related to planning. The question of whether there is already a heat network nearby that could be connected to the data centre could be one of the criteria that is considered.

One of the points that I was going to make has been mentioned by Wim Vanderbauwhede. We have to consider the fact that the data centres will still be producing heat in the summer, when it is less needed. That means that the percentage of heat recovery will be much less than 100 per cent.

In line with that, it is interesting that Germany, for example, already requires some percentage of heat reuse from data centres. The requirements are being phased in. At the moment, 10 per cent of the heat must be reused, but that will rise to 15 per cent next year and 20 per cent the year after that. However, there is a caveat: the requirement applies only where reuse is technically and economically feasible. In other words, necessary conditions must be met in order for the data centres to achieve those percentages.

Sanne Dijkstra-Downie: Thank you very much.

The Convener: David Barratt has a brief supplementary question.

David Barratt: I just want to clarify something. When we talk about small-scale data centres, could we be talking about multiple facilities across urban areas? Are we talking about facilities with less than 1MW of capacity? It would be useful to get an idea of the capacity that is involved.

Wim Vanderbauwhede: The one that I mentioned that can heat a swimming pool is in the kilowatt range—probably 100kW; perhaps a little more. Heating a home requires close to 10kW.

The Convener: Before we conclude, I have two brief questions. Are there any examples of

regulation or proposed regulation that the Scottish Government should consider? For example, Lombardy has introduced a new law this year; Australia is proposing that new large-scale data centres should underwrite their power supplies, limit their water use and pay for any additional water infrastructure; and Ireland will require data centre developers to support the development of new renewable energy projects.

Wim Vanderbauwhede: I wrote in my submission that I do not know much about that. However, I had a look and noticed that Spain is working on legislation to impose stricter limits on the amount of data centre capacity that can be installed in certain areas. Regulation is not my strong point, so I cannot add to what you have just listed. That said, I note that Ireland has introduced a moratorium on additional capacity, but I do not know whether it falls under formal regulation, because it is an ad hoc measure.

Thomas Morstyn: In Texas, there is legislation requiring data centres to provide flexibility during emergency grid conditions. That was brought in quite early, so it is perhaps a bit of a blunt instrument. There are probably more nuanced ways to do that. There are options to make sure that data centres are linked to the grid operators' needs in terms of system stability and effects on congestion, so there is definitely room for regulation.

Alejandro Gallego Schmid: There are several interesting pieces of legislation. For example, the European Union requires quite a lot of data on data centres. That is important. Transparency is crucial, because we cannot tackle what we cannot measure. Steps in that direction are really interesting.

Several moratoriums are in place to enable research to be carried out. For example, in the state of New York there is a one-year moratorium on approving any data centre in order to better understand their capacity requirements. The approach is very interesting in Singapore, where they have a cap, which I think is 300MW. They accept petitions for a share of that capacity and select projects that are, for example, more sustainable or beneficial. In the Netherlands, a moratorium is in place across the country regarding the development of hyperscale data centres, except in two specific areas. Those are quite different examples and approaches.

I would definitely encourage the Polish approach of having greater access to data and a much better understanding of the electricity consumption and heat generation of different potential future data centres.

The Convener: The use of vegetable oil for back-up generation has come up only once this morning. How realistic is it that that could be used for hyperscale data centres? The Scottish Government is considering hyperscale data centres that exceed 50MW.

Wim Vanderbauwhede: I do not know how easy it would be to scale up the infrastructure for creating biodiesel, which is the type of fuel that would be used. However, with regard to local nuisance, let us say, or pollution, that would not help, as it would still create the same kind of NO_x emissions and so on. The amount of pollution is considerable. I calculated it for a 500MW data centre, but we can simply scale it down. If all the diesel back-up generators for a 50MW data centre are switched on, that is like 2,000 lorries idling at the same time, releasing, in effect, a huge cloud of toxic air. Whether the back-up generators use biofuel or not has an effect on CO_2 emissions but not on local pollution.

I think that that is probably the most significant factor, because the assumption is that the back-up generators will not be needed most of the time. Therefore, the total amount of emissions that they produce should be very small—otherwise, there would be a big problem for the grid. Assuming that we cap the total capacity, it might be possible to produce enough biofuel for the back-up generators, but, when they were on, they would cause a lot of pollution locally for a data centre of that size. That problem does not go away.

The Convener: Thomas, do you have anything to add?

Thomas Morstyn: No. I have not looked into that issue in detail.

Alejandro Gallego Schmid: Building on what Wim said, the problem is that we do not have the capacity. It is important to consider that. Nowadays, all the biofuels that are produced in the UK go to transport although there are other sectors that would want to use that biofuel, such as the flooding prevention sector. There is a capacity problem that relates to the availability of biofuel for such purposes. That does not mean that we cannot increase the capacity, but the current capacity has already been allocated for a different purpose, so there will be no room to use biofuel instead of diesel for back-up generators. I agree with Wim that the use of biofuel for back-up generators would solve a small part of the issue of carbon emissions but would not address the local air pollution associated with, for example, NO_x.

The Convener: I have one more question, after which I will bring in Ariane Burgess for a final question. It is a question that I asked the previous panel. As has been mentioned, domestic energy is extremely expensive in the UK. If we decide to proceed with data centres, whether hyperscale or

otherwise, should domestic customers be expected to pay higher bills as a consequence?

Alejandro Gallego Schmid: I am not an expert on cost, but I can see what is happening in other countries. There are already providers of data centres that are assuming the extra cost of electricity bills for local communities. Some states in the United States have started to make that mandatory. In such cases, the cost of electricity for local communities would not be affected. I think that it makes sense for the people who will benefit economically from the development of data centres to assume the extra electricity costs associated with that, but that is a personal opinion.

Thomas Morstyn: That is definitely an important issue. Given that data centre developers are very enthusiastic about building data centres, because of the economic upsides that doing so allows them to access, it does not seem to make a lot of sense for end consumers to end up paying more in their bills. However, there is the potential for that to happen, because, although it is possible to put in place arrangements to ensure that direct grid upgrades are paid for by data centre developers, there are still risks as a result of the way in which balancing the power grid is thought about in the UK. Because the balancing costs and some of the fixed network costs associated with congestion, reserve requirements and so on end up being spread across the bills of all consumers, there is the potential for such indirect effects on system costs to end up flowing through to end customers. Therefore, it is definitely important to think carefully about such issues.

On the other hand, there is also an opportunity for the development of data centres to help in that regard, because one factor that has contributed to energy bills being higher in the UK is the fact that overall energy demand has been relatively flat or even reducing while the fixed network costs and balancing costs have been increasing. Those costs then have to be spread out across a smaller number of kilowatt hours, which increases the price of each kilowatt hour. Indeed, if you have these large sources of demand, you might, with appropriate arrangements, be able to ensure that the full cost of the system—or even slightly above that—is included, which would have the potential of reducing the per unit energy cost faced by other consumers. Even though more energy was being produced and distributed and more money was being spent on energy overall, a lot of that would come from these data centres.

Wim Vanderbauwhede: I do not have much to add to what Thomas has just said. I definitely think that, to the degree that it is possible, the consumer should not have to pay for the costs arising from large data centres being built, because it is not clear that the consumer benefits from their construction in the first place, particularly if they are AI data centres. After all, most of the use of AI inference resources is very concentrated and not evenly distributed. Given that a few big players use most of those resources and drive their growth, most people do not benefit at all from them and certainly should not end up having to pay the bills.

The Convener: Thank you. I call Ariane Burgess.

Ariane Burgess: My question is directed to Wim Vanderbauwhede, who talked earlier about having smaller and more dispersed data centres that would have less environmental impact. Can you clarify what would happen in those data centres? Public sector reform is going on in Scotland at the moment, and in those discussions, certainly with local government, academia and so on, people are expressing great hope that certain aspects of AI will be able to help with the toil of things—to use a term that was used last week. Is that the kind of thing that would happen in these smaller, more environmentally dispersed data centres, or could things such as ChatGPT run in them, too?

Wim Vanderbauwhede: It is all a matter of scale, isn't it? Even a 100KW data centre could, if you wanted, run several large AI inference computers, which would service quite a lot of requests. Therefore, it could do that ChatGPT and Copilot-style work.

It is not so clear from the studies that I have read from the UK Government that there will be that much relief from toil; it seems to be more about displacing what work you do rather than an overall increase in productivity, but that is probably a separate discussion. The fact is that the workload of a data centre depends mostly on what kind of service you choose to put into it. If you put in, say, a GPU server, you are very much saying that it will be an AI data centre, and it effectively cannot be used for much else. From that perspective, there will need to be careful consideration of the dominant work that you want these data centres to do.

Ariane Burgess: I am going to have to follow up on that, because I am still not quite clear. What I am trying to get at is this: if the recommendation was to have smaller, more dispersed data centres, would we still be able to support the country, local government and all the rest of it? I take your point about toil, but would we be able to support that goal and take it forward with smaller data centres that are better for the environment?

Wim Vanderbauwhede: Oh, yes—definitely. A huge amount of resources is not needed to support that particular purpose.

There is quite a bit of a misconception with regard to how much compute you need to do certain things. For example, when you try to detect, say, bowel cancer in X-rays, you use what people call AI—or machine learning, as I would call it—and it uses 100,000 times less energy than sending a query to ChatGPT. You are not going to fill a data centre with all the resources that the NHS needs for that kind of work—well, you might fill maybe a very small one.

It really depends on the specific work that you want to do. With transcription and so on, you use very specialised types of AI, and you do not need a lot of energy in relative terms. Even if we were to cap capacity at what is already 10 times more than what we have now, we would still have plenty of leeway to do all of that work.

Ariane Burgess: Thank you.

The Convener: Thank you very much. That concludes our business in public, and I would like to thank the three panel members for their evidence both this morning and this afternoon, as it now is. It genuinely has been very helpful.

As agreed earlier, we now move into private session to consider the remaining item on our agenda.

12:49

Meeting continued in private until 13:03.

This is a draft *Official Report* and is subject to correction between publication and archiving, which will take place no later than 35 working days after the date of the meeting. The most up-to-date version is available here: https://www.parliament.scot/chamber-and-committees/official-report

Members and other meeting participants who wish to suggest corrections to their contributions should contact the Official Report.

Official Report
Room T2.20
Scottish Parliament
Edinburgh
EH99 1SP

Email: official.report@parliament.scot
Telephone: 0131 348 5447

The deadline for corrections to this edition is 20 working days after the date of publication.

Published in Edinburgh by the Scottish Parliamentary Corporate Body, the Scottish Parliament, Edinburgh, EH99 1SP

All documents are available on
the Scottish Parliament website at:

www.parliament.scot

Information on non-endorsed print suppliers
is available here:

www.parliament.scot/documents

For information on the Scottish Parliament contact
Public Information on:

Telephone: 0131 348 5000
Textphone: 0800 092 7100
Email: sp.info@parliament.scot



The Scottish Parliament
Pàrlamaid na h-Alba